A STUDY OF THE ROLE OF AN UNMANNED AERIAL VEHICLE (UAV) IN CREATING AN ENHANCED VIRTUAL FIELD GUIDE (EVFG) IN GEOSCIENCE FIELDWORK

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ABSTRACT

This thesis investigated the role of an Unmanned Aerial Vehicle (UAV) in the creation of an Enhanced Virtual Field Guide (EVFG) in Geoscience fieldwork. This research used a pragmatic mixed methods approach to investigate the research question "*How can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Field Guide for Geoscience fieldwork?"* The thesis examines the question in four distinct sections; fieldwork, mobile technologies in fieldwork, UAVs in fieldwork and finally, the creation and evaluation of the Enhanced Virtual Field Guide created by UAV technology. To achieve this, online questionnaires, interviews, focus groups and fieldwork observations with a selection of Geoscience staff and students at two UK Universities were utilised.

UAVs are a rapidly emerging commercial technology, however, their uptake and critical discussion around their potential in fieldwork with students has been limited. This study created with the guidance of those interviewed in this research, an innovative Enhanced Virtual Field Guide for students to utilise in their final year fieldwork module and assignment.

Findings from this research with regards to fieldwork and mobile technologies confirms that fieldwork and mobile technologies are still an integral part of a geoscience students course and the majority of students still greatly enjoy the positive aspects of fieldwork. However, this research has discovered many unexplored darker sides of fieldwork and mobile technology use in fieldwork, such as disabilities, distractions, and lack of access for some students. In terms of the educational value of UAVs, this research showcases the many potential benefits for the fieldwork experience. Yet, this thesis highlights the many distinct and unique challenges that are attributed to UAV technologies that have and will continue to hinder their uptake on fieldwork.

The value of this EVFG developed from a UAV has been shown to be a useful tool for educators and students on fieldwork as examined in this thesis, such as an improvement of efficiency in the field, deeper and more peer learning discussions in the field and for it to be an effective learning tool for both educators and students, particularly post fieldwork.

DEFINITIONS

2D	Two Dimensional
3D	Three Dimensional
AA	Absolute Accuracy
ATTI	Altitude Mode
BYOD	Bring Your Own Devices
CAA	Civil Aviation Authority
DEM	Digital Elevation Model
DSM	Digital Surface Model
DTM	Digital Terrain Model
EVFG	Enhanced Virtual Field Guide
GB	Gigabyte
GCO	Ground Crew Observer
GCP	Ground Control Points
GLONASS	Global Orbiting Navigation System
GPS	Global Positioning System
GSD	Ground Sampling Distance
IOD	Institutionally Owned Devices
LIDAR	Light Detection and Ranging
LJMU	Liverpool John Moores University
NQE	National Qualified Entity
PfCO	Permission for Commercial Operations
RA	Relative Accuracy
RMSE	Root Squared Mean Error
RPAS	Remotely Piloted Aircraft Systems
SfM	Structure from Motion

SPSS	Statistical Software for the Social Sciences
SSI	Site of Scientific Interest
UAV	Unmanned Aerial Vehicle
UoC	University of Chester
VFG	Virtual Field Guide
VLM	Virtual Landscape Model
VR	Virtual Reality

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CHAPTER I: INTRODUCTION

This opening chapter is a brief introduction to the study that is presented in this thesis. This chapter explores the background context of the study, identifying the gaps in literature into which this original research fits. The research question and aims are outlined before an exploration of the researcher's background and how this has influenced the development of the research. Following on from this, the chapter will then conclude with an outline of the structure of the thesis.

1.1 BACKGROUND CONTEXT

Fieldwork is a well-established and researched form of education, particularly in the geosciences. Fieldwork excels in taking students out of their four walled classrooms to explore the environment for themselves through practical hands-on inquiry (Boyle, Maguire, Martin, Milsom, Nash, et al., 2007). Not only this but fieldwork often develops fundamental graduate employability skills, such as problem solving, teamwork, technical skills and independent study (Knight & Yorke, 2002). Fieldwork, while regarded as being highly beneficial to students of geoscience degrees, has changed significantly over the years and continues to change in light of technology and the pressures of today's Higher Education system.

With the introduction of mobile technologies such as smartphones and tablet computers, not only the way in which fieldwork is conducted, but also how it is taught has changed considerably (Fuller & France, 2014). A shift has occurred away from large groups of students being taken to a landscape to listen to an outdoor passive lecture from an educator, to today, small groups of students working together actively in the field with technologies to aid their learning. This shift has many well-researched benefits which come under the term 'technology enhanced learning' in the field, yet it has created some distinct challenges that are not as well researched or documented in fieldwork literature.

One form of mobile technology that has the potential to further change fieldwork practice and development is the Unmanned Aerial Vehicle (UAVs). UAVs are not a new phenomenon but commercial UAVs are new to Higher Education. UAVs are used extensively today for research purposes such as disaster relief (Maza, Caballero, Capitan, Martinez-de-Dios & Ollero, 2011), landslide mapping (Lucieer, Jong & Turner, 2014), crop surveying (Bendig, Bolten, Bennertz, Broscheit, Eichfuss & Bareth, 2014), animal tracking and monitoring (Rodriguez-Canosa, Thomas, Del Cerro, Barrientos & MacDonald, 2012), to name but a few in a long list of applications for their use. Nevertheless, one area that is vastly underexplored is in the use of UAVs for educational purposes. There is little empirical research in the literature that explores the use of UAVs in education and specifically for their use on fieldwork as an educational aid.

1.1.1 Originality

Fieldwork is a well-researched topic in education with such literature focusing on the benefits of fieldwork such as skill development (Kent, Gilberston & Hunt, 1997), employability (Arrowsmith, Bagoly-Simó, Finchum, Oda & Pawson, 2011), learning theories (Helaey & Jenkins, 2000) and its ability to enhance learning (Drummer, Cook, Parker, Barrett & Hull, 2008). Yet, as Higher Education in the United Kingdom has changed, the literature suggests that fieldwork is a 'perfect' tool for learning and such literature often paints fieldwork in a very positive light. The first part of this study investigates fieldwork today in relation to established literature to assess its benefits but also to explore the challenges of fieldwork today such as; time and financial pressures, staff resources, student mental health, wellbeing and equality for disabled students which are all underrepresented in fieldwork literature.

Mobile technologies have aided this change in fieldwork and while still a relatively new topic having mainly gained traction in 2010 when smartphones and tablet computers became available, research continues in this area. Research on mobile technologies in education has often been situated around their use in the classroom (Martin & Ertzberger, 2013) and on fieldwork (Welsh & France, 2012). Thus far, established research in this area has investigated technology that is now relatively outdated and researched with a generation of students who were getting to grips with such new technologies. Today, this technology is embedded into society's everyday lives and access to technology and devices has considerably changed and continues to change annually for students. Attitudes toward such technologies and what technologies can potentially provide for students and educators have changed as they continue to develop. The second part of this research therefore investigates the advantages and disadvantages that mobile technologies offer students and educators in today's higher education system. This generation is embedded with technology and while education has been slow to uptake such technologies, it is now an increasingly embedded practice to use such technologies for students from as early as primary school right through to higher education. This research consequently looks to see if such claims made in literature are supported by today's educators and students.

While mobile technologies are embedded into education and fieldwork today, UAVs are not embedded yet. Unlike mobile technologies, there is little research into the influences that UAVs can have for educators and students. Commercial UAVs are a new tool and like mobile technologies have seen an exponential rise in not only numbers but also in advancements. As such, established research has used the many benefits that UAVs offer to explore the role of UAVs in a number of different fields, all except one; education.

This research has attempted to go some way towards closing that gap and encouraging other researchers to investigate their educational benefits further. The third part of this study investigates this unexplored area of UAVs to understand, if and how, UAVs can have an advantage to students learning but also as a tool for educators to deliver such learning.

As UAVs are constantly changing, and the laws and regulations continue to try to keep pace, they are not a common tool used in education. This thesis attempts to document the processes and the challenges of implementing UAVs in fieldwork. As little research exists about UAVs in education, this thesis provides an outline of one way of implementing such devices and evaluates both the positives and the negatives of such a tool. The very act of using UAVs in this research and documenting this process is part of the research in itself.

The final part of this research is the accumulation of all of the above that has come together for the researcher to make a specific learning tool developed through the use of UAV technology. The researcher has created a 3D Enhanced Virtual Field Guide (EVFG) (in conjunction with educators and students) of a specific field site for which a select cohort of students visited as part of their degree program. This research outlines how this EVFG was created and then evaluates how data from a UAV has enhanced the standard VFG as a tool to be utilised by both educators and students on geoscience fieldwork.

1.2 Research Question and Aims

This research focuses on four distinct areas that come together in the development of an educational tool for students to use on fieldwork. In order to establish this, this research has a central research question and a number of aims and objectives to complete in order to satisfy this research question.

1.2.1 The Research Question

This research has one overarching central research question, which is:

> **How can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Field Guide for Geoscience fieldwork?**

1.2.2 Aims

In order to answer the research question, there are four overarching aims that are explored within this research that are deemed by the researcher to be the most important. They are as follows;

(1) **To enhance the understanding of the role fieldwork and mobile technologies play in learning about geoscience in higher education**
(2) **To investigate and document the regulation, the benefits and the challenges to using Unmanned Aerial Vehicles in Geoscience fieldwork**
(3) **To explore and refine how Virtual Field Guides can support authentic learning**
(4) **To evaluate the use of an innovative Enhanced Virtual Field Guide generated from Unmanned Aerial Vehicle Data**

1.3 Researcher Background, Development and Methodology

While the central research question has always been the same, the aims of the research shifted significantly during the literature review and pilot training of the Unmanned Aerial Vehicle. The original aim of this research from its conception was to evaluate the use of UAVs on fieldwork with students. Neither myself nor any of the research team i.e. supervisors, had any experience of the very complex nature of the world of UAV technologies and so it became apparent relatively early on as to the extent and the 'messiness' of UAV regulation in the United Kingdom. To add to such challenging regulation was the issue of permissions and insurance that further complicated matters, which meant that no direct flying of the UAV could be undertaken by undergraduate students. While that is a finding in itself, it was a point of frustration in this research.

Nevertheless, this provided myself with a prompt of 'if students can't fly a UAV on fieldwork, what can be created from it to aid their learning?' and thus, the development of a Virtual Field Guide was born. I have been a Geoscience student in the past for both my Single Honours undergraduate degree and in my Masters in Environmental Sustainability and so I have lived and experienced fieldwork first hand as a student. Not only this but during my time as a Research Assistant and Visiting Lecturer at a North West of England University, I have experience of being on the other side of the fence on fieldwork and have delivered fieldwork. It is through these experiences that an interest in the educational use of mobile technologies in fieldwork developed.

My first point of interest in the use of mobile technologies was on my first residential field course of the first year of my undergraduate degree in February 2010. We were tasked as part of our independent project to explore house prices from the coast in land from Slapton in Devon, England. Our initial plan was to take pictures of houses for sale as we walked in land. We would make a note of the address and then come back to the field centre to look up the house prices on the internet and try to somehow put the pictures onto a map. In 2010 out of the five of us in the group, only one had what could be considered a true smartphone as we know it today; it was a first generation iPhone. It was suggested to us that we should use the GPS geotagging function on the device to take pictures of the houses and upload them to Flickr (an online photograph sharing and storing website) to create a transect map for which we could annotate the descriptions for house prices. I saw first-hand back then the benefit and avenues for learning that technologies could offer students but it also brought with it some distinct challenges.

Now many years later with the introduction of UAVs I wanted to explore whether like myself back in 2010, pioneering researchers and educators were taking a step into the unknown and using such technologies in their fieldwork and teaching. As it became apparent that while research focuses on UAVs for many different applications, there is a distinct gap in their evaluation as a educational tool on fieldwork. Thus, this research was established to not only evaluate UAVs as a tool to potential aid learnig but also to develop something from which students could hopefully benefit from in their fieldwork learning. It has been at the heart of my thoughts while completing this research that as I have faced many regulation challenges and experienced this new unknown world of UAVs, I wanted to make sure this study outlines and signposts the challenges along the way. I have also made sure that where possible any software or equipment is not specialised or overly complex and can be accessed either for free or for a relatively small fee. It is my mantra in this research to not only ask the question "can UAVs be an effective tool" but if they can, how are they, how can they and this is how you can use it yourself. A prime example of this is in the development of the Virtual Field Guide. It is my aspiration that such a model does not languish in the pages of a thesis but other researchers take these ideas, improve them and implement them with geoscience students on fieldwork around the world.

1.3.1 METHOD

While the method is explored in more depth in the following methods chapter, chapter II in order to answer the research question and aims a sequential mixed methods approach was used in this research. As an Undergraduate and Masters student, I often aligned myself with a positivist and empirical stance to research, valuing hypothesis and statistical validation. This changed as my just under three year stint as a research assistant working on a variety of projects from purely statistical projects, to purely qualitative projects to finally, a mix of the two. It was during this time of learning and using both sets of paradigms, that I began to see the merit of both and it was during the two mixed methods research projects that I fully appreciated the pragmatic outlook on research. It became clear to me that while I always valued statistics, I always asked myself the question of 'What works best to answer this question?'. As I developed myself as a researcher, I valued the instruments used by qualitative and quantitative researchers. I value the bigger picture and testing of quantitative research and I value the in-depth detail that qualitative research offers. I firmly believe that in order to fully answer a research question that both the broad and the narrow, the general and the in-depth, the quantitative and the qualitative approach should be used.

This research therefore used sequential mixed methods with the quantitative questionnaire informing the more in depth focus groups, interviews and the development of the model.

1.4 THESIS OVERVIEW

This thesis takes a different approach to the traditional standard of extensive literature review followed by results, then discussions, then a conclusion. Instead, each chapter focuses on each aim and is broken down into paper format. Each chapter has embedded literature, followed by a small methods section, then a combined results and discussion section before offering a conclusion. Each chapter feeds directly into the next chapter providing the reader with sufficient background knowledge and understanding. Each chapter should inform the basis of the next chapter. The final chapter is a synthesis which answers the overall research question.

1.4.1.1 Chapter II – Methodology

As the extensive literature review that usually follows the introduction chapter was broken down into the other chapters, following this chapter is an extensive methodology chapter. This chapter explores in-depth the researcher position before outlining what method, instruments and design this research took. This chapter evaluates both the positives and negatives of each approach and the instruments used in this research and also outlines what specific types of analyses were used to help inform the following chapters.

1.4.1.2 Chapter III – Fieldwork

This chapter explores the first aim of this research which is '*to enhance the understanding of the role fieldwork and mobile technologies play in learning about geoscience in higher education*'. In order to provide this, the chapter begins with a brief history of fieldwork along with the various learning theories on fieldwork. Following a brief methods section, the chapter explores the positive side of fieldwork as supported by established literature such as student enjoyment, enhancement of learning, and skill development. This chapter will then, unlike most established fieldwork literature, explore the negative side of fieldwork for both educators and students such as student pressures and practical barriers to fieldwork. The chapter will provide an overview of fieldwork and its many advantages and disadvantages.

1.4.1.3 Chapter IIIV – Mobile Technologies in Fieldwork

This chapter opens with an overview of the changing nature of fieldwork due to the creation and implementation of mobile technologies in fieldwork. Through primary research and established literature, the chapter then explores students' use of such devices in fieldwork and their attitudes to doing so. The advantages and disadvantages of using mobile technologies on fieldwork are further explored here, along with commenting on the debate in literature of Bring Your Own Device versus Institutionally Owned Devices on fieldwork. In conclusion, this chapter in conjunction with chapter III, will have addressed the first aim of this research.

1.4.1.4 Chapter V – Unmanned Aerial Vehicles

This chapter explores the history and regulation of UAVs as this will provide some background knowledge to the discussion of UAVs as an educational tool. This chapter as per aim (2.) Investigate and document the regulation, the benefits and the challenges to using Unmanned Aerial Vehicles in Geoscience Fieldwork. To do this, this chapter explores the advantages that UAVs can offer educators and students before countering this with barriers to using UAVs in education and on fieldwork that have arisen from this research.

1.4.1.5 Chapter VI – The Generation of the Virtual Landscape Model and the subsequent Enhanced Virtual Field Guide

Now that fieldwork has been explored along with mobile technologies and UAVs as discussed in relation to the research question, the UAV was used to develop a 3D virtual landscape model (VLM) that was subsequently edited to become an Enhanced Virtual Fieldwork Guide (EVFG) for students on fieldwork. Before such an EVFG could be evaluated by educators and students, it had to be created and developed by the researcher. This chapter discusses the nature of Virtual Field Guides before outlining the detailed procedures that had to occur in order to collect and process the data to create the VLM and then the EVFG. This chapter is procedural and methods orientated but is fundamental for understanding the results in the following chapter.

1.4.1.6 Chapter VII – Evaluation of the Enhanced Virtual Field Guide

This chapter is the accumulation of discussion in the previous chapters. It answers the research question of this thesis and the final two remaining aims. This chapter evaluates in-depth firstly the advantages that the EVFG created from UAV data can offer both educators and students. It also explores how students and educators would like the EVFG to be used and how the EVFG was actually used on fieldwork with the students. As part of the evaluation, the negative aspects of the EVFG are explored and recommendations offered as to how future EVFGs should be implemented and improved in relation to the research question. This chapter is deemed the most important in this thesis as it answers the question '*How can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Field Guide for Geoscience fieldwork?'*

1.4.1.7 Chapter VIII: Conclusions and Recommendations

While each chapter offers their own concluding sections, this is brought together into one concluding chapter. This chapter summarises the research in relation to its aims and research question. This chapter also offers a reflection of the research process and its limitations before offering recommendations in light of the conclusion from the data.

1.5 SUMMARY

This chapter has provided a brief introduction to the study beginning with the problems and how this research aims to address them. This chapter has provided an overview of the researcher's background and how this thesis has been developed. Overall, this study is significant because established research has yet to explore UAVs in education and has yet to develop UAV specific bespoke learning tools for educators and students on fieldwork, which this study has done. This study explores the use of a new technology being used in geoscience fieldwork and has aimed to not only evaluate it as an educational tool but also to document the process so that it can be replicated and implemented in education, fieldwork and beyond into industry.

CHAPTER II: METHODOLOGY

2.1 INTRODUCTION

This chapter introduces the researchers approach including their ontological and epistemological position and the methodology and instruments chosen in order to answer the research questions as set out in section 1.2 of Chapter I. This methods chapter is the first of two in this thesis. This chapter focuses primarily on the general overview of methods used in this research with the researcher's justification for their implementation. Small-embedded methods sections are within each chapter that discuss the specific questions used to evaluate the research question and aims of that chapter. This chapter conversely will discuss the methods, instruments, and analysis used in the delivery of such questions in this research. This chapter begins by outlining the methodology chosen before moving onto to evaluating the specific research instruments used. Two analysis sections follow outlining the specific tests and processes that governed the results and discussion of the data in this thesis. Finally, the chapter will finish with a discussion around ethics, risk and safety in this study. A more substantial methods section on the development of the UAV licence and 3D VLM and EVFG generation can be found in Chapter VI.

2.2 PRAGMATIST APPROACH TAKEN

Throughout this research, a pragmatic approach was utilised as it aligns to the beliefs of the researcher. Pragmatism can often be a contested approach to research from the purists of both the quantitative and qualitative paradigms. While both quantitative and qualitative approaches undoubtedly have their advantages and drawbacks for their respective uses, there is a notion in academia that quantitative and qualitative methods are mutually exclusive. There are two different trains of thought in research as to how research should be conducted and as identified by Salomon (1991), can even go as far as stating there to be a '*paradigm war*' that exists between the two. A new paradigm emerged amongst this conflict, which is that of the '*pragmatic*' or '*mixed method*' approach to research (Johnson & Onwuegbuzie, 2004). Pragmatic researchers employ methods that are best suited to answer the research question or problem that they are trying to study (Chow, 1987).

Pragmatic researchers are less concerned by the raging philosophical debates of traditional theory and methods of quantitative vs qualitative purists, but are more concerned by the practical value of the methods and instruments used to answer the research questions (Ostlund, Kidd, Wengstrom & Rowa-Dewar, 2011). Those who employ a pragmatic approach to research recognise the benefits and limitation of both quantitative and qualitative research methods (Onwuegbuzie & Leech, 2005). Pragmatic researchers give themselves independent and free, but informed choice, when choosing suitable methods, techniques, and procedures for their research from both the quantitative and the qualitative paradigms (Chatterji, 2004).

Pragmatist researchers aim to find a middle ground between the two different paradigms through their non-acceptance that the two methods are mutually exclusive (Johnson & Onwuegbuzie, 2004). Instead, as commented by Datta (1994) the paradigm wars have continued to argue about their differences rather than focusing on their broad similarities. Two distinct research cultures emerged, one who professes deep and rich observational data (qualitative) whereas the other (quantitative) favouring generalizable data (Sieber, 1973). The purists of the two paradigms view their research methods as the sole ideal method for research and therefore conform to the incompatibility thesis (Howe, 1988). Paradigm wars have been fuelled by this debate and notion that the two are incompatible, yet it is only relatively recently that similarities between the two have been highlighted in academia (Johnson & Onwuegbuzie, 2004). For example as observed by Sechrest & Sidana (1995) both methodologies of quantitative and qualitative methods use empirical observations to address their individual research questions.

Therefore, the researcher believes that the paradigm war is neither beneficial nor helpful for researchers to be working in silo in their approach to methodology. The pragmatic approach aligns to the outlook of the researcher, which has always been "*What's the best way to answer this question?*" It is the job of a researcher to ensure that the research question is answered to the fullest in the most in-depth and practical way. By not conforming to the purist view of 'only one way is the right way', the researcher believes that using multiple methods gives the most holistic view to answer the research question.

2.2.1 Mixed Methods

Pragmatic researchers as mentioned above do not just choose to do mixed methods because they can; there is a real purpose behind why using such mixed methods is a strength to this approach rather than a weakness. Pragmatic researchers have the choice of how they implement such mixed methods approaches. They can use such methods either simultaneously or inductively, with one method such as questionnaires (a quantitative instrument) leading and shaping the interview process (a qualitative instrument) (Brannen, 2005) which is the approach that was taken in this research. A further benefit to this approach is that qualitative data such as semi-structured interviews can be coded in such a way that it now becomes quantitative data for statistical analysis (Silverman, 2006; Auer-Srnka & Koeszegi, 2007). On the other hand, quantitative data can be converted into qualitative data under certain data collection conditions, although a rare technique, is still employed by some (Driscoll, Appiah-Yeboah, Salib & Rupert, 2007). Such interchangeable methods and approaches allow the researcher to use the best available tools to answer their research question through triangulation (Brannen, 2005). Triangulation of data from multiple sources is what this researcher believes is the strong point of using Mixed-Methods research.

2.2.1.1 Triangulation

This mixed methods approach can be more beneficial to a study than if a single quantitative or qualitative approach is taken (Greene, Caracelli & Graham, 1989). For example, Fink (2003) comments on how quantitative data via a questionnaire can be misleading without the in-depth discussions of a qualitative method. One question of their study asked a closed question on whether criminals should be provided with retraining. Although two participants both answered 'No' the follow up qualitative interviews revealed vastly different reasons as to why they came to their answers. This mixed method approach brings in the element of triangulation of data to ensure that the data is robust and that findings are accurate. Triangulation is a common theme within mixed-method studies and is often one of the reasons that pragmatic researchers cite for why they are using such an approach (Mertens & Hesse-Biber, 2012).

Triangulation of research can exist in different forms within an individual research project (Morse, 1991). Investigator triangulation is when more than one researcher conducts the data collection, coding, and analysis to remove or lessen the researcher bias that may be present (Denzin, 1970). Having multiple investigators increases the likelihood of the results being more accurate and credible (Lincoln & Guba, 1985).

Theory/Methodological triangulation ensures the use of multiple theories and/or methods to study a research problem (Massey, 1999). This is most common in the paradigm of pragmatism where the mixing of data-collection methods is used to suitably answer the research question at hand (Duffy, 1987; Lincoln & Guba, 2000). '*Data triangulation'* is similar to that of methodological triangulation where varying methods of data collection are used to ensure that the research question is being asked and investigated thoroughly (Thurmond, 2001). Data and methodological triangulation is the triangulation method employed in this study for this reason. In order to achieve suitable triangulation, various instruments were used in this research under the *Case Based Approach*.

2.2.2 CASE BASED APPROACH

One element of pragmatic research that is commonly used as a particularly robust research methodology when an in-depth and holistic investigation of a phenomenon is needed, is the *Case based approach* (Yin, 2013). Case based research has been used to great extent in social sciences (Flyvbjerg, 2006; Punch, 2013), education (Merriam, 1988; Bassey, 1999; Gulsecen & Kubat, 2006; Cohen, Manion & Morrison, 2013) and many others disciplines (Hancock & Algozzine, 2015). Case based research can often take a mixed method approach, as it allows the researcher to utilise both quantitative and qualitative research methods, to help guide the research process to explain and answer the research question (Yin, 2013).

Case based/case study methodology are employed when a specific phenomenon or context needs to be examined, explored, and investigated in depth through varying investigative lenses and analysis techniques (Hancock & Algozzine, 2015). A simplistic definition of a case study can be outlined as follows; "[a] Case Study is the detailed examination of a single example of a class of phenomena" (Abercrombie, Hill & Turner, 1984, p. 34). Yin (1984), further defines case based research methodology as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and when multiple sources are used" (Yin, 1994, p. 23).

2.2.2.1 The Advantages and Disadvantages of Case Based Approach

Case-based research is unlike traditional quantitative analysis that seeks to observe and comment on patterns at a macro level; rather case studies observe at a micro level (Zainal, 2007). The effectiveness of case based research is to portray what it is like to be in a particular situation or phenomenon (Eisenhardt, 1989). Meredith (1988) elaborates even further on Yin's definition by adding three core strengths of case based approach:

- The phenomenon can be studied in its natural setting where relevant and significant theory can be generated from the understandings gained through observing actual practice.

- The case method allows the questions of why, what and how, to be answered with a relatively full understanding of the nature and complexity of the complete phenomenon.

- The case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon not fully understood.

The latter two points align well with the research questions of this study, which is investigating a new and emerging technology that is yet to be used in fieldwork with students or regularly in education. It further aligns to the fundamental questions of this research which is 'how can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Field Guide for Geoscience fieldwork?'

There is debate about the effectiveness of case based research as a single research methodology. Miles (1979) remarks that case based research should be limited to use in the exploration phase of a larger research programme, citing that it offers limited robust data. Yin (1981) however counters this argument by pronouncing that there is a lack of understanding from advocates of other research methods about the types of applications of case based research. Primarily, this view has developed from a lack of sufficient case study design by case based researchers. Criticism of such a method arises from the notion that case based research is predominantly interpretative and less quantitative, although this is frequently not the case, the perception still exists in some academic circles (Yin, 1981). Such views as Smith (1991) who remarks that case studies are there to be criticised due to their investigations of the peculiar, rather than the regularities.

There is common consensus of the strengths and weaknesses of the case based approach as outlined by Adelman, Kemmis & Jenkins (1980) and Nisbet & Watt (1984), see Table 2.1 for key points.

Table 2.1: Strengths and weakness' of Case Based approach

Advantages of Case Based approaches

- Data is strong in reality due to being at one with the phenomenon and often investigated through the eyes of those 'who live it'. This provides a natural platform for generalisation.
- Strength comes from the ability to explore and explain the complexity of a phenomenon or case in its own right.
- They provide a 'step to action' in that they contribute to the here and now through practical insights. They provide sufficient data for others to reinterpret and use.
- They 'speak for themselves'
- They provide unique insights into issues and phenomenon which may be lost via large-scale research methods.

Disadvantages of Case Based Approaches

- Data can be difficult to organise compared to other research methods.
- Results may not be open to generalisation.
- They are not the easiest method to crosscheck and can include bias if triangulation of methods is not used.

The main advantage of case based research over other methods, is the study of a phenomenon in natural reality (Yin, 2011). The subject(s) in question are observed within the context and environment that it naturally occurs which is in contrast to other methods, such as experiments that isolate phenomena from their context in order to observe a limited number of preconceived variables (Yin, 1984). The flexibility that case studies offer in terms of their methods is also useful to researchers. The rich descriptions of qualitative data that are often collected through case study methodologies along with quantitative data, allow the researcher to explore the complexities of the phenomenon and its interaction in the real world, which sole survey or experimental research may not capture (Adelman et al., 1980). This is important for this study as to investigate the use of mobile and UAV technology in fieldwork or the subsequent learning tool, the EVFG, in a real life course/study environment is vital to understanding their effects on students in reality. If such technologies were tested in isolation from the students findings would not be 'true to life' in the sense that findings would not be representative of the research questions in this study.

Some disadvantages of case based research as outlined by Yin (1984) are that "too many times, the case study investigator has been sloppy, and has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions" (p 21). Case based approaches can suffer from their limited numbers of participants leading some to raise concerns about their effectiveness at generalisation (Gomm, Hammersley & Foster, 2000). This is most often the case with intrinsic single case studies and less of an issue for instrumental and collective case studies (Leonard-Barton, 1990). A final criticism that is often directed at case study approaches is that the data collection process can be too long and difficult to summarise and conclude the findings, while being resource and time intensive for the researcher (Yin, 1984).

2.2.3 EFFECTIVE CASE BASED DESIGN

One of the main reasons case based research receives criticism is the perceived idea that it lacks robustness as a standalone research tool compared to the traditional paradigms of research (Smith, 1991). In order to combat this, a well-detailed and rigorous design is of paramount importance (Yin, 2013).

2.2.3.1 Detailed Review of Literature

In order for a successful design of a case study to happen, first a review and construction of previous research, literature, theories, and relationships that are a part of the intended study must be compiled by the researcher (Baxter & Jack, 2008). Even research that is heavily inductive and theory building in its approach, still needs a review of where the research fits (Miles & Huberman, 1994). A comprehensive literature review was therefore conducted for this research. Initially, this was conducted as a standalone chapter before any data collection commenced. This extensive literature review has been divided up into the dedicated literature review sections of each of the following separate chapters. One of the benefits of completing a large initial literature review chapter was that it allowed the researcher to develop informed research question and aims to address gaps in current literature and to help inform the focus of the study. Too often, this is where case based researchers rush into the data collection processes without having a clear and defined research focus and questions.

2.2.3.2 Developing a Research Question(s)

In the development of case based research it is essential to have a well-defined research question, as that informs and guides the choices made in the subsequent data collection phase (O'leary, 2004). As noted by Voss, Tsikriktsis & Frohlich (2002) the research question is often to be made up of one or more constructs. This allows the "researcher to measure constructs more accurately. If these constructs prove relevant, then the researcher(s) have a firmer empirical grounding" (Eisenhardt, 1989, p. 536). Zainal (2007) comments that although a detailed research question is needed before the start of data collection, there is an acceptance that the research question may shift over time. This is seen as a particular strength to this research methodology, as it continually allows the researcher to shape the research through the development of continued new knowledge and not being fixed to a single inadequate research question. Nevertheless, Voss et al (2002) remarks that that researchers should try to stick to the original research question. It is not a basis for inadequate starting research questions or for researchers to go on a 'fishing expedition' by collecting data that will inform a subsequent research question. If researchers take this approach, they risk entering into the pitfalls of case study research as outlined by Yin (1981). No research question was altered since the formulation in this research. This was due to the extensive literature review conducted.

2.2.3.3 Selection of the number of cases

Case based researchers have to decide whether to focus on a single case or a multiple-case design (Voss et al., 2002). Single case studies allow the researcher to examine in-depth a single phenomenon and utilised when there is no opportunity for replication (Bennett, 2004). Single case studies have their limitations as outlined by Leonard-Barton (1990). Due to only one event or phenomenon observed at only one specific time, there is a distinct possibility of the researcher misinterpreting the data and inducing researcher/selection bias (Seawright & Gerring, 2008). Although such an issue is present in multi-case case studies, the nature of triangulation of methods and data, along with replication within different timeframes and locations are in place to guard against this bias (Thurmond, 2001). Single case studies suffer most from construct validity and their ability to be replicated or generalised (Verschuren, 2003).

Multi-case designs are implemented to understand a phenomenon in real-life events, yet can show replication rather than sampling logic (Yin, 2013). The researcher can replicate the case through pattern matching which is a technique that links more than two items of information from the same case and other cases, with each item supporting previous results (Campbell & Fiske, 1959). This method employs data and methodological triangulation, which increases the confidence and robustness of the data and findings in question (Thurmond, 2001). Therefore, a multi-cased approach was employed in this research rather than a single case.

2.2.3.4 Case Study Types

Yin (1984) identifies three types of overarching case study types, Explanatory, Descriptive and Exploratory. Merriam (1988) further developed this by creating three types of case studies, Descriptive (narrative accounts), Interpretative (developing conceptual ideas to examine initial assumptions) and Evaluative (explaining and judging a phenomenon). Stake (1994) refined the categories of Yin (1984) & Merriam (1988) and identified three types of case studies:

• **Intrinsic** case studies – These are used to understand and evaluate the particular phenomenon in question; often these are standalone single case studies.

• **Instrumental** case studies – used to examine a particular phenomenon in order for the researcher to gain sufficient insight into a particular issue or theory being studied in the phenomenon.

• **Collective** case studies – are a collection of instrumental case studies that are brought together to give a more holistic view of the issue or phenomenon.

The collective case study approach was chosen for this research as this allowed the researcher to understand if the phenomenon in question i.e. mobile technologies in fieldwork, UAVs and 3D EVFGs, have a collective benefit to students. Intrinsic case study was not chosen as while the three cases here can stand alone, the aim of the research was to investigate how they all fit in together and be collectively used in education.

Collective Case Studies in this research are presented as chapters throughout the thesis. All cases link into each other and the cases revolve around phenomena such as fieldwork, mobile technology in fieldwork, UAVs and finally, UAV generated 3D Virtual Field Guides.

2.3 Sequential Mixed Methods and Research Instruments

A mixed methods sequential approach was employed in this research to help understand and explore the research question and aims. Sequential mixed methods are one of the most popular forms of mixed methods design in research, through the collection of quantitative data to inform the collection of qualitative data or vice a versa (Tashakkori & Teddlie, 1998; Creswell, Plano-Clark, Gutmann & Hanson, 2003). Sequential mixed methods are used in this research as the quantitative data analysis provided a general overview of the research question and provided question generation for the subsequent qualitative methods. This combination of both allows the data to support, explain, and contextualise the data collected (Rossman & Wilson, 1985; Creswell et al., 2003). Now that the epistemological stance and overarching methodological approach has been outlined, the following sections will comment and justify on the types of research instruments that were used in this research. As mentioned above, as the overarching methodological approach to this research is multiple case based approach, it allowed the researcher to use a variety of methods in order to answer the research question.

2.3.1 Sample Size

In order to conduct a robust collective case study, the researcher selected a suitable sample that could be studied and replicated in regards to the phenomenon in question. The sample population chosen for this case based research were current geoscience undergraduate degree students and staff at Liverpool John Moores University (LJMU) and the University of Chester (UoC). Sample size varied within each method of enquiry in this study, the population of geoscience students at LJMU at the time of the study was 305 students while 180 existed at UoC. This cohort was used in the delivery and completion of the online questionnaire. From this questionnaire, respondents identified if they wished to be contacted for further follow up interviews or focus groups and this formed a selective sample for these instruments. Observations of fieldwork to which the researcher had access to fluctuated between 8 and 30 students depending on the module type. The inclusion of two different geoscience populations was for the following reasons. Firstly, both institutions had various students under the geoscience umbrella for example UoC had single honours geography students but also geography natural hazards students and a variety of combined students. LJMU had single honours geography students but also a cohort of outdoor education students who while differ in their courses to geography students still have multiple modules of geography embedded within their courses and are classed as geoscience students. Secondly, access to such a variety of geoscience students was used to investigate any differences between such cohorts in the evaluations of each case. Finally, not only were the different cohorts different but the way the institutions and departments operate are different to and this was also part of the evaluation process. If for example the EVFG proved beneficial to all geoscience students in this research, then it provides a strong basis for it to be an effective tool for fieldwork. If it does not, then an evaluation can occur investigating if it is an effective tool for some students and institutions and not others and why this may be.

The final part of this study was the investigation of the implementation of an EVFG that was developed for the Outdoor Education final year module fieldtrip and assignment that consisted of only eight students. Sample size overall was limited for the researcher in terms of access.

2.3.2 Data Collection Design

Table 2.2 is a summary of the main methods used in this research and procedures that needed to take place in order for this research to occur. Fig. 2.1 demonstrates the methods map that was utilised in this research.

Table 2.2: Summary of methods used in this study

Procedure or Intervention	Participants	Number of participants	Avg. Time to complete
Questionnaire (Online)	LJMU/ UoC Students	98 with 91 used (total population 305)	10 minutes
Semi-Structured Interviews	LJMU Students	Selected from the participants who agreed to be interviewed	1 hour average
Semi-Structured Interviews	LJMU/UoC Staff	5	58 minutes average
Focus Groups	LJMU Students	Selected from the participants who agreed to be interviewed	1 Hour
Observations of fieldwork	Observing LJMU Staff/Students	Varied between 8 – 30	8 hours
Student Assignments	LJMU Students	8	N/A
Procure UAV	Researcher	1	2 months
Remotely Piloted Aircraft Systems Licence (RPAS)	Researcher	1	80 hours online learning. 10 hours flying. Licence exams over a condensed 3 day period
PfCO (Permission for Commercial Operations)	Researcher	1	4 months
Developing the 3D model	Researcher	Multiple Models created	4-8 months

Methods Process Map

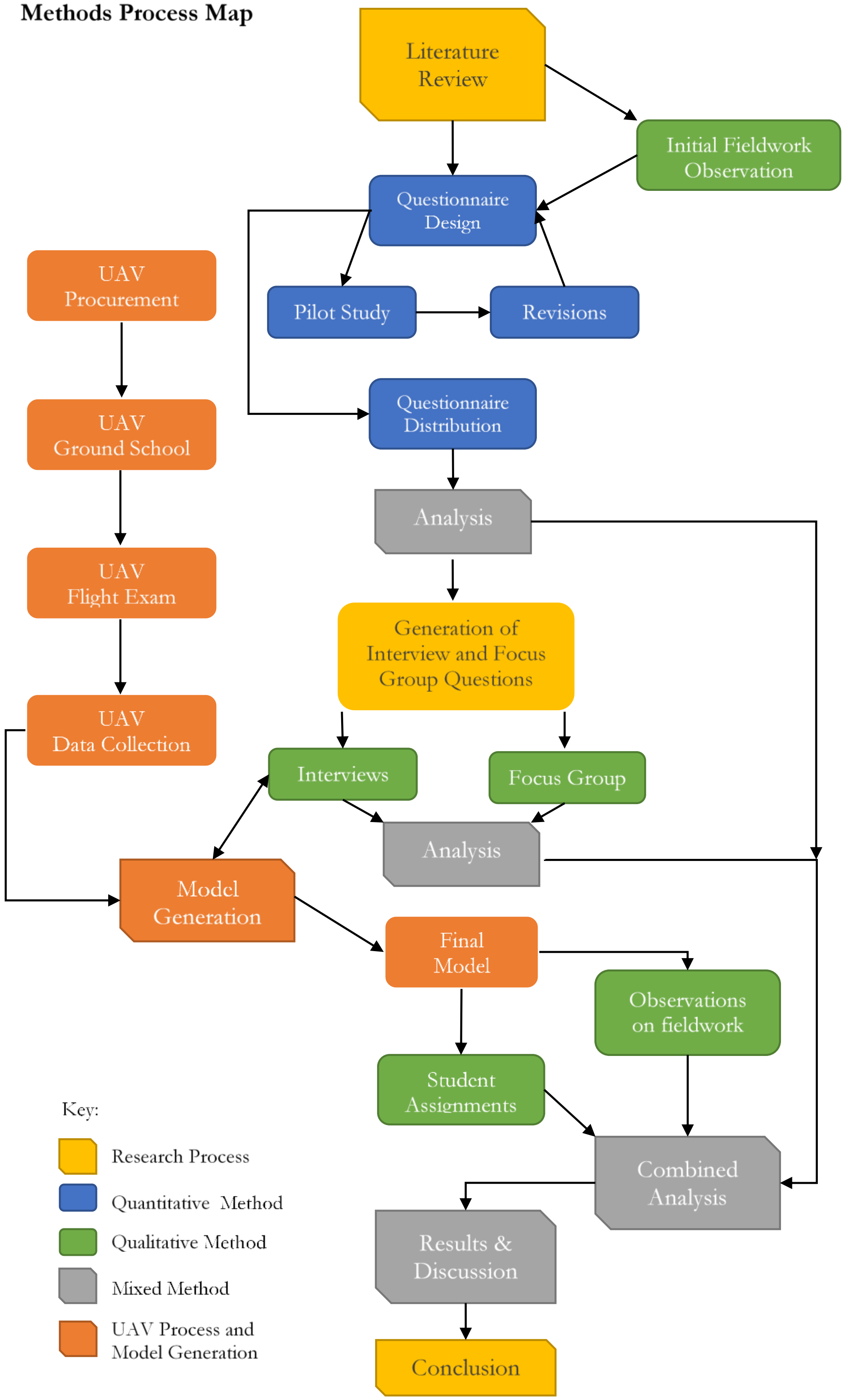


Fig. 2.1 – Research Methods Process Map

2.3.3 QUESTIONNAIRES

Questionnaires are an effective method for quantitative data collection (Sudman & Bradburn, 1982). Questionnaires are primarily employed in research to collect standardised and often numerical data from a large number of respondents that can be relatively easy to collate and analyse (Wilson & McLean, 1994; Basit, 2010; Fowler, 2014). Questionnaires are used to collect sufficient data so that statistical tests can be used to understand links between variables and to offer generalisations of the data or population in question (Rossi, Wright & Anderson, 2013). Ackroyd & Hughes (1992) identified three types of questionnaire surveys; factual surveys, attitude surveys, and explanatory surveys. This research employs a mixture of factual and attitude questionnaires in order to answer the research question (appendix A). Questionnaires have their benefits through standardisation, unlike other methods such as interviews or observations as each respondent is asked the same question, in the same manner consistently throughout the process of the survey (Yu & Cooper, 1983). Therefore, inconsistency in how a researcher asks a question to different respondents is eliminated (Saris & Gallhofer, 2007).

2.3.3.1 Online Questionnaires and their Advantages

For this research an online questionnaire was sent to all geoscience students at LJMU and UoC via the appropriate gate guardian (appendix B). Online questionnaires have increased in popularity in recent years over traditional paper questionnaires (Yun & Trumbo, 2000; Nie, Hillygus & Erbring, 2002) and today are the most common vessel for data collection for quantitative researchers (Bryman, 2015).

Online questionnaires have many benefits to the researcher and to the participants that have helped to aid the growth of online questionnaires in research (Wright, 2005) and it is due to these benefits as discussed below, that they have been used this study. Online surveys have been used to good effect by gaining wide participation from users in different localities (Garton, Haythornwaite & Wellman,1999) and for accessing participants who may be reluctant to air their views if the questionnaire was conducted face to face (Wright, 2005). This was pertinent to this research as it was not practical for the researcher to travel continuously to each University nor practical to gain access to individual classes without causing significant disruption to the students. Therefore, accessing students via online means was deemed by the researcher to be the most appropriate course of action.

Time and cost that online surveys can save a researcher has further fuelled the popularity of online surveys (Taylor, 2000). Due to the nature of online surveys, a large sample can be sent the survey providing they have access to the internet. This means that the researcher can collect data from a vast sample from all over the world in the matter of a few clicks, saving vast amount of time and resources (Garton et al., 1999; Taylor, 2000; Yun & Trumbo, 2000).

Face-to-face surveys typically take the longest time to complete (Tiene, 2000) while completed postal questionnaires can take time to be received by the researcher (De Vaus, 2013). Online questionnaires, however, are often quick to complete and once completed the researcher receives the data instantaneously. This decreases the time for waiting and increases the productivity of the researcher by working on other parts of the research while the data collection process takes care of itself (Llieva, Baron & Healey, 2002; Andrews, Nonnecke & Preece, 2003).

Accuracy of data collected can also be improved by using online surveys. As the participant is directly inputting the results, there is no room for misinterpretation from the researcher (Sue & Ritter, 2012). Online surveys can now be coded directly by software and placed directly into analytical programs such as SPSS. This reduces researcher error through potential coding errors or mistakes that can often occur with large data sets (Wright, 2005).

Although researcher bias is present in all forms of questionnaires, it can be reduced through online questionnaires due to their anonymous nature and sampling strategies (Tingling, Parent & Wade, 2003). Bias can be further reduced through participants having to answer some questions before moving to the next one. This means the questions can be answered in a way the researcher intended unlike postal questionnaires that allow the participant to look ahead which may induce bias (Evans & Mathur, 2005). However, in postal questionnaires the participant knows how much further they have to go in order to complete the survey (Schonlau, Fricker & Elliott, 2001). Therefore, online surveys should employ some form of visual representation of completion in order to keep engagement high for a completed questionnaire (Evans & Mathur, 2005). For the questionnaire used in this study a progress bar was included at the top of each page.

Cost is a major factor in implementing online surveys over traditional paper copies, as it costs less than half the cost for each online survey compared with traditional paper counterparts (Jackson, 2003). Paper copies cost money, regardless of sample size, as the researcher has to account for paper; ink, printing, posting (if postal questionnaires are used such as envelopes and stamps) and data entry sheets. Online surveys have no need to account for this due to their digital nature (Yun & Trumbo, 2000). Online survey software design, distribution and analysis software such as Online Survey formally "Bristol Online Surveys" used in this research is relatively inexpensive as it is free for students (Bristol Online Survey, 2017).

2.3.3.2 Online Questionnaire and their Disadvantages

Online questionnaires do nonetheless have their limitations. Online questionnaires have an issue of sampling bias and sampling number (Howard, Rainie & Jones, 2001; Andrews et al., 2003). For studies that wish to capture a population, due to the online nature of questionnaires, members of that population who are not on the internet or have access to the survey, are in effect discounted from the surveys reach (Evans & Mathur, 2005). This is limited somewhat in this study as all participants have access to computers and University emails. Nonetheless, the researcher could not guarantee that all students regularly check their university emails or whether they actively engage with them.

Response rates from online surveys are contested in literature. While some believe response rates are greater than traditional methods (Mehta & Suvadas, 1995; Stanton, 1998; Thompson, Surface, Martin & Sanders, 2003), others such as Nulty (2008) compared response rates from online vs paper and found on average, online had 23% fewer respondents and in some cases up to 53% less. This was reflected in this study with around 32% of the student cohort completing the questionnaire. One issue that can occur with online and emailed questionnaires is the possibility for them to be viewed as spam email by the universities firewall/email filter and also by the participant and therefore, not even be delivered to the respondent at all (Andrews et al., 2003; Evans & Mathur, 2005).

In order to increase participation of online questionnaires many researchers offer a reward as an incentive for completion. Offering rewards can sometimes lead to multiple entries being made by the same participant in order to increase their chances of winning the prize, be that a voucher or more substantial award (Buchanan, 2000; Van Selm & Jankowski, 2006). Self-selection bias also exists in this form of method. In any population, some are inclined more than others to complete online surveys (Stanton, 1998; Thompson et al., 2003). This online survey however did employ the use of a small voucher competition for those who wished to enter upon completion. It was ensured that only one University email address could be used per entry and over 60% of those who took part did not in fact enter themselves into the competition.

2.3.3.3 Questionnaire Design

In order to begin designing a questionnaire, the researcher must establish what measurable data they hope to gain, in order to answer the research aims and objectives they have set (Sudman & Bradburn, 1982). Questionnaires are designed to translate abstract ideas into defined and measurable questions (De Vaus, 2013). The researcher must break down the abstract concept into various components and dimensions to understand what needs to be measured to satisfy the research question (Patten, 2016). Key topics were identified from the literature and the observations to explore these questions. In order to gain data on numerous variables within the sample, mixed questions were employed by the researcher to obtain data that could be compared across groups in the sample such as closed questions and more open questions to encourage more understanding of a particular topic. As shown in Fig. 2.1 the questions used in this survey were generated through a variety of literature, the initial fieldwork observation and questions devised by the researcher in order to obtain data in relation to the research question and aims. In the following section, questions derived from literature are in Green. Mostly, questions were derived from established mobile technology literature, particularly the work of the Enhancing Fieldwork Learning research group i.e. Welsh, 2012; Fuller & France, 2015; Mauchline et al., 2017 who used a series of questionnaires to practitioners and students in their research. Questions generated from the fieldwork observations and general researcher developed questions are in orange.

2.3.3.4 Dichotomous Questions

This survey utilised a series of closed and fixed questions to attain data about the composition of the sample and provides a useful point of comparison. Dichotomous questions usually require a yes or no answer and this compels the respondent to answer on a particular issue and not to 'sit on the fence' (Cohen et al., 2013).

Throughout the questionnaire, closed dichotomous questions gathered data that can be compared across the sample and can provide a useful point of analysis, Table 2.3. The data collected could be used to make generalisations of the sample but were also used to help inform qualitative methods that are also employed in this research (Krosnick & Presser, 2010). For example, if a student identified that mobile technologies were beneficial to their fieldwork, the how and why was investigated through interview and focus group questions. This allowed more discussion to take place could have been achieved in a questionnaire.

Table 2.3: Dichotomous Questions utilised in the Questionnaire

Dichotomous Question	Response
Population Characteristics:	
Gender	Male/Female
Age	18-19/19-20/21-22/23-24/24+
University	LJMU/UoC
Degree Classification	BSc/MSc
Current Level of study	L4,L5,L6
(8) Do you own a smartphone?	Yes
(9) Do you currently use your smartphone for educational purposes i.e. for lectures or in fieldwork?	No
(10) Do you own a tablet device?	
(11) Do you currently use your smartphone for educational purposes i.e. for lectures or in fieldwork?	
(21) Do you use social media i.e. Facebook, Twitter to discuss assignments?	
(22) Have you used a UAV/Drone before?	
(23) Would you encourage the use of UAVs in fieldwork?	
(10.a) What smartphone make do you own?	Samsung Apple Windows Other
(18) Do you take time after fieldwork exercises to reflect on what you have learnt and experienced?	All the time Sometimes Rarely Never

Dichotomous questions are useful in funnelling respondents for further questions, such as 'if answered yes, go to Q2' (Sudman & Bradburn, 1982). Dichotomous questions are easy to code and analyse for the researcher (Bradburn, Sudman & Wansink, 2004). The disadvantage with closed questions is that they force the respondent into categories that may not represent their feelings and thoughts (Brace, 2008). Closed questions on their own further limit the respondents' ability to clarify their reasoning behind their answer. For the example above (Q23), if a student answered 'Yes' although the researcher can see that a student would encourage the use of UAVs in fieldwork, they do not know how or why they think this. Two respondents who answered 'Yes' may have completely different reasons for coming to their conclusions. Closed questions do not allow for the exploration of this and that is why mixed questions such as Likert scales and more open questions need to be employed on questionnaires (Creswell, 2013) and therefore are used in this research.

2.3.3.5 Likert Scales

There are a number of Likert scale questions in this survey, Table 2.4. Likert scales are more open than closed questions but are still closed enough in the sense that they are easier to quantify and compare through statistical analysis (Allen & Seaman, 2007). Likert scales are mostly used for psychometric testing of attitudes, beliefs, and opinions (Geoff, 2010). They are the most popular type of question on a survey, therefore respondents are familiar with the layout and how they should answer the question (Carifio & Perla, 2007). Likert scales use a question that is in a statement form for which the respondent selects one option on an ordinal scale of how much they agree or disagree with said statement (Oppenheim, 1992). This data provides an ease of quantitative conclusions and comparisons (Trochim, 2006).

Likert scales have issues in that often the scale is from "Strongly Agree" to "Strongly Disagree", to what extent a person feels strongly about something is subjective to each respondent (Pell, 2005; Cohen et al., 2013). Likert scales unlike dichotomous questions allow the respondent to select a neutral answer such as "unsure" or "I do not know". This can create an issue where some may elect to select a default neutral response or to "sit on the fence" and therefore not give a true reflection of their true feelings or opinions (Fernandes & Randall, 1991). For the most part in this questionnaire a four point Likert scale was used to eliminate this. However, this unsure option was left in a number of questions to make a 5-point Likert scale in the questionnaire where the 'Unsure' was a valid point of information in relation to the question. Some research suggests that people try to avoid extreme choices such as "strongly agree" as this implies total assurance that may make some respondents err on the side of caution (Youngman, 1984). Lastly, the options presented to the respondent might not encompass the exact thoughts and feelings of the respondent (Cohen et al., 2013).

Table 2.4: Likert scale Questions utilised in the Questionnaire

Likert Question	Response
(12.1) "I have a high level of competency with technology"	Strongly Disagree
(12.2) "Using new technology in fieldwork increases my skills and employability"	Disagree
(12.3) "Fieldwork is important for my studies"	Agree
(12.4) "I enjoy going on fieldwork"	Strongly Agree
(26*) To what extent do you agree with the following statement: "I think using UAVs in my fieldwork studies could help to enhance my interest and engagement with the subject"?	Unsure*

(13) How likely are you to use your mobile technology device in fieldwork?	Highly Unlikely Unlikely Likely Highly Likely
Rank the following in terms of importance to you on fieldwork, 1 being most important. (19.1) Social and Personal Development (19.2) Developing skills such as problem solving, team work and communication (19.3) Helps to place what is taught in the lecture into real world scenarios and helps to make the connection between the two (19.4) Developing technical skills such as data collection, use of specialist equipment (19.5) Experiencing a landscape or area in person (26) How beneficial can UAVs be as a collection tool, 1-5 with 5 being very beneficial	1-5
(24) How comfortable do you feel about using UAV technology in fieldwork studies?	Very Comfortable Comfortable Uncomfortable Very Uncomfortable
(25) How useful do you believe UAVs can be in your fieldwork?	Not useful at all Not very useful Unsure Useful Very useful

2.3.3.6 Multiple Choice Questions

Multiple-choice questions were utilised in this survey to gain an insight into complex phenomena, Table 2.5. Categories need to be discrete and have no overlap and be mutually exclusive (Kronsnick, 1999). The benefit of this type of question is the ability to quickly code and analyse the data to give frequencies of responses (Cohen et al., 2013). Multiple-choice categories may not include all of the relevant options and provide only quantitative data with very little room for interpretation (De Vaus, 2013).

Table 2.5: Multiple Choice Questions utilised in the Questionnaire

Multiple Choice Question	Response
(9.a) How do you use your device for educational purposes?	- For checking University email - For checking the University App - For research i.e. Journal articles

(11.a) How do you use your tablet for educational purposes?	- In Lectures i.e. Note taking, downloading lecture slides - Fieldwork - i.e. note taking, pictures, recording data - Accessing material in the field i.e. digital field guides and applications - Other
(14) What concerns/issues do you perceive there to be when using mobile technology in fieldwork?	- The weather damaging the device - Dropping or damaging the device - Lack of technological skill - Course or course tutor does not allow for the use of mobile devices - Prefer traditional methods - None - Other
(15) Would you encourage the use of institutionally owned mobile technology devices in fieldwork?	- "Yes, it's a great idea" - "Yes, providing there was no penalty for accidental damage" - "Yes, if tutors encourage it" - "No, I prefer using my own device" - "No, I am worried about damaging the device" - "No, I don't see the benefits of using mobile technology in fieldwork"
(20) If you don't know something on fieldwork for an assignment, how do you normally go about finding the information?	-Look it up on the internet in the field through mobile technologies - Look in academic journals/books post fieldtrip - Discuss it verbally with fellow classmates - Discuss it with fellow classmates on social media i.e. Facebook, Twitter - Ask the tutor - Other
(28) How would you like to see UAVs used in fieldwork? Select all that apply	- To collect pictures of field sites and fieldwork - To collect video imagery of field sites and fieldwork - To map the field site for student use - To collect data to create a 3D model of the field site to be used later by the student

	- To create a 3D model of the field site that can be used in a virtual field guide before the trip starts - Other
(30) What skills do you think UAVs can bring to your fieldwork experience? Select all that apply	- Practical hands on flying experience - Planning skills - Communication and Team work - Data collection - Complex skills such as photogrammetry and 3D modelling - None - Other

2.3.3.7 Open Questions

Open questions are also employed in the survey to obtain detailed information that cannot be acquired by closed or fixed questions (Rattray & Jones, 2007). Open-ended questions allow more freedom for a respondent to express their views in relation to a topic (Foddy, 1994). This type of question can catch the "authenticity, richness, depth of response, honesty and candour" of the respondent (Cohen et al., 2013, p. 225). It further provides additional information that may not have been captured by the questions set out in the survey (Fowler Jr., 2013). However, unlike the other methods outlined, open-ended questions are more difficult to extract quantifiable data and to provide clear comparisons between groups and for the researcher to interpret (Polgar & Thomas, 1995). There will also be an increase of workload for the researcher in terms of coding in order to extract the data needed. Too many open-ended questions without the direction of closed or fixed questions can be difficult for a researcher to understand how or why, a respondent has come to the conclusions they have with regard to the questions asked (O'Cathain & Thomas, 2004).

Open-ended questions need to be coded by the researcher through the design of a coding frame with certain categories into which the responses fall (appendix C). Each category has a numerical value that allows the researcher to run statistical analysis, Table 2.6. The categories are subjective and created by the researcher and issues may arise when some answers do not fit neatly into one category (Kelley, Clark, Brown & Sitzia, 2003).

Table 2.6: Open Ended Questions utilised in the Questionnaire

Open Ended Questions
(16) How do you think mobile technologies can enhance your learning experience in fieldwork?
(17) How do you think mobile technologies can hinder your learning in fieldwork?
(18) What concerns do you have around the use of UAVs in student fieldwork?

2.3.3.8 General Limitations

Questions should be asked in a neutral manner regardless of question type in order to reduce any potential researcher bias that can occur with leading questions (Stone, 1993). Leading questions are asked in such a way, or have responses that indicate there is only one acceptable answer to the respondent (Cohen et al., 2013). This is most common when conducting face-to-face questionnaires and is somewhat alleviated in this study due to the online nature of its distribution. Nevertheless, questions should always be clear and concise regardless of the intended audience. The use of complex and technical language can lead to misunderstanding from the respondent or may mean missing data due to the respondent not being able to answer the question (Clifford, Cope, Gillespie & French, 2003). Questionnaires should avoid offensive and insensitive questions or responses such as 'Old' instead of specific ages (Fink, 2002).

Linguistics in a questionnaire are always present, especially in the ambiguity of words (Youngman, 1984). For example, the term 'regular' in a question such as 'how regularly do you use mobile technologies in fieldwork' is ambiguous as without definition how regular is regular? This issue also arises when asking students about their perceived "competency" with technology or their "Comfort" levels with UAVs. Such concepts are defined by each individual and can pose a challenge when comparing between groups. Finally, one of the major challenges with questions is in receiving insufficient numbers completing the survey and not having sufficient data in order to run statistical analysis (Hunter, 2012; Patten, 2016). In this study, questionnaire data was analysed and helped inform the qualitative process, the semi-structured interviews and focus group.

2.3.4 INTERVIEWS

Interviewing is a core method in qualitative research and is an effective tool for this study to build upon the quantitative responses gained through the questionnaires. Interviews move away from the quantitative stance of viewing respondents as simple data towards a recognition that respondents can generate knowledge from conversation (Kvale, 1983).

Interviews allow the respondent and the researcher to explore and discuss their interpretations of the real world and the phenomenon in question (Gubrium & Holstein, 2002). Interviews gather data through the direct verbal interactions between respondents; this differs from questionnaires due the regimented way a respondent can answer to a set question (Cannell & Kahn, 1968).

Interviews are used for three main purposes as outlined by Tuckman (1972). Firstly, interviews can be used as the core research method for gathering data in a particular study in order to answer the research questions. Secondly, it is a useful tool in testing hypothesis in relation to the research question and or, through induction, creating new hypotheses and theories. Lastly, interviews are effective methods when used in conjunction with other methods both quantitative (such as surveys) and qualitative methods (such as field observations).

Interviews have both their benefits and limitations as a research method (Beiske, 2002). Some advantages of interviews are that they have a much higher response rate than questionnaires due to the respondent feeling a part of the research and therefore more valued and motivated (Goyder, 1985). Interviews provide more in-depth data of a particular phenomenon than any other method of data collection (Kvale, 2008). The opportunities for the researcher to ask questions and to probe responses are much greater than those that in a questionnaire (Moser & Kalton, 1977). A researcher can delve deeper into particular topics as the interview progresses depending on the nature of the interview, allowing greater freedom to explore data in relation to the research question (Oppenheim, 1992).

The limitations of interviews are that there is an inherent bias present (Borg, 1963). Online questionnaires for example, can mitigate some of the researcher bias due to the researcher not being present and the respondent being anonymous to the researcher (Bryman, 2015). By conducting face-to-face interviews, the researcher is present and this may affect how some respondents answer the questions that may not reflect their true thoughts or feelings (Williams, 1968). In the analysis phase of the interview, the researcher must subjectively place the respondents into categories and here is another opportunity for errors and researcher bias to appear (Chenail, 2011). Interviews with numerous members of the sample need to be conducted as each respondent is different in their viewpoints and so it is difficult to use generalisation from only a few interviews (Gubrium & Holstein, 2002). This is often a problem as limited numbers of interviews often take place compared to surveys, which can be distributed to a large sample (Doody & Noonan, 2013). There comes a challenge in the sampling of interviews and saturation. Students interviewed in this research voluntarily self-selected themselves for an interview via the questionnaire, whereas staff were contacted to participate via the researcher's connections and the use of snowball sampling (Biernacki & Waldorf, 1981) to gain access to other staff. There are three broad different types of interviews a researcher can employ in their research; Structured, Semi-Structured & Unstructured with each having their strengths and weaknesses (Stuckey, 2013). For this research, the researcher utilised the *semi-structured* interviewing method as discussed below.

2.3.4.1 Semi-Structured Interviews

Semi-structured interviews serve three purposes and they are: (1) To gain qualitative but also quantitative data from a population, (2) gain deep insight into phenomena, and (3) to find out the 'unknown' that may not have occurred to the researcher (Harrell & Bradley, 2009). Semi-structured interviews are a type of interview that have a relatively open but focused question framework (Whiting, 2008). The questions that the researcher would like to ask to attain specific information are formulated in advance and each respondent is asked the same core questions in the same manor (Brinkmann, 2014). The difference that semi-structured interviews have over other interview techniques is that although questions are set out before the interview, the researcher has the freedom and the flexibility to ask new questions within those questions to develop upon the interviewee's answers (Gray, 2004).

Semi-structured interviews allow a more two-way conversation to occur which can create trust and improve the reliability of the results (Barriball & While, 1994). Although some new questions are asked to gain a deeper understanding of a topic or phenomenon, due to each respondent being asked specific questions. It provides a useful base for comparison between respondents and helps to triangulate any conclusions the researcher may reach (Cohen & Crabtree, 2006). Semi-Structured interviews give the researcher the freedom to probe new questions as the interview progresses, which may lead to new data that the researcher did not initially plan for (Longhurst, 2003). This freedom also extends to the order in which the researcher asks their questions. Throughout the course of the interview, the interviewee may already have answered a proceeding question. Therefore, those who employ semi-structured interviews can alter which order they ask their questions in order to facilitate the flowing direction of the discussion (Longhurst, 2003). The critical aspect of this is that semi-structured interviews still ask the core questions that can provide a useful point of comparison. These 'core-questions' may be lost in an unstructured interview or feel out of place in a structured interview where both interviewer and interviewee are constrained by the regimented interview schedule (Galletta, 2013).

Semi-structured interviews need a robust and detailed '*Interview Guide/Schedule*' that the interviewer can follow without disrupting the flow of the conversation. In this study, the researcher broke down the interview schedule into '*themes*' that were generated from the data that emerged from the questionnaires. Such themes were colour coded on the interview guide, with core questions highlighted. Further to this, question prompts were displayed on the interview guide with potential follow up questions. This was created by the researcher through a combination of their own experience of interviewing but also guided by the literature review and the questionnaire data. A further benefit to this interview schedule was a notes section included in each theme that allowed the researcher to make notes such as what questions to ask or any pertinent information. A detailed example of the schedule used can be found in appendix D.

2.3.4.2 Limitations of Semi-Structured Interviews

While semi-structured interviews were deemed the most appropriate method for this part of the research, there are limitations to the semi-structured interview method that the researcher had to be aware of (Creswell, 2013). Due to the flexibility that the approach allows, the researcher must be aware of the possibility for the questions to go off topic and therefore limit the useful amount of data collected in relation to the research question (Rowley, 2012). There was an attempt to alleviate this through the detailed interview schedule. Researchers can often be undecided in how much they allow the exploration of these 'off track avenues' of discussion in case they lead to new information or if they are wasting time. This was the main confliction and limitation factor for this researcher in this study. For the most part these 'off-track avenues' provided useful information but there were times in the interviews where some of these turned into what the researcher called 'data dead-ends'.

The 'flexible' approach of semi-structured interviews also raises a challenge for interviewers is due to the need to ask the specific questions, the researcher may have difficulty in shaping the interview towards those questions and some may feel out of place due to the course that the interview has taken (Kajornboon, 2005). The interview may generate vast amounts of 'extra data' that may be difficult for the researcher to sort into what is relevant and what is not (Qu & Dumay, 2011).

Researchers should be aware of the need to eliminate leading questions to interviewees to ensure that truthful answers are attained (Leech, 2002). While again, there was an attempt to reduce this through the interview schedule, at times due to new information, questions that the interviewer had not planned for and are made up 'in the moment' may have included some leading words that may have influenced the interviewee. A researcher needs to listen intently to the answers given by the respondent so that there is no duplication of data by asking questions that have already been answered (Seidman, 2013). This can often be a difficult skill for interviewers to master. There is an art to keeping track of the interview and what the interviewee is saying, all the while formulating and preparing the next question (Moser & Kalton, 1986).

While online questionnaires are often impersonal and the researcher can 'send and forget', interviewing is very much reliant on the skills of the interviewer. The interview is a verbal exchange and as such relies heavily on the communication and approachability skills of the researcher. The need to encourage participants to talk freely and establish rapport with the respondents are all vital skills a researcher should possess when conducting interviews (Doody & Noonan, 2013).

Lastly, researchers should be aware of impression management during interviews such as how they dress, the interview location, and if any food or drinks are offered, as all can influence the interviewee (Ellis, West, Ryan, & DeShon, 2002). Impression management is not often discussed when conducting research and is more often discussed in applications for jobs interviews (Stevens & Kristof, 1995). Nevertheless, the principles are the same for researchers who should to be aware of its effects. In terms of clothing, dressing formally for an interview with a student may establish an unintentional power relationship between interview and interviewee. Likewise, when interviewing staff members this may also occur. The researcher's goal here was to wear smart casual clothing that was both informal enough for students, yet formal enough for the setting of Higher Education. This was intended to reduce any unintentional power relations from arising. In terms of the places that interviewees were interviewed, for staff the researcher gave the option for the respondent to decide where and when to meet. Four staff members offered to hold the interview in their office while one met the researcher in the neutral location of a campus café. This allowed the interviewees to feel safe and secure in 'their own space' and it was hoped that this would facilitate and encourage more open and honest discussions.

For students, this was more of a challenge as they lack their own places such as offices which they can call their own space. The researcher decided to 'book out' a small lecture room that students have used on their course to create a familiar environment. The rooms selected had glass paned doors and windows to ensure that the interviewee felt comfortable in the situation. While no food or drinks were offered to the interviewees, all staff members offered the researcher either to make or to buy them a coffee for 'taking the time to travel and meet them'. The researcher agreed to this offer each time so as to build rapport and to offer a way to 'break the ice' for the interview.

2.3.4.3 Justification for the use of Semi-Structured interviews

Overall semi-structured interviews were chosen due to forming part of the wider case study approach. The interview purpose was to question and converse with students and staff to gain a deeper understanding of their thoughts on fieldwork, mobile technologies and UAV use that had emerged from the questionnaire. This also provided a useful avenue to explore additional data not present within the questionnaire, which was to reveal impressions of both staff and students being introduced to a test version of the UAV 3D generated field guide. It was key to gaining rich and deeper insights into any issues, thoughts and feelings that students and staff had with this new technology. It provided the researcher with the flexibility to explore new avenues while collecting data from core questions that were useful for formulating comparisons and conclusions.

The act of interviewing to support this research was instrumental in the development of the UAV generated 3D EVFG, which is discussed in greater depth in Chapter VI. After each interview, the VLM and EVFG was subsequently changed or altered based on staff and student feedback until data saturation of the EVFG was achieved. This information could not have been obtained through a questionnaire as it would limit the amount of detailed feedback and the 'why' and 'how' to their answers. Therefore, the researcher believes that such method was both a useful companion to the development of data from the questionnaire and an excellent tool for developing new data. In support of semi-structured interviews, focus groups were also employed.

2.3.5 FOCUS GROUPS

Focus groups were used in a limited capacity in this research to compliment other methods of qualitative research, the semi-structured interview and field observations. Focus groups differ from semi-structured interviews through the reliance on the interaction of the group chosen and less from the researcher directing the questions (Morgan, 1988). It is through this group interaction that the respondent's views emerge organically, rather than the researcher's ideas and agenda shaping the conversation (Kitzinger, 1994). Focus groups can be defined as "a group of individuals selected and assembled by the researcher(s) to discuss and comment on, from personal experience, the topic that is the subject of the research" (Powell & Single, 1996, p. 499). Focus groups as highlighted by Krueger (1988) and Morgan (1996) are useful because they can:

- Generate questions for semi-structured interviews or can be created out of the data obtained in previous interviews to discuss topics further
- Generate hypothesis from the data obtained from the group
- Provide a useful qualifying and triangulation method of data with data gathered through interviews and questionnaires
- Provide insights into issues that may not have been apparent from previous data collection methods
- Be economical – Can obtain large amounts of data from a single focus group with multiple respondents

Focus groups are primarily used by researchers to draw upon the experience, attitudes, and beliefs from a group that would otherwise be unfeasible through other methods (Kitzinger, 1995). Due to the nature of the focus group, it allows the researcher to find out significant issues and what is significant about them, for the group in question (Morgan, 1996). The researcher therefore, is in a better position to draw links between what people say and what they actually do (Lankshear, 1993).

The use of focus groups in this research allowed for a better understanding, from a student's perspective of the data that had emerged from the questionnaires. While interviews are an effective method, they can often be time consuming and can often not encompass enough diversity of the population in question.

A focus group schedule was created from building upon the data collected in the questionnaires, with key questions grouped under thematic headings. Visual clues were also used by the researcher to help aid and prompt the discussion in the group. This included printed out graphs and charts for the students to look at while discussing the questions.

Some data from the questionnaire raised questions to the researcher such as 'why is that?' and 'Is this the same for all students?' such questions can be facilitated effectively in a focus group setting. Focus groups were also deemed less 'intimidating' than one to one interviews due to friends and colleagues being present and the nature of focus groups being discussions generated by themselves rather than the researcher (Stewart & Shamdasani, 2014).

2.3.5.1 Focus Group Limitations

Focus groups do however pose some challenges to the researcher, although some of these issues can be mitigated through careful planning and delivery, some are unavoidable with this technique (Edmunds, 2000). The researcher has much less control over the depth and type and quality of the data produced compared to other methods such as questionnaires or interviews (Morgan, 1988). Although a large amount of data is obtained from focus groups, they can often generate less in depth data about broader issues due to focusing on one or two particular issues (Krueger & Casey, 2014). This was a challenge the researcher faced as only a select few questions could be used in the relatively short time-frame available. Therefore, not every question the researcher would like to have asked about the data generated from the questionnaire was asked.

It is noted by Morgan (1988) that more in depth data can be collected through individual interviews of the same number but recognises the time constraints that they posed. Time constraints and recruitment was a major issue in this study for focus groups. Students are busy with module classes and assignments and are often in the case of both universities not always on campus. The days they are, are often relatively condensed and most free time available was between classes or over their lunch. Hence, the researcher struggled to recruit participants and even when participants were found, trying to arrange a time and a place to facilitate a suitable number of candidates proved an almost impossible barrier, especially as many students had part time jobs in this sample.

The researcher cannot force participants to participate and while it was frustrating that students would agree in principle to participate, they would often fail to respond to follow up emails. At first this was deemed by the researcher to be a fault on their part however having spoken to their course leaders such lack of email communication was 'normal'. The course tutor stated that the best way to get them to do something is 'tell them face to face and keep telling them'. While lecturers have such opportunities, the researcher does not and instead, relied on the 'good will' of students to follow up and commit. Every effort was ensured to make the process as transparent as possible and even the suggested inclusion of food (such as cakes) could not entice a greater number of respondents.

Upon reflection, the researcher hypothesised that such students are under increasing pressure in higher education and taking part in further research was not something they saw as a benefit. For the students who did take part in the focus group and interviews, they expressed at the end of both that they saw an intrinsic personal benefit to participating in the process for their own future research, as it allowed them to gain experience and an understanding of how to do a focus group/interview. Therefore, perhaps for future research the researcher will highlight this point of development for students in the recruitment process.

The size of the focus group is an important one for a researcher to get right. Too small and the intra-group dynamics are amplified, too large and it may become hard to control and for everyone to have their say, meaning that vital data could be missed (Acocella, 2012). The researcher has the key role of directing the focus group but must strike the fine balance between being too directed but not too hands off as for the discussion to become off track. It is the responsibility of the researcher to ensure that all participants feel comfortable and have their say (Krueger, 1997).

2.3.6 Field Observations

Observational research is an effective qualitative method that allows the researcher to observe and record what is happing in situ (Patton, 1990). Observations allow the researcher to understand the complexities of an event or phenomenon and to observe issues or data that might have been missed through other methods such as questionnaires and interviews (Taylor, Bogdan & DeVault, 2015). Morrison (1993) outlined four key points that observations allow the researcher to investigate, they are: (1) the physical setting, (2) the human setting, (3) the interactional setting and (4) the programme setting.

There are different approaches to observational research from the highly structured to unstructured. Highly structured approaches to observation will have the researcher know what they are looking for or a pre-ordained observation list (Sapsford & Jupp, 2006). Unstructured observation is when the researcher is unclear of what they will be looking for and will observe and then decide what observations were important (Limb & Dwyer, 2001). Highly structured observations seek to clarify and accept or decline a hypothesis, whereas unstructured observation is a means to creating a hypothesis (Cohen & Crabtree, 2006).

2.3.6.1 Advantages and Disadvantages of Field Observations

As with all methods, there are limitations and advantages to using them in research. Unstructured and highly structured approaches have advantages and disadvantages; however, both have some common cross over. The advantages of both are they allow the phenomenon to be observed in the natural setting so that it can provide useful data to the researcher (Sapsford & Jupp, 2006). Observations allows the researcher to see what is done rather than what the respondents say they do (Gill, Stewart, Treasure & Chadwick, 2008). It is an effective tool in triangulating results that have been obtained from other methods to help support a hypothesis (Mathison, 1988). The negative impacts of both are concerned with how involved the researcher is in the observations (Bonner & Tolhurst, 2002). If the respondents know that they are being observed then they may alter their behaviour due to the presence of the researcher, the Hawthorne effect (McCambridge, Witton & Elbourne, 2014). If the observer does not make it clear to those being observed that they are being observed, then this contravenes the notion of consent and poses ethical challenges (Angrosino, 2007). The main drawback with any type of observational research is that it is highly selective (Cohen et al., 2013).

2.3.6.2 How Field Observations were employed in this research

Field observations were used throughout the study, specifically in relation to fieldwork activities. Observations, however, were never the main focus of data collection techniques in this research but provided a small useful tool to enhance further the triangulation of data that had emerged from the questionnaires, focus groups, and interviews. Field observations provided useful information to the researcher at different times.

While the literature review was being conducted and the formulation of the questionnaire was being developed, the researcher attended a final year Outdoor Education fieldtrip to the Yorkshire Dales. Students were made aware that the researcher had come along to observe and to get a feel for how fieldwork takes place at LJMU. The researcher has extensive prior experience of fieldwork having been a Geography undergraduate and participated in fieldwork as a staff member but at a different institution to the institution being studied. Therefore, the researcher wanted to ascertain how both students and staff conduct fieldwork at this institution. This unstructured approach however on this initial fieldtrip was conducted with some questions that the researcher wanted answering such as (1) How is the content delivered, (2) Are students using mobile devices, (3) How are students learning and (4) How could a UAV or a VFG enhance this experience?

Observations were jotted down roughly in a notepad and subsequently written up on a brief word document, which can be found in appendix E. Observations here were useful in the formation of the questionnaires as it allowed the researcher to see the difference between literature and practice.

As the research progressed, the researcher had the opportunity to attend other field trips, except this time the researcher used a more structured approach to their field observations. Observations were used here as outlined by Gill et al (2008) to see what is done rather than what the respondents say they do. At this point, the researcher was in the position to qualify and triangulate such data from the methods discussed above. It allowed the researcher to observe how students interacted, how they used their mobile technology devices and to get an overall sense of their feelings of being out on fieldwork. This was all used to triangulate what they said with what they had done. In the end, this triangulation was useful as students did what they said and therefore offered some useful validity to the results.

A further benefit to this observation was in the final fieldtrip where students were given the latest version of the EVFG before and after their fieldtrip. It gave the researcher the opportunity to ask and observe the effect the EVFG had on their fieldwork experience. While this is discussed in more detail in Chapter VII, an example of this in action is witnessing students commenting on how the cliff had eroded and looked different from the EVFG. The students preceded to open up the EVFG on their devices and started to discuss without intervention or prompt from the researcher or staff member potential causes for why this may have occurred. Such observations provided an effective triangulation tool as from the interviews it was hypothesised that the EVFG would facilitate such learning, yet to see it being observed helped to qualify such statements. This potentially useful piece of data may have been lost if observations had not been made.

2.3.7 Student Assignments

In order to ascertain the learning effect of the UAV generated EVFG, an additional evidence was considered alongside the methods discussed. In agreement with the course tutor, an evaluative section was introduced into the final year module of the Thurstaston fieldtrip assignment. As discussed in more detail in Chapter VI, the EVFG was developed for a small cohort of final year Outdoor Education students to use on this specific field course. It was deemed that as students had no more 'contact time' before they officially left as students, that the most effective way to gain data would be to use data from their evaluations in their assignments.

This proved to be a challenge in terms of ethics and ensuring confidentiality however, this is outlined in section 2.6. The assignment method proved to be an effective tool in triangulating both data from the interviews and observations but also provided effective supplementary new data to both methods.

2.3.8 Pilot Studies

Pilot studies are vital for all aspects of this research. Pilot studies can be used two ways in social science research. Firstly, they can be used as feasibility studies in preparation for a major study (Polit, Beck & Hungler, 2001). They can also be used as a qualifying process to test out method techniques and to test for errors. It is the latter use which is developed in this research (Baker, 1994). Pilot studies are useful as they test the adequacy of the research instruments and their associated protocol. It establishes whether they are workable in their intended setting and can identify issues that can be corrected before the main study begins (Teijlingen van, Rennie, Hundley & Graham, 2001). The advantage of a pilot study in case based research, is that it provides the opportunity for the researcher to have indications of any issues that may arise in the research process that may jeopardise the outcome of the study (De Vaus, 2013). Pilot studies are used in this research as a way of refining the methods used such as to test the suitability of the questions asked in both the questionnaires, interviews and focus groups.

A successful pilot study is not a guarantee of success for a full-scale research project (Collins, 2010). This is due to their basis on smaller numbers that may not be representative of the study population. The researcher has to decide whether to include the pilot study data within the actual main research. There are issues associated with this such as those taking part in the pilot study being exposed to the methods or intervention beforehand, unlike other respondents in the survey. Pilot studies can also take up significant resources such as cost and time, which can make a difficult decision if a pilot study deems the study to be unsuccessful (Teijlingen van & Hundley, 2001).

In this research a pilot study of a group of recently graduated geography students were used via the researchers own connections. This group was chosen as it provided a useful opportunity for the researcher to test such methods on a representative sample of geoscience students, in a setting that would be used for the main study. After the pilot study was conducted, subsequent changes were made to the schedules and questions. This mostly consisted of altering the scale to read the same across questions, grammar and wording and position of the questions.

2.4 Quantitative Analysis

Once the research instruments had been implemented, different forms of appropriate analysis were conducted depending on the instrument used. Analysis shows the process which the researcher has followed in order to understand and make sense of the data. The following section outlines the analysis procedure used for the positivist statistical tests on the quantitative data.

2.4.1 Coding Frame and Inputting Data

Once the questionnaire had been distributed and collected over a period of four months, data was reduced into a form that was easy to analyse. This was achieved by coding (Huberman & Miles, 1983). Pre-coding was used for closed questions in this survey where each answer was assigned to a numerical identifier that the analytical software could understand and interpret. For the more open-ended questions in the survey, the researcher generated codes as the responses came in. This process of coding was an inductive thematic analysis, which is explained in section 2.5.2. Once a coding frame had been created (appendix F) and checked for errors, the researcher then began coding the responses that were online. Although the online software 'Bristol Online Surveys' can generate a pre-coded dataset for excel, codes may not be what the researcher had in mind and therefore a thorough error check was conducted on the Excel master dataset.

Once the errors were removed, the Excel master dataset was transferred into the chosen package for statistical analysis by the researcher, which is the IBM Statistical Package for the Social Sciences v24 (SPSS) (IBM Corp, 2016). Such software is highly regarded amongst social science researchers for its effective user-interface and the ability to run dedicated statistical tests. Once the coded data was imported into the software, the researcher manually inputted the variable names behind the numerical identifiers that were present in the code sheet. A further error check was conducted before any analysis could take place.

2.4.2 Test of normality: Parametric or non-parametric tests

Before any statistical tests and analysis could take place on the questionnaire data, it was important to understand how 'normal' the data was. The testing of normality of data is one assumption that must be met when conducting specific statistical tests. The term 'normality' in data is used to explain the distribution of the data in question (Ghasemi & Zahediasl, 2012). 'Normal' data is data that is assumed to be from a population that is evenly distributed. If the data is not 'normal' i.e. not from a population that is evenly distributed then only non-parametric tests can be used (Field, 2009). Parametric tests are often deemed to be more powerful forms of analysis (Sheskin, 2003).

Non-Parametric tests are viewed as less powerful statistically speaking, than their parametric counterparts. Despite this, non-parametric tests are useful for when the sample size is small, not evenly distributed (for example when ordinal or ranked data cannot be removed) or when the median is the better form of analysis than the mean (Frost, 2017). Knowing the normality of the data dictates which statistical tests can be used. Specific tests are aligned with non-normal or normal data. Parametric tests cannot be used on non-normal data yet nonparametric tests can be used on either forms of data (Laerd Statistics, 2018).

To test normality within the data was relatively straightforward in SPSS. Following the explore option selected data can be run to include a 'Test of Normality' and 'Normal Q-Q plots'. Such a test presents information from well-established tests of normality which are (a.) Kolmogorov-Smirnov test and (b.) Shapiro-Wilk test (Laerd Statistics, 2018). For this research, it was decided to use the Shapiro-Wilk test as this is often appropriate to use for sample sizes around 50 or less (which was often the case for this data when breaking down variables such as gender and course type) but such a test can handle data as large as 2000 (Shapiro & Wilk, 1965). To understand how normal the data was is as simple as observing the significance level of the data produced in a Shapiro-Wilk table. If the significance level is greater than 0.05 then the data is deemed 'normal' and therefore parametric tests can be used. If the significance level is less than 0.05 then the data varies significantly from a normal distribution and therefore only non-parametric tests can be used. The completed test can be seen in appendix G.

While some of the data (individual variables) within the study were normally distributed, the majority of variables within the same tests were not and therefore all statistical tests within this study were non-parametric. As mentioned previously non-parametric tests can be used on both normal and non-normal distributed data.

2.4.3 Descriptive Statistics and Nonparametric Tests

The first stage of analysis that was conducted on the data were some basic descriptive statistics such as frequency, mean, median and mode. Descriptive statistics are effective as they quantitatively summarise information within the data. Not only this, but getting a handle on the data in such a way leads the researcher to conduct further more in-depth tests. For example, what gender believe UAVs to be beneficial the most or does this vary significantly between the course levels and titles? Such basic descriptive data opens the researcher to explore these more in-depth relationship/ cause and effect questions to be analysed.

2.4.3.1 Chi-Square Test for Association

The Chi-Square test was used in this research when follow up questions from the descriptive statistics were needed. Chi-Square was used when the researcher wanted to test for independence between variables e.g. Do males use mobile technologies more in fieldwork than females?

In order to employ Chi-Square the data must pass certain assumptions: (a.) The two variables that are to be tested must be either 'Nominal' or 'Ordinal' i.e. categorical data (b.) Each variable must have two or more categorical or independent groups and (c.) each cell of the cross tabulation must have an expected count greater than 5 (Laerd Statistics, 2018).

Chi-Square tests can be a test run while formulating a 'Cross tabulation' in SPSS. Cross tabulations are an effective tool for assessing the frequency or percentage of data across variables. The cross tabulation on SPSS will run the test with a Chi-Square test box displayed below it. If the Pearson Chi-Square row is less than 0.05 in the Asymp. Sig (2-sided) column then there is a statistically significant association between the two variables. A workflow of a chi-square test can be found in appendix H. Throughout the results sections of this thesis, Chi-Square tests are denoted in text by $\chi 2$ and are presented in the following format:

Variable Name $\chi 2$ (Degrees of Freedom, N = number of cases) = Value, *p* significance

Example:

LJMU students $\chi 2$ (1, N = 84) = 6.39, p .011.

2.4.3.2 Mann-Whitney U Test

While Chi-Square is an effective statistical test for association between nominal variables, it is not suitable for when variables between two independent groups are continuous and not normally distributed. Mann-Whitney U tests are the equivalent of the independent samples T-test employed when data is parametric and seeks to observe differences between two discrete groups or populations along an ordinal/ranked scale (Laerd Statistics, 2018). As with the Chi-Square test, there are certain assumptions the data must meet in order to be able to be run with any validity. The Mann-Whitney Test stipulates four different assumptions:

(a.) The dependent variable should be either continuous or ordinal (i.e. Likert).

(b.) The independent variable will consist of two independent groups that are categorical (i.e. Gender).

(c.) There must be different participants in each 'group', for example there can be no Female Geographer who is also an Outdoor Education student.

(d.) Must be run on not normally distributed data. However, it is imperative that in order to effectively interpret the results, the distribution shape of the independent variable must be known. If the distribution shape is the same then the test can be run to measure the medians of the dependent variable, whereas if they are different only the mean ranks of the dependent variable can be measured (Nachar, 2008).

With reference to (d.) the shape of each variable is important, especially if the researcher is trying to observe the differences between the medians of each population. It is a relatively simple task to include a histogram (population pyramid style) in the workflow of the statistical test on SPSS. For a detailed example of a Mann-Whitney U test being conducted as part of this research see appendix I. While the distribution shape of each test was run, regardless of the outcome, mean ranks were used as the form of analysis. After all, Mann-Whitney is a sum ranks tests and due to the use of four to five point Likert scales rather than continuous scores, median values did not represent where any significance lay in the data. Mann-Whitney U tests are written in text as follows:

Example of Mann-Whitney U in text

> A Mann-Whitney U test was run to determine if there were differences in [Likert scale question] score between [Variable a] and [Variable b]. Distributions of the [Likert] scores for [Variable a] and [Variable b] were [either similar or not similar], as assessed by visual inspection. [Likert] scores for [Variable a] (mean rank = *) [were/not] statistically significantly [higher/lower] than for [variable b] (mean rank = *), U [Mann-Whitney U score] = *, z [standardised test statistic] = *, p [significance level] = **.

2.4.3.3 Kruskal-Wallis H Test

Mann-Whitney U is an effective nonparametric test to determine the statistical difference between two variables within a population i.e. Male or Female, Kruskal-Wallis H is also a rank-based nonparametric test that seeks to determine the difference within a population of more than two independent variable groups (Kruskal & Wallis, 1952). This test was most often used in this research to assess differences in student levels of study i.e. 4-6 and in student cohort i.e. Geography, Geography Combined and Outdoor Education students. While there are many similarities to the Mann-Whitney U test, there are differences in the workflow and how the test works as explained below. As with all tests, Kruskal-Wallis H has a series of assumptions that must be met in order for the test to be valid. This test has the same assumptions as that of the Mann-Whitney U test in section 2.4.3.2.

Once all assumptions have been met the researcher can use SPSS to run a Kruskal-Wallis H test via the nonparametric, independent samples function, a full workflow can be found in appendix J. Kruskal-Wallis H assumes that there is a Null Hypothesis, which is often that the distribution of scores is the same across the variable studied. In the text, this is represented by the symbol H_0. SPSS tells the researcher once a test has been run whether they should reject or accept the null hypothesis as seen in Fig. 2.2.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Using new technology in my fieldwork increases my skills and employability is the same across categories of Degree Title Recoded.	Independent-Samples Kruskal-Wallis Test	.026	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Fig. 2.2 – SPSS Kruskal-Wallis Test display to reject or accept the null hypothesis

If a significance is found then while this is useful, it does not tell the researcher where exactly the significance is between the variables and therefore a Post-Hoc test is needed (Sheskin, 2003). This extra step is different to that of a Mann-Whitney U test where this is not needed. If a non-significant value is generated from a Kruskal-Wallis H test then this is reported and a Post-Hoc test is not completed (Laerd Statistics, 2018). Before this however, a box plot of distribution is generated in order to ascertain whether the data distribution shape is the same. No data in this research was the same and therefore mean-ranks were used by the researcher in their analysis of this test. Results of the Kruskal-Wallis test are outlined in the text as follows:

H0: [Title of the Null Hypothesis]. A Kruskal-Wallis H test was run to determine if there were differences in [Independent Variable Name] score between [number and names of the Dependent Variables]: "Name 1" (n=Number of cases), "Name 2 " (n=*) and "Name 3" (n=*). Distributions of [Independent Variable Name] scores were not similar for all groups, as assessed by visual inspection of a boxplot. The distributions of [Independent Variable Name] scores [were/not] statistically significantly different between groups, $\chi2$ (Degree of Freedom) = Test Statistic, p = Asymptotic Sig. (2-sided test) value.

2.4.4 Post-Hoc Testing

If a significance was found at this stage of the Kruskal-Wallis H test, then a post hoc test was run to define where the difference lay. This test is conducted automatically in SPSS for the researcher if a significance is found at this stage and such workflow can be seen in appendix K.

The post hoc test that is run on the data is a 'Pairwise Comparison' test. Dunn (1964) stipulated exact calculations and workings for when a specific pairwise comparison is made across the dataset. Inherently, this is different to that of the Mann-Whitney U test as discussed previously which only uses data that is involved in each specific pairwise comparison. To use an example from this research, if the researcher wanted to assess current level of students education i.e. first, second or final year students and the extent to their agreement of the statement that they enjoy fieldwork, a Mann-Whitney U test would conduct a singular pairwise comparison between "first year" and "second year" students (as only two can be tested) and therefore emits "final year" students from the calculation. Using the Dunn (1964) procedure, a pairwise comparison would test between all levels of students in the one test.

Dunn's (1964) procedure has very comparable characteristics to that of similar post hoc tests preceding a one-way ANOVA. While alluded to above, it is possible for multiple Mann-Whitney U tests to be run for the pairwise comparison (1st year-2nd year/ 1st year-3rd year/ 2nd year-3rd year etc.) and then including a Bonferroni correction for multiple comparisons. Why this is not advised is despite the number of tests, only data from two groups are ever used. Thus, there is room for doubt that these two methods will agree. Dunn's z-test "approximates the exact rank-sum test statistics by using the mean rankings of the outcome in each group from the preceding Kruskal–Wallis test and basing inference on the differences in mean ranks in each group" (Dinno, 2008, p. 298).

This test is embedded within SPSS as a default following on from the Kruskal-Wallis test. Nevertheless, while Dunn's (1964) test is effective, there is debate around which specific method should be employed with some researchers preferring other such tests for pairwise comparisons (Laerd Statistics, 2018). As this test was the default and was specifically designed to be used after a Kruskal-Wallis test, the researcher elected to use this method of pairwise comparisons.

2.4.4.1 Bonferroni Correction

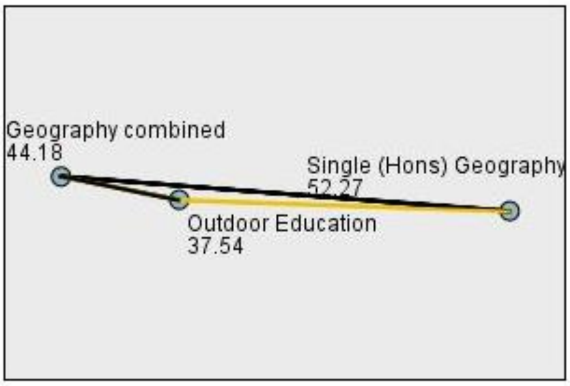
As touched on briefly above, a Bonferroni Correction is utilised at this post hoc stage of the test. As alluded to with the multiple Mann-Whitney U tests, the Dunn (1964) method tests multiple null hypotheses and therefore type 1 errors could be introduced into the data (Sheskin, 2003). A Bonferroni Correction is an adjustment to the *p* value (significance level) when multiple either independent or dependent tests are performed simultaneously on a single dataset (Napierala, 2012). In its simplest form, a Bonferroni Correction is the division of the Critical *p* value by the number of comparisons being made (Abdi, 2007).

Without such a correction, a false positive may occur in the results and therefore the probability that at least one result is significant by chance increases (Laerd Statistics, 2018). In this study, a Bonferroni Correction was automatically applied via this Kruskal-Wallis H test in SPSS.

2.4.4.2 Interpreting the significance between the data with Dunn pairwise comparison

In SPSS, the researcher is presented with a graphical representation of a Pairwise Comparison and also a table as shown in Fig. 2.3. From this representation, it is quick to identify the significance level between groups at a glance. This either can be done via the coloured line on the graph or via the orange highlighted adjusted significance level in Orange on the SPSS generated table. What this line or table tells the researcher is that 'a' has a statistically significantly different distribution (i.e. mean rank) of a score [e.g. enjoyment of fieldwork] than 'b'.

Pairwise Comparisons of Degree Title Recoded



Each node shows the sample average rank of Degree Title Recoded.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Outdoor Education-Geography combined	6.643	6.434	1.032	.302	.906
Outdoor Education-Single (Hons) Geography	14.731	5.468	2.694	.007	.021
Geography combined-Single (Hons) Geography	8.089	6.534	1.238	.216	.647

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Fig. 2.3 – SPSS view of a Dunn and Bonferroni corrected pair-wise comparison graphical representation

In order to express this in the results section, the statement from the Kruskal-Wallis test as seen in section 2.4.3.3. is used:

Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented. This post hoc analysis revealed statistically significant differences in [Independent Variable

Name] scores between [Dependent Variable a.] (mean rank = *) and [Dependent Variable b.] (mean rank = **) (p = [Adjusted significance value]), and between [Dependent Variable c.] (mean rank = **) and [Dependent Variable a.] (p = [Adjusted significance value]).

2.5 QUALITATIVE ANALYSIS

As outlined, this research used a mixture of methods and therefore uses different forms of analysis. This section outlines the coding process for data obtained from the interviews, focus groups and the open-ended questions of the questionnaire. Following on from this the analysis of the observational data is discussed.

2.5.1 TRANSCRIPTION

Before any analysis of the data could be conducted, the data had to be first transcribed from the audio that was used to record the interviews and focus groups. Transcription of interviews is a vital component and the researcher had to be careful at this stage as vital data can be lost through poor transcription techniques (McLellan, MacQueen & Neidig, 2003). The researcher recognised the limitations of transcribing from an audio tape only. Audio transcriptions do not capture the non-verbal communication such as body language and the way the interviewee answers a question. This data is somewhat lost in the transcription process (Lapadat & Lindsay, 1999). As transcriptions are a translation from the spoken to the written word, it is difficult to deny that it is already interpretative (Kvale, 2008).

Misher (1991) further comments that due to the changing nature of language and their meanings, that the data is capable of endless reinterpretation. Therefore, the researcher was aware that transcriptions alone cannot tell the whole story. Transcription was completed by the researcher using the transcription feature in the nVivo 11 pro software package.

The researcher tried to transcribe where possible within 24-48 hours of the interview taking place as the interview was still relatively fresh in the researcher's mind. It was decided by the researcher to not include any 'erms' or hesitations within the transcription for readability and therefore transcribed non-verbatim. The researcher was less concerned about how they said it but was more concerned about what was said (Grbich, 2013). However, any indications of laughter are incorporated into the transcript to show a positive attitude and to reflect the rapport of the interviewer and interviewee.

Once transcribed, the researcher checked the transcript for any errors by listening back to the audio file while reading the transcript again. This was completed at least twice per interview. A full copy of the transcripts for both the interviews and focus groups can be found in appendix L.

2.5.2 THEMATIC ANALYSIS

Thematic analysis is one of the most common forms of analysis employed by qualitative researchers despite its lack of acknowledgement in literature (Boyatzis, 1998). For some, thematic analysis is not a method in its own right, however, Braun and Clarke (2006) are strong advocates for using thematic analysis as a standalone method of analysis.

Braun & Clarke (2006) argue that thematic analysis is a very flexible and diverse approach to data analysis. As outlined by Braun & Clarke, thematic analysis fits into a broader methodology that is free of theory and restrictive epistemologies. This is an effective use of analysis for a pragmatic researcher who is not fixed to one method or epistemology.

Thematic analysis is a method for "identifying, analysing, and reporting patterns (themes) within data. It minimally organises and describes your data set in (rich) detail" (Braun & Clarke, 2006, p. 79). Boyatzis (1998) takes this further by commenting that it goes beyond this to providing interpretations of the various aspects of the research questions.

Despite its popularity, there is no set procedure in how a researcher should conduct thematic research (Attride-Stirling, 2001; Tuckett, 2005). Thematic Analysis is different from other analytical methods that often seek patterns across data because it is not theoretically bounded (Joffe & Yardley, 2004). The thematic process starts when the researcher while conducting interviews, or at least in the analysis stage of the transcription, actively looks or becomes aware of 'interesting data' (Braun & Clarke, 2006). This eventually progresses in thematic analysis to the reporting of not individual pieces of data but collectively as a *'Theme'* as discussed in section 2.5.2.2. Despite there being no set way to complete thematic analysis, Braun & Clarke offer some phases that provided guidance for the analysis of this research as outlined below.

2.5.2.1 Familiarisation and coding

In order to make sense of the qualitative data collected, the data was broken down into categories for analysis (Glaser & Strauss, 1967; Dey, 2003). This loosely followed an axial coding model (Kendall, 1999). This model seeks to break down the data in three distinct steps. The first step was to '*open code'* through the process of the researcher taking the data apart. This provides the researcher with an analytic process in which properties, dimensions, and concepts can be identified. For the researcher, this was achieved through multiple rereads of the data and then analysing the data to code initially at first line by line. The researcher elected to code sentences or phrases rather than individual words so as to make sense of the data in the analysis stage.

The researcher coded at first anything that was relevant to the research question and to the aim of the questions asked in the interview. This coding was conducted in the software package Nvivo 11 Pro (QSR International Pty, 2017). Nvivo was chosen as an effective way to manage and sort the data and the ability to integrate SPSS and questionnaire data into the software to help with the combining of results later on in the research.

The coding occurred after each interview or focus group. At the point of the interviews when the researcher was starting to hear the same data and therefore no new knowledge was generated (saturation), the second phase of analysis occurred. At this stage, the researcher printed off the computer generated codebook (appendix M) and sorted the codes to combine and delete code names that either were duplicates or codes that covered the same data. Following on from this, the codes were regrouped into sub-categories that in turn fed into grouped categories. The researcher attempted to link the categories into each other in a rational manner. Miles & Huberman (1994) state that the act of coding is a vital part of the analysis procedure and Tuckett (2005) comments further that coding is the act of organising data into meaningful groups.

2.5.2.2 Themes

Finally, selective coding was employed to select a theme and assess its relation to the other categories present to understand an issue (Strauss & Corbin, 1990). A coding frame can be viewed in appendix N. A theme in essence tries to capture groups of data that hold some answers to the research question employed. Often a theme is composed of data that has meaning and is present across the data set (Braun & Clarke, 2006). There is no set theme size, it can be a small part of the data or may be large part of multiple data sets. For this research, the researcher created themes that they deemed relevant to the research questions. While most of these themes were present across the entire dataset, they were not always present. Braun and Clarke state this approach to be acceptable because "researcher judgement is necessary to determine what a theme is" (p.82).

Themes that are generated from the qualitative data are there to provide the reader with a sense of the important and most predominant themes that are within the overall data in order to answer the research question. This was chosen rather than in-depth descriptions of small parts of the data as it is an effective process for when "investigating an under-researched area, or with participants whose views on the topic are not known" (p.83) which is what this research aligns to.

In order to generate the themes and subsequently name them, the researcher once again printed off the codebook that now had descriptions of each code embedded along with how many times it appeared in the data and across how many sources. The researcher cut out each theme individually and continually evaluated each code and placed them into a theme that was most relevant. As seen in Fig. 2.4, this was not done on a computer as the researcher felt it was more effective to swap, change, renegotiate, and visualise the themes forming through this by hand method. The act of cutting each code up and physically moving them around under theme headings on the floor was a useful tool for the researcher to enable a visualisation and organisation of the data.

The generation of themes was challenging at times especially in deciding the name of the theme or if a code straddled two themes or no theme at all. It is acknowledged that to some extent theme generation is subjective and driven by the own views of the researcher. Therefore, to add an extra layer of validity the researcher sought a '*critical friend*'. This critical friend was an experienced qualitative researcher. Their job was to view the data, the codes generated and themes created. This provided the researcher with the opportunity to explain and justify why codes are within certain themes and what that theme represents. This provided a useful triangulation of data to ensure the themes that are presented in this research are accurate and justified (Gibbs, 2007).

Once this was completed, the researcher had themes and subsequent sub themes of data. Each theme is a basis for the discussion and analysis sections of the subsequent chapters in this research. A process was followed from an adaptation of Braun and Clarke's (2006) procedures, Table 2.7.

Fig. 2.4 – Paper representation of theme generation

Table 2.7: Theme generation and development

Process	No.	Criteria
Transcription	1	Data transcribed and checked for errors
Coding	2	Codes generated in text
	3	Codes checked for duplication and similarities and combined or deleted
	4	Codes grouped into sub categories
	5	Group codes into themes
Analysis	6	Data interpreted and analysed rather than descriptive
	7	Critical friend employed to ensure themes and data sufficient
	8	Themes and subsequent data sufficiently answers the research question
Writing	9	Method clearly outlined
	10	Themes provide useful basis for discussion in text

2.5.2.3 Challenges of Thematic Analysis

While thematic analysis is a relatively straightforward tool of analysis for qualitative data there are some challenges and pit falls that the researcher needs to be aware of. Thematic analysis requires analysis to take place and not to simply place data into themes for which perhaps the questions have been asked in the interview or are preconceived themes from a previous literature review. Further to this, weak analysis is the generation of themes where the data does not fit the theme or provides superficial data to support the theme. The researcher had actively engaged with the data in an in depth manner and avoided this by generating the themes through often-difficult personal discussions and deliberations of the themes. As by doing it by hand "the 'analysis' of the material … is a deliberate and self-consciously artful creation by the researcher, and must be constructed to persuade the reader of the plausibility of an argument" (Foster & Parker, 1995, p. 204). This was further supported by seeking a discussion with a critical friend to reaffirm and challenge the researcher on the themes produced.

Researchers who employ thematic analysis in their work need to ensure that the data presented and the subsequent claims made about the data are matched to the theme. For example as noted by Braun and Clarke (2006) "In such an (unfounded) analysis, the claims cannot be supported by the data, or, in the worst case, the data extracts presented suggest another analysis or even contradict the claims" (p.95).

2.5.3 Open Ended Questionnaire Data

While the above offers an in-depth outline of how both interviews and focus groups were analysed a similar process was conducted for the open-ended questions in the questionnaire. The open-ended questions provided useful supporting material to support data from the other sources. A process, as outlined above, was also followed here although the quantity of written data was less due to the formatting of the questionnaire. Due to the data generated by the questionnaire, the researcher grouped the themes and subsequent sub categories by number of mentions. This provided the researcher with not only themes to discuss in a qualitative manner but also to use the data in a quantifiable way to support data generated in the questionnaire. This approach provided the researcher with added flexibility and triangulation opportunities in the research. An example of part of a theme map generated from the questionnaire of open-ended questions can be seen in Table 2.8 with the theme in bold and sub-categories below.

Table 2.8: Theme Map Example

NAME	REFERENCES	DESCRIPTION
TECHNICAL ISSUES	**47**	**Technical issues from battery life to weather damage can be a hindrance to mobile technology use**
Technical fault – Loss of data	11	Technical faults leading to a complete loss of data collected
Damaging the device	6	Damage to the device from either dropping, general use or weather
Weather	6	Weather issues such as damage to usability in rain and cold conditions
Battery life	6	Lack of battery life hindering their use
Fault in the device can stop data collection	5	A fault in the device leading to no plan B or the ability to collect data from the device
Technology usability (Lack of ease of use/information)	5	Issues with usability, ease of use or lack of instructions on how to use it
Reliability	6	Reliability concerns Not as robust for data collection than traditional methods i.e. pen and paper
Lack of signal to access internet or resources	2	Lack of connectivity to access external resources and information

2.5.4 Observational Data

Observations were only a small part of the data collection processes and early on, the decision was made for the majority of the observations to take a much more unstructured approach. Unlike traditional ethnographic observational field notes, the notes in this research were much briefer. As these short observational notes were used in this research to triangulate what was said with what was done the field notes were originally placed into the researcher's field notebook. Post fieldwork, and within 48 hours, the researcher retyped and added anything of relevance to the notes but in digital form. From this, the researcher then followed the same process as outlined above to thematically analyse the data.

2.5.5 Analysis for Student Assignments

The student assignments formed part of the data triangulation processes. While they were written texts, thematic analysis was still conducted on the assignments as outlined thus far. The researcher noted how many times reference to the EVFG where made and in what context. Any external links or pictures that had shown engagement with the EVFG in the assignment was recorded along with a tally of how the EVFG was used. This numerical approach helped the researcher to triangulate all of the data from the interviews and focus groups which were conducted before the model went live, to viewing it in action via observational notes to then seeing post fieldwork how students had used it. The use of student assignments also served the purpose of evaluation. Themes of positive and negative aspects were conducted within the documents. Not only did this provide a useful tool for the researcher to continue to plan for future editions of the EVFG but provided a useful triangulation tool between what staff deemed positive or negative and what students did. Often these were very similar and gives the researcher confidence that findings are robust. Any quotes or images used in the results and discussion sections from the assignments are displayed as screenshotted figures.

2.6 Risks and Ethics

Risks and ethical procedures are imperative in any type of research (Bryman, 2016). While this research was relatively risk free and ethically approved there were processes in place to ensure that this research was both ethically sound and limited in risk to both the participants and the researcher.

2.6.1 Risk

As with all methods of research, there are potential risks to the researcher and the research participants (Cohen et al., 2001). All risks have been ratified by the Liverpool John Moores ethics committee for this research. Overall, the risks to the researcher and the participants were relatively low in terms of the impact of the questionnaires, interviews, focus group and observations. In order to reduce the risk to the participants, participant information sheets outlining the risks to the participants were given out in advance of any research intervention-taking place (appendix O). The participant information sheet gave in-depth detail of what the research was about, how long it may take the participant and what associated risks there may be to them.

While the instruments used were mainly risk free, special consideration was given during the interviews and focus groups. For the participants, and especially the students, the researcher gave specific thought to the location used. They ensured that any intervention took place in a room that had windows and made sure that the participant had informed someone that they were taking part in the interview. This was done to ensure they felt comfortable and safe and if for whatever reason they wanted to leave that they could and had easy access to do so. Participant welfare was paramount for the researcher.

The researcher informed someone of the location and the expected time it would take them to complete the interview. This was especially true for travelling to meet participants who the researcher had not met before and had to ensure their safety. While no issues were envisaged nor did any occur, it was planned for.

2.6.2 Anonymity

All interventions used in this study were anonymous and all interventions avoided using participants that were vulnerable or asking questions that were deemed intrusive or offensive. Throughout the research key identifying markers such as names, job titles etc. were removed to ensure this anonymity was kept. To further reduce risk any signatures, names and data were stored on a password protected university account, any hard copies were stored in a lockable filing cabinet (to which only the researcher had access), and this was located in a lockable office space. For the assignments, it was essential that the anonymity be kept so that the researcher was not aware of student names on assignments. To combat this, the course tutor took out the relevant sections of the assignments and placed them into a word document and sent the file via a password protected email.

2.6.3 Consent

In order to reduce any associated risks with research and to be ethically sound, consent is needed from all participants involved in a study (Taylor, et al., 2015). Consent is an key part of ethical research and all participants in this research have consented to being a part of the project. Signed consent was sought for interviews and focus groups, whereas implied consent was used for questionnaires. Consent was also sought from landowners when operating from non-public land for UAV flying. This was conducted under approval of the LJMU ethics committee.

2.7 General Limitations of Methods

Throughout this chapter, the researcher has given explanations to the use of the methods and instruments chosen along with limitation sections for each. However, some overall limitations were; time, cost, equipment and participant engagement.

Time was a major limiting factor in this research for two reasons. Firstly, as noted in this Chapter, arranging a suitable time for students to engage in research was difficult and this was compounded further due to not always having access to such students due to term time timetables. This was most prominent in the evaluation of the EVFG, while the researcher would have liked to have had interviews with those students, due to the fieldtrip being their last official day on the course, this was not practical. The research had to be conducted within the bounds of the course schedule and the researcher had no control over when the fieldtrip was to take place. Unfortunately, due to the time it took to create the EVFG and the time span of this research, this fieldtrip was the only viable trip that could be evaluated with the EVFG. Future fieldtrips occurred outside of the allotted time for this research.

The UAV procurement, licencing and VLM collection process as outlined in Chapter V was far more time intensive than the researcher had initially anticipated. The procurement procedure and time taken to become legally qualified as an RPAS pilot took almost a year that was not envisaged at the start of the research. This was not due to any particular barriers; it is just a long and detailed process. This meant that any data collection with the UAV was limited until this capacity was achieved and the process of creating the Operations Manual for example, which is a 20,000-word document, took focus away from data collection and analysis at times in order to complete it. Despite this however, it did provide useful data for the researcher to know the process and helped to triangulate some of the comments from practitioners when it came to laws and licencing of UAV flying in their teaching. The process was also important to follow as this research attempts to highlight the issues and challenges the preconceived idea that UAVs are a simple buy and use easily.

Cost and time were a hindrance to this research, as while the licencing requirements took a lot of time and money, the researcher had to invest their own money into this research project. The researcher decided to buy a drone in order to speed up the process and avoid time-consuming internal University politics. It is the researcher's belief that if this action was not taken then no data would have been collected and therefore this research would not have been completed. Cost and time was also a further limiting factor when trying to secure dedicated software and hardware in order to process the UAV data to make the 3D VLM. Due to a lack of equipment and software on campus, a dedicated PC had to ordered and set up and due to a lack of institutional licences for the software, the researcher had to invest in their own licence or make use of 30-day free trials. Again, this may well be a challenge that other researchers or institutions may face, so while an issue, it did provide useful information about the challenges of creation of the VLM and EVFG.

The researcher was limited in help from a lack of experts in this field for the creation of the 3D VLM and UAV flying. All procedures, revisions and development of the model was due to the researcher's tenacity and through a long process of trial and error and self-learning. Such time intensive exercises did affect the number of data stages collected.

All researchers would always want more data and this is no different here. As mentioned, gaining participant engagement from students was difficult and this is one of the challenges of such research. Nevertheless, despite these limitations and challenges there were far more advantages than disadvantages to the methods employed in this research. The following chapters will now explore in-depth the different cases to answer the research question and they are written as separate chapters, starting with the first, *Fieldwork*.

CHAPTER III: FIELDWORK

This chapter answers the first part of the first aim that is "*To enhance the understanding of the role* ***fieldwork*** *and mobile technologies play in learning about geoscience in higher education*". An overview of what fieldwork is and more specifically the changing nature of fieldwork over the years are outlined through established literature. This chapter then delves into some of the learning theories that underpin fieldwork after a brief methods section. Through the combination of established literature and the data collected from this study, the advantages of fieldwork but also the many challenges that both staff and student's face are explored. A conclusion about the role fieldwork plays in learning about geoscience is offered before moving into Chapter IV: Mobile Technologies on Fieldwork.

3.1 HISTORY OF FIELDWORK

Fieldwork in the United Kingdom (UK) is of vital importance to undergraduate teachings of Geography related disciplines (Lathrop & Ebbett, 2006). It is an essential aspect of geoscience and not only is it held in high esteem by practitioners but arguably and most importantly, students believe it to be an enjoyable and effective method of learning (Fuller, Gaskin & Scott, 2003). Fieldwork in Geography based subjects in the UK is part of the Quality Assurance Agency's benchmark that states, "Geography is intrinsically a field-based subject. Field experience is an essential part, and all geographers require the opportunity to plan, undertake and report significant fieldwork during their programme" (Quality Assurance Agency, 2014, p. 11).

Fieldwork is an element of teaching that takes the students out of their four-walled classroom and into a learning environment that is outdoors (Lonergran & Andres, 1988). This exposes students to a method of teaching and learning that cannot be duplicated in the classroom environment, it deepens the students understanding of complex processes and rapidly develops various skills (Healey & Roberts, 2004; Stoddart & Adams, 2004). Fieldwork can often vary in location, length, objectives, and style (Amit, 2003). It can be as simple as taking students outside of the classroom to explore the campus grounds, to more expansive multi-day trips abroad (Dando & Weidel, 1971).

A common theme throughout all fieldwork studies is providing the students with the opportunity to actively engage with the outside world (Quality Assurance Agency, 2014). Gold, Jenkins, Lee, Monk, Riley, Shepherd et al. (1991) attempted to classify fieldwork into five different categories. In the UK, most if not all of these fieldwork types are covered on undergraduate courses (Fuller, Edmondson, France, Higgitt & Ratinen, 2006).

- **Short Field Excursions:** Often local sites accessible for students and staff; can be during a lecture slot or half a day due to time limitations.

- **Cook's Tour:** Further afield than short field excursions and usually longer in length. Tutor-led with minimal input from students. Often a more descriptive method of teaching and learning.

- **Residential Course:** Allows for an increase in travel and time at the field site. Often using one location as a base camp from which to work. This allows for more student engagement and learning through the incorporation of the different aspects of learning styles.

- **Study Tour:** A multi-location activity over a number of days; differs from a residential course due to the lack of a base, a new location is visited each day.

- **Project work:** Often led by students who design and implement their own learning through data collection in the field. This is more student-led than tutor led.

Fieldwork has changed over the years and continues to transform with the increase in accessible data, ease of mobility and access to sites, and external factors such as a decrease in staff and student time and institutional expenditure. Fig. 3.1 shows an adapted and updated schematic model of the changes to fieldwork in recent years (Kent, et al., 1997).

1950-60s:

Referred to as the 'Cook's tour' which is an approach to fieldwork of observation and description with little student engagement or critical thinking on their part. It is highly dependant on the tutor.

1970-80s:

A slow progression from 'Cook's tour' towards participatory fieldwork. Field trips begin to incorporate the use of problem solving skills and project based field courses. This provides students with some degree of autonomy.

1990s:

Student numbers rise rapidly in the UK, raising issues of fieldwork cost, accommodation, administration and environmental impact concerns of fieldwork (McEwen, 1996).

Late 1990s – 2000s:

Low cost airline boom providing cheap package deals and accessibility to international field locations. A distinct move away from Cook's tour to more independent thinking and student led projects on fieldwork, honing many graduate skills.

2010- Present day:

Rapid increase in technology has enhanced but also replaced certain aspects of traditional fieldwork practices. Reduction in government funding and tighter budgetary constraints have led to alternatives to field trips such as virtual trips and guides.

Fig. 3.1 - Timeline of Fieldwork Change

3.1.1 COOK'S TOUR

In the 1950s and 60's the *Cook's tour* method of field trips was most prominent. The Cook's tour method of fieldwork teaching was often to take students to a local fieldwork site or somewhere within the UK (Kent, et al., 1997). The Cook's tour method of fieldwork revolved around the traditional method of observational based learning. This method is very descriptive for the students and is very tutor focused and led (Clark, 1996).

This method limited any involvement, engagement, or critical thinking by the students (Fuller & France, 2015). Students often identified this type of field study as 'boring' or 'unengaging' (Brown, 1969). Students would miss important information unless prompted and had the tendency to regurgitate the information given by the tutor (Kent, et al., 1997). Cook's tour type field trips nevertheless provided the benefit of taking the students out of their classroom environment and allowed them to see processes, structures and methods first hand, especially when reinforced by on-site tutorial-style discussion (Couch, 1985).

Although there has been a move away from the Cook's tour type methods to more research and problem-solving approaches, this does not mean that one is more superior over the other (Fuller et al., 2006). As argued by Gold et al (1991), Cook's tour methods work well for first-year undergraduates instead of the more challenging analytical approaches. Many South Asian Universities still employ Cook's tour methods of fieldwork in their teachings and in the UK today, elements of observationally based studies are incorporated into both human and physical geography participatory fieldwork to give a more holistic approach to learning (Goh & Wong, 2000). As outlined by Fuller and France (2015), Cook's tour type field trips still have their place today when incorporated with new and emerging technologies such as digital videos.

3.1.2 PARTICIPATORY FIELDWORK

Cook's tour field trips are mostly resigned to the history of the 1960s in the UK when methods of teaching field courses started to move away from observational studies, to one of more complex geographical processes with an element of independent research and problem solving for students (Gold et al., 1991; Bradbeer, 1996; Kent et al., 1997; Pawson & Teather, 2002; Bracken & Mawdsley, 2004; Drummer et al., 2008). Although teaching and projects on this new type of field course were still tutor-led, there was flexibility to allow the tutor to decide on which group projects to initiate and what methods of data collection should be used (Cloke, Kirby & Park, 1981). This is an effective way of getting students to develop their skills while still under the guidance of a tutor (Boyle et al., 2007), and this allows students to learn by doing, which can be argued to also be an effective learning method (Race, 1993).

Fieldwork offers the development of many of the skills deemed desirable to be employable (Vodenska, 2000; Dumbraveanu & Dumitrache, 2007). Graduate attributes such as teamwork, communication and, independent problem-solving skills are all at the heart of the today's field courses (Spronken-Smith, McLean, Smith, Bond, Jenkins, Marshall et al., 2016). Many employers and universities are beginning to outline the desired graduate attributes that they would like students to achieve during their time in higher education (Barrie, 2004). Graduate attribute skills are defined as the "qualities, skills and understanding a university community agrees its students would desirably develop during their time at the institution and, consequently, shape the contribution they are able to make to their profession and as a citizen" (Bowden, Hart, King, Trigwell & Watts, 2000 p.2).

Participatory field courses have been shown to foster such attributes; nonetheless such field courses pose a few challenges. Studies by Tinsley (1996) demonstrate that during student-led projects in the field, students felt more engaged and committed than during projects that had been designed and led by staff. This shift in ownership of learning in the field has taken time for academic staff to have a change of approach to 'stepping back' and guiding group projects and helping groups to establish their own research objectives and ideas, rather than one introduced by themselves (Slater, 1993). Participatory field trips are much more resource and time intensive than traditional Cook's tour methods (Faubion & Marcus, 2009), while there are some logistical and health and safety challenges due to different groups of students at different locations on the trip that must also be considered (Boud & Feletti, 1991).

3.1.3 Fieldwork Today

A further shift occurred on fieldwork due to the introduction of the internet, ICT systems and more recently, mobile technologies (Fuller & France, 2014). Now many students possess mobile technologies that allow them to access data pre, post and during a field trip (Welsh, Mauchline, Park, Whalley & France, 2013). It has been over 30 years since Gardiner & Unwin (1986) first used computer-based technology in fieldwork to analyse results collected, which is standard practice for students today.

Such rapid expansion of technology and ICT in fieldwork has allowed students and tutors to become more efficient and autonomous in the field (Martin & Ertzberger, 2013). Technology such as mobile applications and handheld data collection devices such as tablet and GPS have sped up the data collection process (Wentzel, 2005); therefore, they can facilitate more learning objectives per field trip than ever before (Welsh & France, 2012). Mobile technologies have also allowed a different form of teaching to occur on field trips through the use of collaborative data collection, off-campus learning, and student guidance via social media (Chen & Huang, 2012).

Despite all of this new technology and its incorporation into today's field trips (for which more detail is given in Chapter IV), there is still an intrinsic need for physical field trips. Nevertheless, there has been a continued decline in the number of field trips taken in the UK due to a number of reasons (Leydon & Turner, 2013). Firstly, there has been a rapid increase in higher education student numbers in the UK (UK GOV, 2016) and Geoscience subjects continue to rise to record levels (Royal Geographical Society, 2016). This increase in student numbers has placed enormous amounts of financial pressures on faculties along with staff time commitments to complete fieldwork (Welsh & France, 2012). Such pressures have created a dilemma where some institutions are opting to pay for compulsory fieldwork while offering many alternative or additional fieldwork at a cost to the student (Fletcher & Dodds, 2004). This raises equitable concerns and places burdens on students who cannot financially afford such extracurricular activities (Fuller et al., 2003). Students at an unfair advantage are also brought to light through the need for field trips to be inclusive of disabilities and differing needs of students and genders (Rose, 1993; Hall, Healey & Harrison, 2004).

3.2 METHODS

Now that a brief history of fieldwork has been outlined the following sections evaluate just how effective fieldwork is for learning of students. Along with an evaluation of the learning theories at work on fieldwork, the advantages and disadvantages of fieldwork for both staff and students are explored. In order to evaluate this concept, a selection of 10 questions was used from the questionnaire. These questions consisted of students thoughts/opinions of fieldwork (n=3), learning theories (n=3) and ranking of importance of selected aspects of fieldwork (n=5), Table 3.1

Table 3.1: Questions used from the questionnaire to evaluate students thoughts about fieldwork

Question Category (question number on the questionnaire) (n= number of responses)	**Question Type**
Learning Theories	
(18) Do you take time after fieldwork exercises to reflect on what you have learnt and experienced? (n=91)	Likert
(20) If you don't know something on fieldwork for an assignment, how do you normally go about finding the information? (n=91)	Multiple Choice
(21) Do you use social media, i.e. Facebook, Twitter to discuss assignments? (n=90)	Dichotomous
Opinion of fieldwork	
(12.3) "Fieldwork is important for my studies"(n=90)	Likert
(12.4) "I enjoy going on fieldwork" (n=86)	Likert
(13) How likely are you to use your mobile technology device in fieldwork? (n=90)	Likert
Important aspects of fieldwork	
(19.1) Social and Personal Development	Ranked
(19.2) Developing skills such as problem-solving, teamwork and communication	Ranked
(19.3) Helps to place what is taught in the lecture into real-world scenarios and helps to make the connection between the two	Ranked
(19.4) Developing technical skills such as data collection, use of specialist equipment	Ranked
(19.5) Experiencing a landscape or area in person	Ranked

Following on from the questionnaire, Geography and Outdoor Education lecturers both male (n=4) and female (n=1) took part in individual semi-structured interviews which lasted for approximately 58 minutes each. One student was formally interviewed alongside observations on fieldwork. A focus group with first-year outdoor education students (n=4) was also held lasting one hour. Quotes from interviews and focus groups are displayed in the text with the respondent's identifier as follows (Position A-E, Discipline). Lecturers are given identifiers A to E as to separate them due to their same position and disciplines, the focus group using identifiers A1-4.

3.3 LEARNING THEORIES OF FIELDWORK

While fieldwork today has changed due to technology and increased pressures, fieldwork is still very much practical and hands-on based. Over time, different learning theories have been used to advocate that fieldwork is vital for enhancing student learning. Learning is something that everyone experiences but is a complex phenomenon to explain or define (Ormrod, 2011). Driscoll (2000) attempted to classify learning as "a persisting change in human performance or performance potential which comes about as a result of the learners experience and interaction with the world" (p.11). This definition encompasses many of the aspects of traditional learning theories such as behaviourism and cognitivism (Siemens, 2005).

This one definition, however, is not a complete definition of learning. There are conflicting arguments about how knowledge is acquired. For example, Kolb (2014) believed that knowledge is acquired through individual experiences and how the individual interacts with the world around them. Foder and Pinker, the founders of modern nativism, considered that knowledge is an innate process that is inherited at birth (Kuhl & Meltzoff, 1997), while Nonaka (1994) observed that knowledge is created through thinking and reasoning.

Greenfield (2004) discussed that from the moment an individual is born, no other individual experiences the same events in the same order and therefore, each individual has a very different learning experience from another individual. Vygotsky (1978) and Hobson & Welbourne (1998) supposed that knowledge and learning is a process of one's own understanding of the world around us, and this is enhanced by social interactions to help the individual to construct their own knowledge.

Although the learning experiences are different, such as internal and external influences, they all believed that learning takes place only within the individual (Bransford, Vye, Stevens, Kuhl, Schwartz, Bell, et al., 2006). These traditional theories do not outline learning that occurs outside of the individual, for example learning that is facilitated through technology (Siemens, 2005).

Before discussing the advantages and disadvantages of fieldwork, it is essential to understand the fundamental learning theories that govern fieldwork. Learning theories on fieldwork play a vital role in how courses are delivered, how students interact with peers, the tutor, and the environment. Understanding about learning theories underpinning fieldwork can help to understand this shift in fieldwork delivery today and provides a basis to understand staff and students thoughts of fieldwork. The two most common learning theories are discussed below (1) *experiential learning* and (2) *situated learning.*

3.3.1 Experiential Learning

Experiential learning theory is a model of how adults learn and develop with a particular emphasis on the role of 'experience' in the learning process (Kolb, Boyatzis & Mainemelis, 2001). Kolb's model of experiential learning is a basic scaffold for the most common forms of fieldwork courses where students get to see, do and then reflect.

Experiential learning theory has its origins in the work of Piaget and his cognitive-development epistemology (Piaget, 1976) along with the philosophical stance of Dewey (Dewey & Ratner, 1939) and Lewin's social psychology (Lewin, 1939). Experiential learning theory can be defined as "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p. 41). Experiential learning is more than a hands-on approach as it incorporates reflection on doing (Felicia, 2011). Experience in this model is split into two definitions, the concrete experience and the abstract conceptualisation of the experience (Kolb et al., 2001). According to Kolb (1984) in his learning cycle, concrete experiences form the basis for observations and reflections in learners.

Kolb's experiential learning cycle consists of four main events in a student's learning process. Firstly, the student learns through concrete and tangible experiences. Following on from this, a learner observes the phenomenon in question, they then form abstract concepts and then finally, they test or apply their new knowledge in a new situation.

Experience is not easy to define as learners see the world through their own lens (Jonassen & Land, 2012). Some learners understand the world or new information through experiencing the concrete or the tangible, where there is a reliance on their senses to make sense of their reality (Kolb, 1981). Other learners prefer to conceptualise via abstract thinking and relying on order, systematic planning, and analysis rather than the senses (Kolb, 1976). For example, in a group setting some individuals prefer to watch how it is done before tackling it themselves, whereas others will jump right in. The 'watchers' in this case rely on observation of the reality that they see, whereas the 'doers' prefer to create their reality through experimentation (Kolb et al., 2001). There is no right or wrong learning style, both sets of learners learn through their individual experiences of either observing or doing. Learning as stated by Zuber-Skerritt (1992) is not about the outcome but about the process.

Fieldwork, therefore, provides ideal facilitation of Kolb's model by taking students out of the classroom experience to understand new and complex topics through experiencing them first hand, be that via observation or doing (Boyle et al., 2007). Experiential learning on fieldwork is the direct encounter by the student with the phenomena in question, rather than thinking about it in abstract form in a lecture hall (Jakubowski, 2003). Kolb (1984) argues that the experiential learning model that they proposed does not always have to begin at the concrete experience stage necessarily, however regarding fieldwork, this is often the first and fundamental element of learning through fieldwork (Healey & Jenkins, 2000).

Field trips bolster the idea that the learner learns best through their connection to realities being studied (Keeton & Tate, 1978). Scarce (1997) states, "Field trips may best be seen as an example of short-term experiential education" (p.291). Kolb's (1984) experiential learning model has been adapted below in Fig. 3.2 to simulate the learning process in a geoscience fieldwork setting.

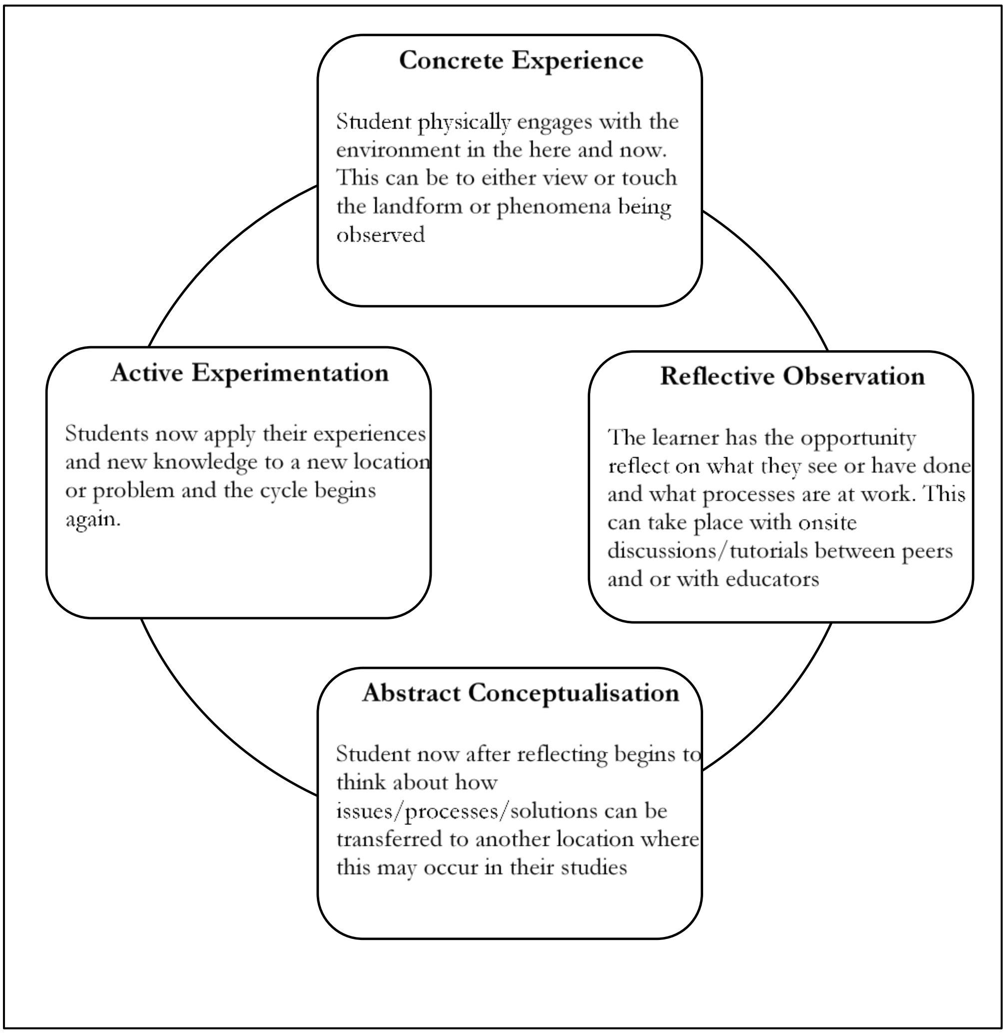


Fig. 3.2 - Adaptation of Kolb's Experiential Learning model for fieldwork

Although experiential learning is an effective way for many students to learn (Wurdinger, 2005), it is not a guarantee for successful learning by students on fieldwork (Merriam, Caffarella & Baumgartner, 2007). Kolb (2014) mentioned that in order to gain genuine and long-lasting knowledge from a particular experience the learner or student must possess the following skills.

The learner must be good at making decisions and have problem-solving abilities. These skills are needed so that the student can reflect on what has been learnt, how a problem has been solved and more importantly, how and what has been learnt can be applied to a new situation (Boud, Koegh & Walker, 1987). Fieldwork for many geoscience degrees is often about developing such skills in students, particularly in the first year of undergraduate study (Kent, et al., 1997) yet the assumption made is that all students not only possess such skills but have equal skill development.

The second quality Kolb (2014) mentioned is that the learner must possess analytical skills that are needed to conceptualise the experience. Fieldwork by its very nature develops critical analytical thinking and problem-solving skills through tasks set on the field course (Kern & Carpenter, 1986). This skill, along with the decision and problem-solving skills are skills that are most often developed on fieldwork (Healey & Roberts, 2004). However, if a student struggles to grasp such skills their 'learning experience' is hindered in relation to Kolb's model.

The final assumption and issue of Kolb's model are that it is highly dependent on the skill of the learner to deeply reflect on their own experiences. Reflection is often an essential learning and development skill to possess (Boud, Koegh & Walker, 1996) and undergraduate students will often be exposed to some form of reflection throughout their academic careers (Stewart & Richardson, 2000). However, true and deep reflection can often be a difficult skill to master for a student (Leijen, Lam, Wildschut & Simons, 2009). Jacobson and Ruddy (2004) believe that an educator who asks the right questions and can guide a student's reflection pre, post and during a fieldwork experience can open new learning and thinking opportunities. Therefore, to gain the most out of the fieldwork experience, it is useful for educators to allow periods of reflection, be that via group discussions or to set an assignment that gets the student to reflect on their experience of the fieldwork in order to answer the question (Rogers, 2001). If students do not reflect or do not reflect in depth, then the learning benefit of being in such an outdoors location is limited.

In this research 18% (n=16) of students rarely reflect on their experience of fieldwork with 3% (n=3) never reflecting. Only 20% (n=19) always reflect on fieldwork, and this raises a question of how accurate and effective Kolb's learning theory is in reality on fieldwork. Kolb's learning theory while popular is not the only theory at work on fieldwork. Fieldwork is seldom solitary in nature, and while Kolb's theory explores the learning process of the individual, due to the group nature of undergraduate fieldwork, another theory is needed.

3.3.2 Situated Learning

Lave and Wenger (1991) argue that learning occurs when it is situated within a specific context, activity and culture. *Situated learning* is ideal for fieldwork as it accentuates the ideology that what is learnt should be specific to the situation (Anderson, Reder & Simon, 1996). Therefore, learning about a specific landform development process while being in that environment on a field trip, can help develop learning in an individual (Pawson & Teather, 2002). Situated learning develops knowledge for an individual by placing the situation in context or put simply, focuses on the relationship between the social situation and the learning that occurs within it (Lave & Wenger, 1991). Previous learning theories such as experiential learning have often focused on the individual cognitive processes for learning. However, Lave and Wenger's (1991) situated learning theory looks at learning through the lens of social engagement. They argued that knowledge is co-constructed within social interaction and collaboration between individuals in a group and is an essential part of situated learning were learners then become a part of a "*community of practice*" (Lave, 1991). There are four key concepts in situated learning proposed by Lave & Wenger (1991), they are (1) content, (2) context, (3) community and (4) participation.

Content in situated learning often deals with the facts and the practicalities of how a task is done. Lave and Wenger (1991) emphasise that content in situated learning is more akin to the how an individual uses the facts to complete a task or solve a problem, with a critical focus on their reflective process and higher order thinking.

The context in situated learning is when such knowledge or processes which have been developed in the content stage, can be applied to a specific context (McLellan, 1996). Situated learning aligns well to fieldwork settings where students can apply their new knowledge (lecture or book knowledge) in a specific and different environmental context (on fieldwork) (Kramer & Stern, 1995).

Communities help the learner to reflect and interpret their own processes to the problem and negotiate with others in their learning community to help them reflect further on their own experiences (Anderson et al., 1996). This negotiation is facilitated by the fourth stage, participation. Participation is where the learner actively engages with other members of the community to select and deselect ideas and possible solutions through group negotiations in order to solve the problem. They rely on each other's levels of knowledge to collate and create new knowledge that benefits all members of that learning community (Hung & Chen, 2001).

Situated learning is not an all-encompassing learning theory; instead, it is primarily used to understand the learning process in activities (Billett, 1996). Situated learning is problem-driven as it tests the psychomotor and intellectual skills of a learner (Stein, 1998) and this is where situated learning and fieldwork align (Brickell, Herrington & Harper, 2005). Fieldwork today is often problem solving based and is used to get students to see a problem first hand (Spronken-Smith et al., 2016). The student gets to see the problem and then is often given tasks to collect data and work in small teams to understand what is causing the problem and then to offer solutions (Kern & Carpenter, 1986). Today's fieldwork, therefore, is much more about active participation and problem solving than traditional cooks tour field trips of the 1960s (Fuller, 2006).

As fieldwork has shifted to smaller groups that aim to solve problems on fieldwork, fieldwork is now very group focused. This shift in fieldwork allowed students to help each other to learn through their interaction and negotiation of their ideas (Haigh & Gold, 1993). Today, residential fieldwork trips in geoscience will often end with a group presentation whereby the groups of students have been set a task that is often question focused. The students have to work in their groups to collect data, understand and interpret such information and then work together to solve and present (Boyle et al., 2007).

The effect of students working in groups to solve problems through situated learning and the suggestion of a "*communities of practice*" is evident in this research with 82% (n=75) of students most likely to discuss a problem verbally with their fellow peers on fieldwork before seeking the information elsewhere, usually the tutor, Fig. 3.3.

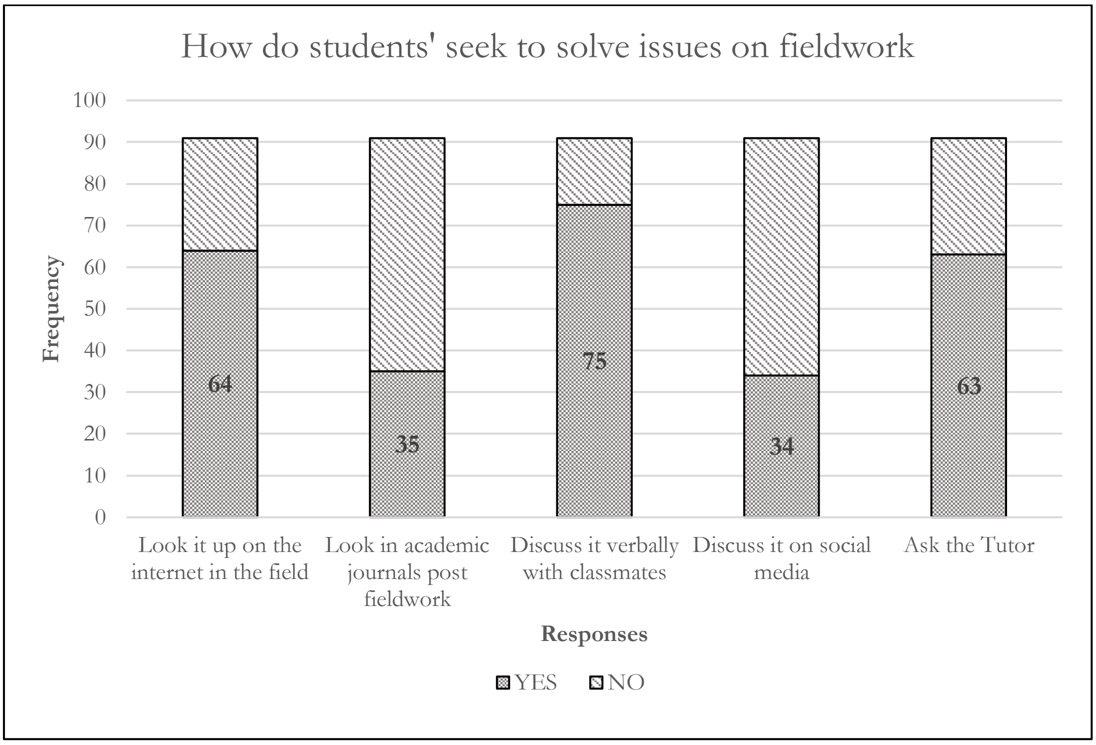


Fig. 3.3 - How do students seek to solve problems on fieldwork

Evidence for this emerged in the focus group with outdoor education students as they alluded to seeking experts in their group to solve issues as demonstrated below.

> A3: …Well in climbing I wouldn't hesitate to ask A2 anything and Paddling it would be Matt but then if it's like a specific learning thing, then I'd always ask the tutor usually.
> A1/A2/A4: Yeah.
> Interviewer: So you're kind of identifying individual experts...
> A3:...Specialists in the group yeah.
> (Level 4, Outdoor education students)

Discussing problems verbally between peers does somewhat support the idea that communities of practice do exist amongst students on fieldwork. A chi-square test for association was conducted between gender and discussing problems verbally between classmates on fieldwork. All expected cell frequencies were greater than five. There was a statistically significant association between gender and discussing problems verbally between classmates on fieldwork, $\chi2(1) = 4.740$, $p = .029$. There was a moderately strong association between females and discussing problems verbally between classmates on fieldwork more than males, $\varphi = .228$, $p = .029$.

The internet was the second most selected choice followed by the tutor in third. If a true community of practice existed amongst students, they would rely on their collective knowledge alone rather than seek the advice of a traditional source of knowledge which is the tutor. Nevertheless, what this does demonstrate is that students in this sample do not just seek information out solely from tutors but mix this with the discussions of their peers, showing a development of learning behaviour on fieldwork.

3.3.3 APPROACH TO FIELDWORK NEEDS TO BE EFFECTIVE

While fieldwork is undoubtedly important, it does not make an effective teaching and learning method in its own right (Lonergran & Andres, 1988). As detailed by Longergran and Andres (1988) taking students into the field does not guarantee an enhanced learning experience. For this to occur, it must align to the curriculum of the course (Andrews et al., 2003). This alignment provides the students with the opportunity to transfer learning from elements in the classroom to real-world scenarios (Biggs, 2003). There should be an emphasis placed on preparation and debriefing of students both pre and post field trip to continually assess the effectiveness of students understanding of the link between the course materials and the field trip (Kent et al., 1997).

3.4 THE IMPORTANCE OF FIELDWORK

Fieldwork is deeply rooted in the ethos of Geoscience degrees, and this is clear in this sample with 96% (n=86) of students agreed or strongly agreed that fieldwork is important for their studies. This agreement supports established literature that outlines the importance of fieldwork in geoscience studies (McEwen, 1996; Fuller et al., 2003; Wall & Speake, 2012). Students stated in this research that an essential aspect of fieldwork is that it enables them to get out into the field to make the connection between what is taught in the classroom to what happens in the real world. It can be argued that this is a fundamental aspect "*as geographers, that you get out of the classroom and you learn about the environment that you live in*" (Lecturer [B], Geography).

Students referred to fieldwork facilitating "*practical knowledge as opposed to book knowledge"* (Female, Level 5, Student). This is supported in one account by a lecturer who sums up the nature of fieldwork "*it's real, and I think that's the heart of it…it's not on a piece of paper, it's not talking about it or looking at a video, it's doing it, feeling it, touching it*" (Lecturer [D], Outdoor Education). As outlined in the introduction and the learning theories, what lies at the heart of fieldwork is the ability for students to get out into the field to solve problems through the interaction with the landscape. One account by a student interviewed supports this notion in the literature that this is a key and core strength of fieldwork as she recalls how physically seeing such landscapes and processes in person helps her to better understand the world around her and thus, increases her sense of learning.

> You can sit there and read a book or a passage a thousand times, and it won't sink in… Someone can tell you "valleys are created by glaciers". Great! But they'll never understand it until they go out there and look at how those rocks are moved and then you actually not only get to understand the process but the power and magnitude of that particular situation
>
> (Female, L5 Student, Outdoor Education)

Fieldwork, therefore, provides an out of the classroom experience for learners to learn and to understand new and complex topics through first-hand experience (Boyle et al., 2007). This was reinforced by one lecturer who believes that in a classroom "*you can't recreate that experience of going out to seeing these processes in the real world, seeing the features that these processes create*" and the versatility of fieldwork learning as "*you never quite know what you're going to see when you get out there it changes day to day*" (Lecturer [A], Geography).

Fieldwork can often be necessary not only for learning but what did emerge from this study is the importance of fieldwork for marketing purposes for departments. Departments recognise that "*marketing is very important*" and that the draw of fieldwork, especially overseas field trips have "*great value*" with "*80% [of students] recognise that [fieldwork] was you know a good selling point*" (Lecturer [B], Geography).

3.4.1 STUDENTS ENJOY GOING ON FIELDWORK

Studies by Blunsdon, Redd, McNeil & McEachern (2003) have shown that enjoyment in fieldwork is often linked to engagement and therefore a deeper understanding of learning occurs. For this sample, 86% (n=77) of students agreed or strongly agreed that they enjoy fieldwork, supporting the notion that fieldwork is inherently enjoyable (Gold et al., 2003 & Boyle et al., 2007). This was not only reflected in such a high percentage of enjoyment amongst students but was also recognised and valued by lecturers with one believing that students often "*in module evaluations or in the National Student Survey, they single out fieldwork as being the highlight experience [of their degree]*" (Lecturer [B], Geography). Throughout the interview process, it became apparent that this enjoyment of fieldwork was reflected through the personal experiences of both staff and students. While the need to keep fieldwork cannot be based on enjoyment alone, there are many benefits to learning when students enjoy what they do (Brophy, 2013). If students enjoy what they do and are engaged, then the learning potential is vastly increased (Blunsdon et al., 2003). It has become apparent that the current shift in fieldwork away from the Cook's tour method has been beneficial for fieldwork as a concept. As noted by Brown (1969) students on Cook's tour fieldwork often felt bored, and this affected their learning. How staff and students articulated what it was about fieldwork that made it so enjoyable was often through two distinct reasons, (1) being outdoors and (2) the social aspect.

3.4.2 Enjoyment Of Being Outdoors & The Social Aspect Of Fieldwork

Firstly, staff and students enthused about simply being immersed in a different outdoor environment to that of a classroom as a basis for their enjoyment. The account below sums up the thoughts of many in this study about the simplicity in the enjoyment of being outdoors on fieldwork.

> From my point of view, I just enjoy being there in the landscape and I think being there gives you the inspiration … if you're actually going into the field and you're there, and you have the wind and the rain or the sunshine, whatever it might be that day, it actually inspires you to stay within that field and to keep that interest.
>
> (Female, Level 5, Outdoor Education Student)

When students were asked to rank a selection of fieldwork aspects of what was important to them, fieldwork helped to place what was taught in the lecture into the real work, was the most important aspect of fieldwork regardless of any of the variables in this study, Table 3.2. The reason for this was according to students in this study is due to this enjoyment of being outdoors and the ability for this to facilitate the connections between what is taught in the classroom into real-life scenarios. This connection was echoed by one lecturer in how visiting a location is more beneficial to learning for their students than a location they have not visited.

> So here is a worksheet and here is some data from someplace in America and yeah, you can do some analysis on that but it's so much more meaningful if it's based on somewhere you've been and seen. "Okay that river we stood in we did our own

measurements now here is our data" and better still some secondary data from that very same river, [it] just brings it to life.

(Lecturer [D], Outdoor Education)

Table 3.2: Ranks of importance on fieldwork

Variable	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Male	Helps to place what is taught into the real world and make the connection between the two	Developing skills such as problem-solving, teamwork and communication	Social and personal development	Developing technical skills such as data collection, use of specialist equipment	Experiencing a landscape or area in person
Mean Rank	**2.50**(SD=1.48)	**2.75**(SD=1.11)	**3.04**(SD=1.43)	**3.32**(SD=1.47)	**3.39**(SD=1.47)
Female	Helps to place what is taught into the real world and make the connection between the two	Developing technical skills such as data collection, use of specialist equipment	Developing skills such as problem-solving, teamwork and communication	Experiencing a landscape or area in person	Social and personal development
Mean Rank	**2.29**(SD=1.33)	**2.78**(SD=1.30)	**2.84**(SD=1.21)	**3.51**(SD=1.46)	**3.58**(SD=1.42)
University LJMU	Helps to place what is taught into the real world and make the connection between the two	Developing technical skills such as data collection, use of specialist equipment	Developing skills such as problem-solving, teamwork and communication	Social and personal development	Experiencing a landscape or area in person
Mean Rank	**2.47**(SD=1.46)	**2.81**(SD=1.35)	**2.94**(SD=1.26)	**3.25**(SD=1.40)	**3.53**(SD=1.44)
University UoC	Helps to place what is taught into the real world and make the connection between the two	Developing skills such as problem-solving, teamwork and communication	Developing technical skills such as data collection, use of specialist equipment	Experiencing a landscape or area in person	Social and personal development
Mean Rank	**2.27**(SD=1.31)	**2.68**(SD=1.06)	**3.16**(SD=1.41)	**3.41**(SD=1.48)	**3.49**(SD=1.48)
Level 4	Helps to place what is taught into the real world and make the connection between the two	Developing technical skills such as data collection, use of specialist equipment	Developing skills such as problem-solving, teamwork and communication	Social and personal development	Experiencing a landscape or area in person
Mean Rank	**2.27**(SD=1.39)	**2.86**(SD=1.49)	**2.91**(SD=1.19)	**3.27**(SD=1.35)	**3.68**(SD=1.39)

Level 5	Helps to place what is taught into the real world and make the connection between the two	Developing skills such as problem-solving, teamwork and communication	Developing technical skills such as data collection, use of specialist equipment	Experiencing a landscape or area in person	Social and personal development
Mean Rank	**2.48**(SD=1.41)	**2.79**(SD=1.21)	**3.10**(SD=1.40)	**3.24**(SD=1.53)	**3.38**(SD=1.45)
Level 6	Helps to place what is taught into the real world and make the connection between the two	Developing skills such as problem-solving, teamwork and communication	Developing technical skills such as data collection, use of specialist equipment	Social and personal development	Experiencing a landscape or area in person
Mean Rank	**2.32**(SD=1.39)	**2.73**(SD=1.12)	**2.95**(SD=1.29)	**3.45**(SD=1.57)	**3.55**(SD=1.44)
Single (Hons) Geography	Helps to place what is taught into the real world and make the connection between the two	Developing skills such as problem-solving, teamwork and communication	Developing technical skills such as data collection, use of specialist equipment	Social and personal development	Experiencing a landscape or area in person
Mean Rank	**2.45**(SD=1.29)	**2.61**(SD=1.26)	**2.68**(SD=1.42)	**3.55**(SD=1.31)	**3.71**(SD=1.40)
Geography Combined	Helps to place what is taught into the real world and make the connection between the two	Developing skills such as problem-solving, teamwork and communication	Experiencing a landscape or area in person	Developing technical skills such as data collection, use of specialist equipment	Social and personal development
Mean Rank	**2.30(**SD=1.49)	**2.90**(SD=0.85)	**3.20**(SD=1.44)	**3.25**(SD=1.33)	**3.35**(SD=1.73)
Outdoor Education	Helps to place what is taught into the real world and make the connection between the two	Developing skills such as problem-solving, teamwork and communication	Social and personal development	Developing technical skills such as data collection, use of specialist equipment	Experiencing a landscape or area in person
Mean Rank	**2.32**(SD=1.46)	**3.00**(SD=1.27)	**3.14**(SD=1.36)	**3.18**(SD=1.33)	**3.36**(SD=1.56)

Less evident in literature is the social aspect and the group bonding that occurs on fieldwork. This supports the findings in the literature (c.f. Stott & Hall, 2003; Fuller et al., 2006; Marvelf, Simm, Schaaf & Harpe, 2013; Stott, Allison, von Wald et al., 2016) who comment that geoscience fieldwork has many social benefits such as feelings of belonging to a group and increasing their interactions with their fellow peers as well as the traditional skills.

Social and personal development on fieldwork is often an overlooked but essential part of fieldwork education. When students were asked to rank what was most important to them on fieldwork in this study, *Social and Personal Development* jostle for position for the two least selected ranks of importance on fieldwork by students (Table 3.2). However, Outdoor Education students place this aspect of fieldwork at number 3 in importance compared to Single Hons Geography students at 4, and Geography combined place it in last.

This difference was somewhat a surprising result considering the studies that have been completed which state that this social interaction was most often a high priority for students on fieldwork. One explanation at least for the differences between the cohorts in this study is that Outdoor Education students often differ in their outlook on careers compared to traditional geography students. Outdoor education students tend to enter practical vocational employment opportunities such as recreational and sporting activities (Prince, 2005). While it is important that they understand the theory and the processes that govern the landscape that they operate in, employers in this field value the practical element of assessment and qualifications such National Governing Body Awards more (Barnes, 2006; Stott, 2007; Stott, Zaitseva & Cui, 2014).

Due to this nature of working towards practical rather than academic awards and being in an environment where communication on safety grounds is key, this may well explain why such students place the social element of fieldwork much higher than Geography students do. Interestingly, males place the social aspect of fieldwork higher than females in this study although it was not statistically significant. Upon further investigation, students believed that group bonding and teamwork fell under the guise of communication skills rather than the social aspects. Therefore, while they were aware and acknowledged the social dimension of fieldwork, they did not explicitly separate the two as lecturers did.

While students did see the social aspect of fieldwork as important, staff were often more direct and explicit in acknowledging the social dimension of fieldwork. Students who carry out geoscience fieldwork indicate a 'geographical reality' while expressing more social benefits such as feelings of belonging to a group and increasing their interactions with peers and tutors (Fuller et al., 2006; Marvelf et al., 2013). Lecturers believed that "*social and group bonding that you get on fieldwork…is actually a really important part of geography as a discipline*" (Lecturer [E], Geography). Lecturers noted this social aspect as being important for the overall student experience and an acknowledgement that fieldwork is "*not just about whether they can cite the physical laws of fluvial geomorphology back. It's much more about the whole experience nowadays*" (Lecturer [E], Geography). Fieldwork according to the lecturers in this study, believed it helped their students to develop a sense of community and helped to break the 'traditional barrier' between lecturer and student (Moore-Cherry, Healey, Nicholson, & Andrews, 2016). This breakdown of barriers is an important part of higher education if educators are to foster student engagement within a subject (Kahu, 2013) as Lecturer A recalls how they believe fieldwork facilitates this.

> You get to know your peers in a different way … you may sit in a lecture theatre with them, and over the three years, you might build up a relationship but going away in the first year for a week or whatever kinda' builds that group identity and sense of community. You see staff in a different light, you sit with them at meal times, you probably go the pub in the evening, and you see that different side to them, and you realise actually, they are people, they're not just a distant presence up there at the top of a lecture theatre.
>
> (Lecturer [A], Geography)

While social bonding and this break down of barriers can be achieved in the classroom it is often accelerated in a fieldwork setting as noted by Lecturer A. Fieldwork, therefore, has more extending learning development opportunities than just the fundamental learning of a specific subject. Fieldwork prides itself on the development of extra skills that students gain which makes them some of the most employable disciplines in higher education (Lyon, 2017).

3.4.3 Enhanced Skill Development

Skill development is one of the key aspects of fieldwork to develop not only the practical skills such as data collection and use of specialised equipment but also develops the interpersonal skills (Kent et al., 1997; Boyle et al., 2007; Krakowka, 2012).

Solving problems and working in teams effectively are just some of the graduate attributes that geoscience fieldwork often develops (Hill, Walkington & France, 2016). Concerning employability, it gives the students the "*opportunities to solve problems to develop those hands-on doing stuff skills so that they don't graduate as monotonic robots*" (Lecturer [B], Geography). How fieldwork fosters such skills is often due to being away from the classroom and at times access to tutors. Students, therefore, are forced into solving their own issues out in the field, which develops their independence and teamwork skills as one lecturer explains:

> If your equipment breaks what do you do next? How do you fix this if you've got no one to ask? You've got to think for yourself, and that's one of the things, one of the skills we try and develop with the students.
>
> (Lecturer [E], Geography)

3.4.3.1 Soft Skill Development: Problem Solving, Team Work and Communication

Students badged the social element of fieldwork within the soft skills element of fieldwork. Students except for females, LJMU students, and level 4 students (ranked 3rd) placed the development of problem-solving and team working skills as the 2nd most import aspect of fieldwork to them. Problem-solving can be argued to be a core concept of fieldwork as it "*allows them [students] to solve real-world problems rather than hypothetical ones*" (Lecturer [E], Geography) and is embedded within the learning theories of experiential and situation learning as discussed previously. Problem-solving skills is an aspect of fieldwork that is often in the forefront of fieldwork design for lecturers. Lecturer D summaries how they designs fieldwork tasks in order to facilitate this development of problem-solving on fieldwork for his students:

> I set them a problem or a task and series of tasks, so they have a little bit of guidance, but you want them to go off and quickly become independent and face these problems that you know are there, but they don't.
>
> (Lecturer [D], Outdoor Education)

Problem-solving, therefore, is an important aspect of fieldwork trips in today's higher education. Hung (2002) believes that problem-based learning in the delivery of courses helps a student to gain a higher, deeper, and more productive level of thinking along with communication and negotiation skills. For *Technical Skill Development*, such as data collection and use of specialist equipment, females place this as second most important as do Level 4 students, the rest place it at 3rd most important whereas males place this as 4th most important. Practical hands-on skills such as the use of specific technical equipment and questionnaire and interview techniques are important, not only to develop critical skills relating to the course, but they also increase their independence in complex data gathering which may be used in future employment (Ritchie, Lewis, Nicholls & Ormston, 2013).

Technical and specialist skills are often subject and fieldwork specific, but they can be from the use of handheld GPS equipment to more specialist equipment such as spectrometers.

3.4.4 Fieldwork Enhanced Employability

Such skills that have been mentioned above as being developed during fieldwork are often skills that are deemed desirable by employers (Hill et al., 2016). Graduate attributes such as teamwork, communication, self-reflection and independent problem-solving skills, are all at the heart of today's field courses (Spronken-Smith et al., 2016). Ninety-three percent (n=82) of students agree or strongly agreed that fieldwork increased their employability skills, Fig. 3.4. This high rate of agreement is also reflected in graduate employability figures as in 2014/15 Destinations of Leavers from Higher Education (DLHE) survey; geography graduates were less likely than any other social science graduates to be unemployed at 4.9% (DLHE, 2016).

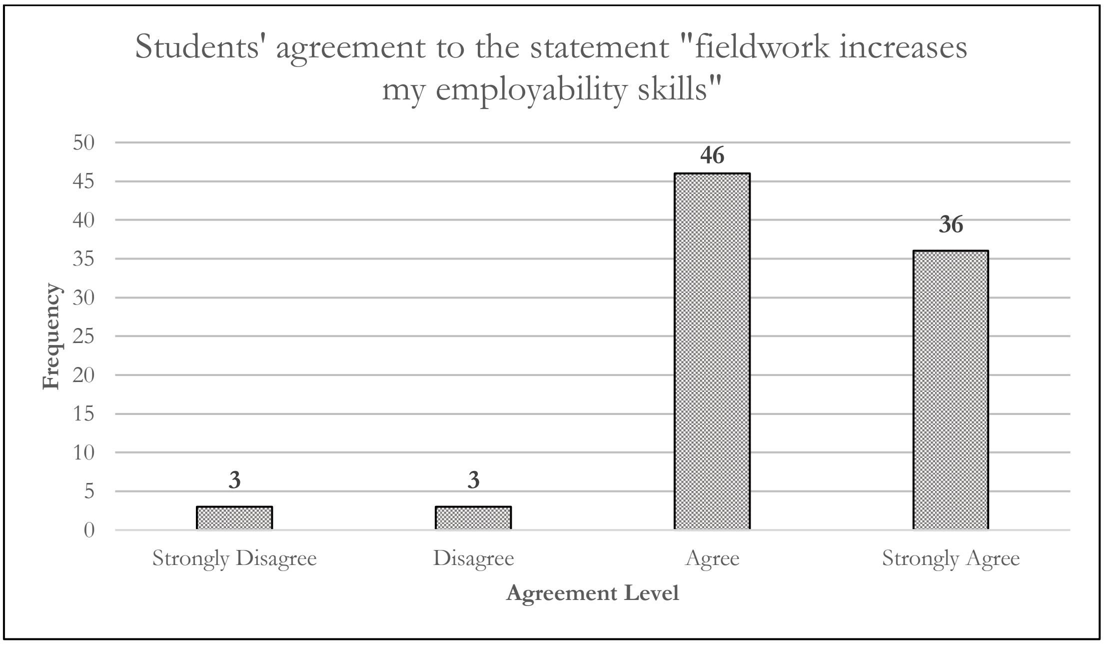


Fig. 3.4 - Agreement to the statement, "Fieldwork increases my employability."

One lecturer determines why he believes fieldwork makes his students so employable:

> …Someone with some common sense, the ability to be able to think before they act and to plan, and design, and execute, and do something which is methodical. That sort of skill is what you get by doing fieldwork and doing practical work… that's one of the competitive advantages that geography has over other disciplines.
>
> (Lecturer [B], Geography)

3.4.5 Summary Of The Advantages Of Fieldwork

Thus far, this chapter has explored the learning theories underpinning fieldwork and has explored the many advantages it offers both students and educators. The data in this research supports established literature which suggests that fieldwork is not only important to staff and students but provides an environment to enhance learning, skill development, foster social belonging and breakdown of student staff barriers along with employability potential. Nevertheless, some evidence in this research has emerged that not all aspects of fieldwork are positive.

3.5 The Negative Aspects Of Fieldwork

There are some significant negative impacts that fieldwork can have on both staff and students that have emerged from this research. These challenges can range from the practical elements of fieldwork such as resources, travel and staff time, to the more deeply ingrained issues around student disability, mental health, and student well-being. Established literature on fieldwork often paints fieldwork in a very positive light for staff and students, often citing some of the positive findings as outlined in this study thus far. However, while some contradictory literature exists on the negatives of fieldwork, it is by far more weighted to the positive. The rest of this chapter now focuses on the negative aspects of fieldwork that emerged from the interview data with staff and students.

3.5.1 Student Pressures

Issues surrounding student pressures and student health and wellbeing was a recurring theme arising from the data when discussing the negative impacts of fieldwork. All lecturers acknowledged that not all students are as positive about fieldwork as established research (Kent, et al., 1997; Boyle et al., 2007; Dunphy & Spellman, 2009) suggests. A typical response of lecturer views on students and fieldwork is as follows:

> Some students they get quite anxious about the unfamiliarity of going out in the field, certainly if it involves residential or overseas that there was a bit of nervousness about that. Some students certainly don't like that, so it isn't for everybody.
>
> (Lecturer [B], Geography)

The student experience is often a very important part of any degree in today's higher education system (Tomlinson, 2017). It became clear that lecturers often believed that these negative opinions from students around fieldwork were often due to the student being anxious or concerned about being away from home or in an unfamiliar environment. One lecturer believes the issue is as simple as "*some hate it because they don't like getting up early, they don't like sitting on a bus, they don't like being away from home so … they're out of their comfort zone*" (Lecturer [E], Geography). However, more severe issues of anxiety or nervousness in students can be from a fear of being away from support networks.

3.5.1.1 Student mental health and wellbeing

Mental health of students and their wellbeing is becoming increasingly more prominent to staff and is now a much more discussed subject within higher education (Richardson, Elliott, Roberts & Jansen, 2017). One report by the Higher Education Funding Council for England (HEFCE) stated that there had been a 220% increase of students with a known mental health condition since 2010-11 (HEFCE, 2017). Lecturers recognise that some students have such issues and have mechanisms in place to offer pastoral care on fieldwork and to offer alternative field trips for such students to alleviate such concerns.

> Some students have got such severe anxiety that they don't want to go on field trips. So we'll give them an alternative; otherwise, we would give them their own room or ensure they can share with somebody they're close to or happy to share with.
>
> (Lecturer [B], Geography)

There are issues however about alternative field trips and digital alternatives such as virtual field trips, which often fail to recreate the experience in a different setting (Cliffe, 2017). Further issues arise due to the extra demands on resources and costs to departments to create or support such alternative field trips. In addition to this, often university lecturers lack sufficient mental health training and provisions to adequately deal with such challenges (Universities UK, 2016). This lack of provision was reflected in this research with the lack of guidance to disabilities on fieldwork as discussed more in section 3.5.2.

3.5.1.2 External commitments of work and finance

One issue that arose from this data that is rarely investigated in research is the acknowledgement that students often work during term time and therefore, it can often clash with jobs and be significant pressure for students. In 2013, the insurance provider Endsleigh in partnership with the National Union of Students discovered that 57 % of students worked alongside their fulltime university degree (Richmond, 2013). This poses a challenge for some students especially for residential field trips that can often be for a number of days away at a time. Further issues arise when students are combining degrees as "*the different combinations of degrees [means] timetabling residential fieldwork can be a challenge*" (Lecturer [C], Geography). This timetabling issue can often put pressure on students if they miss part of their other courses and often have to catch up in their own time or miss out entirely on their learning.

Pressures on students can also be financial rather than the personal. While the departments interviewed paid for all compulsory field trips from the departmental budget, there was an acknowledgement that the financial cost of some fieldwork can be a "*big pressure when you might not be able to afford it*" (Lecturer [E], Geography). This often manifested itself in the form of students not being able to afford adequate clothing or equipment. Thus, it can potentially create inequality for those who cannot afford such items or cannot contribute financially towards the cost of field trips and therefore either miss that extra experience and learning, as outlined by Fletcher & Dodds (2004), or feel disadvantaged compared to their peers.

3.5.2 Disability On Fieldwork

Alongside mental health issues, disability on fieldwork is that a physical or mental disability is something that traditionally Geoscience degrees have not had to contend with. Geoscience degrees have often had a poor uptake of students with disabilities due to the nature of the physical activities of fieldwork. Nevertheless, in recent years there has been "*a lot more students with some form of disability both physical and mental*" (Lecturer C], Hazards) entering into Geography. Overall, disabilities in Higher Education is on the rise with 56% more students in 2017 having a known disability than in 2010-11 (HEFCE, 2017). Such disabilities can be a barrier regarding "*equality for students and accessibility*" (Lecturer [D], Geography) and a challenge for departments "*in terms of legal requirements*" (Lecturer [C], Hazards).

Many disabilities in students in Higher Education today are in the form of diagnosed dyslexia, dyspraxia or Attention Deficit Hyperactivity Disorder for which many are supported through the receiving of grant money from the Disabled Students' Allowance to help with equipment and pastoral support (HEFCE, 2017). The issue of having physically disabled students on a field course, particularly overseas, is a challenge for staff in terms of ensuring the student's safety while on fieldwork as outlined below.

> The international [fieldtrip] there is that unsurety. You don't know if [there was an issue] on top of Mount Vesuvius, how you get out of the situation? I mean we plan for it, but it's always a barrier in terms of language, and you know you're not going to get the same response times as you'd get in the UK.
>
> (Lecturer [C], Hazards)

While the safety of their students was apparent as a top priority for all lecturers, there was a deeply rooted concern held by Lecturer C that should something happen to a disabled student on fieldwork; the University may deem it too risky and therefore pull the entire field trip. This stance would impact not only the disabled student but also the entire cohort and potentially the course itself. While not as explicit from the other staff members, there was a concern due to a lack of guidance about how to incorporate and safeguard disabled students on fieldwork. This concern can potentially be down to, as Universities UK (2015) report, departmental staff lacking sufficient training in this regard. Lecturer C stated that;

> For the university and you know [University name] might be a little bit more risk averse than some Universities and as such, if something goes wrong, you do worry are they going to pull the field trip. So there is that always playing in the back of your mind.
>
> (Lecturer [C], Hazards)

How universities view disabled students and how much risk they attribute is different to each institution. While it cannot be assessed here, it does raise the question that if a non-disabled student happened to become injured on fieldwork would the lecturer be so concerned that the university in question would pull the field trip? Despite this challenge of lack of clear guidance, from the interviews in this study, there does seem to be a desire to include and help disabled students but a distinctly implied acknowledgement that disabled students do require 'more work' and therefore have added risks for fieldwork.

This does not mean, however, that lecturers in this study are trying to distance or exclude such students; in fact, the opposite has occurred despite the lack of institutional guidance. Regardless of these concerns of accessibility, risk and provision, all lecturers had plans to include disabled students in their fieldwork but approached this differently, even within their respective departments. Lecturers would often try to where possible include such students on the original field course in some manner. If this is unfeasible, all lecturers referred to offering students alternative field trips or, in one case, changing the entire field trip in order to accommodate a disability as she recalls a time when this occurred.

> When I was at [University name], we had a student who was in a wheelchair, and our usual field trip was you know a walk up a mountain, so because we had that student with us, we changed the entire field trip to accommodate that student. We did that around a lake which had a boardwalk so that it went around it…the following year we reverted back to the walk up the mountain.
>
> (Lecturer [E], Geography)

Changing an entire field trip could potentially change the nature and the reason and objectives that were initially planned for the students. While this may be the case for some field trips, Lecturer E does not "*feel that disabilities or accessibilities or lack of accessibilities would hinder students overall because ultimately as long as those learning goals are met in some way, then that's fine*" (Lecturer [E], Geography).

While changing an entire field trip may be a radical move, other lecturers have tried softer approaches to inclusion. One lecturer encourages where possible to open a dialogue with students. In this process, it gives the student ownership of their disability while alleviating such issues of anxiety by empowering the student to make their own decisions and not to feel forced into the original trip, as alternatives are available. However, these extra provisions or alternative field trips take more time, resources and costs to be achieved and as such, it is a significant burden to staff and departments. Therefore, if a student with a disability could explore the field site virtually then this may well go some way to reducing that inequality and divide for students. As such, this is a crucial reason for the development of the EVFG in this study and explained in Chapter VI & VII.

3.5.3 Practical Barriers To Fieldwork

While apprehensions raised by lecturers around student pressures and welfare were a concern, there are some practical challenges of fieldwork that can also be a significant barrier. Such practical barriers that were raised by staff where time, costs, resources, and student engagement.

3.5.3.1 Time on fieldwork

The issue of time or a lack of time often came up in discussion with lecturers. This concern of time ranged from the issue of finding time for staff, to the issue that fieldwork and its process is inherently time-consuming. Some staff "*don't want to commit to having to do it every single year at the same time [as it] is quite a big ask*" (Lecturer [D], Outdoor Education). For other lecturers, the issue of time of fieldwork is that that time is not gained back and often has to take precedence over their core roles and responsibilities. As explained by the lecturer below, the act of participating on fieldwork does not absolve other duties such as marking and therefore can be a challenge to balance.

> The week-long field courses they're very time intensive for staff because you can't do anything else other than be teaching [there is] no other time for marking or preparation that week. So you still have to do all the work that you're supposed to be doing anyway even though you've been away for the week.
>
> (Lecturer [E], Geography)

The planning process of such field trips whether that be residential or half-day trips is the most significant barrier to some lecturers regarding time. For staff, this time is often spent "*recceing the field sites, making sure that there is enough for the students to do, health and safety, costing, all that takes time*" (Lecturer [E], Geography). Time is also an issue while on fieldwork as it is "*often a one-shot experience*" (Lecturer [E], Geography) for students and for staff due to often only visiting that location once on their course. Hence, there is a pressure to maximise the time out in the field. For Lecturer D, fieldwork is time intensive due to students not turning up on time, travelling to and from fieldwork sites as they outlined the challenges below of a typical fieldwork day.

> [The] Yorkshire [fieldtrip] so the clock starts ticking at 8.30[a.m.], and I've arrived at 8.15[a.m.], and I've got the minibus keys, and you know, unless you're very very lucky 80% of the students will be there by 8.30[a.m.], they won't necessarily be ready, but they'll be there, and there is always two or three 'Oh they're just coming now there is a taxi' [Laughs]. So there is always the clock is ticking all the time and you've got to get there, get kitted out, parked, travel problems if there is a hold up on the journey and all that so.
>
> (Lecturer [D], Outdoor Education)

Time was the number one barrier to all lecturers when discussing their issues with fieldwork. Lecturers constantly wanted more time and ways to maximise what time they have in the field with students. This reason formed one of the main basis for the introduction of mobile technologies as discussed in Chapter IV and formed one of the main reasons for the development of the EVFG as discussed in Chapter VII.

3.5.3.2 Cost and Resource limitations of fieldwork

Cost is a significant challenge for students, but it is also a costly affair for the department where the "*university sector [is in a] reasonably challenging time having to justify the money we spend and what we do with student fees*" (Lecturer [A], Geography). The majority of the budget of the departments that were interviewed was spent on compulsory fieldwork. This complaint can be rectified if compulsory field trips costs are placed onto the student. For the departments interviewed at these two Universities there is a belief that compulsory fieldwork should be paid for by the department as "*if the costs was put onto the students, we feel [they] already pay enough*" (Lecturer [A], Geography). Consequently, there is a challenge to get the balance between the institution and student funding right and the associated burden of placing that pressure on the student or the department.

The cost element also manifests itself regarding resource provision on fieldwork be that for staff resources or physical resources and equipment. Often this appeared in the interviews of lecturers working with limited resources or being constrained by this for example "*I don't think it's a case of can't do more but like every other thing there are limitations in terms of resources*" (Lecturer [B], Geography). This resource issue is also when it comes to staffing and student numbers as "*on overseas residential you're going to get them into smaller groups, then you're going to have to get a suitable number of staff to get them to facilitate*" (Lecturer [B], Geography). Such practicalities are also born out of the need for gender balance and representation for staff on fieldwork with students.

> We'd like to have neutral gender representation of staffing on a field trip …and that is a challenge because currently, our staffing gender balance is not 50-50…So we end up taking a female technician or a female post-grad to try and even out and make sure, but that is a challenge that I don't think that should be overlooked.
>
> (Lecturer [B], Geography)

As such, resource requirements do dictate the scope of field courses and can often be a hidden barrier. As mentioned by one lecturer above, such issues as time and resources are challenges that students do not necessarily see or appreciate. Such practical issues are also rarely reflected in the positive literature of fieldwork.

3.5.3.3 Fieldwork Fatigue

One lecturer raised the concern that too much fieldwork could be a bad thing. Fieldwork, as has been demonstrated, is a very useful tool to help students learn but it must be in conjunction with other methods such as traditional lecture-based exercises as students "*wouldn't want [fieldwork] all the time and I'm sure you wouldn't, you get fed up with everything…in the end you do want variety*" (Lecturer [D], Outdoor Education).

This was also reflected by another lecturer who believed that fieldwork did have a challenge in trying to keep it new and relevant to his students as "*Ultimately there becomes a bit of fatigue when you say sketch that again or count 50 of them stones over there and compare them to those 50 stones over there and they're like 'Oh we did that' so you know it can get a little bit repetitive*" (Lecturer [B], Geography).

3.6 CONCLUSION

This chapter has continued to show that fieldwork is still a meaningful and effective use of student and staff time and is still a vital learning tool for geoscientists. Students and staff alike are keen to stress the benefit of fieldwork that enables them to get out into the environment to facilitate the transition from textbook knowledge into practical knowledge, something that classroom-based activities may struggle to recreate. This chapter supports the many findings of established literature that fieldwork supports skill development and students notice this too along with the ability for fieldwork to enhance their employability skills.

However, this research also brings to light the darker side of fieldwork and just some of the significant challenges fieldwork faces. That can range from disengaged students to highly complex physiological and psychological issues in students that can make fieldwork a challenge. Staff time and the pressure fieldwork places on it along with the many issues associated with cost continue to be barriers in today's higher education system. The issue of student health, wellbeing and disabilities are distinct new challenges for the discipline to address. Technology may go some way to help this issue, but departments cannot wait to act, they must act now.

It is hoped that through highlighting these issues further research and discussion can be opened to share best practice in how best to combat these issues to ensure that fieldwork is accessible and inclusive to every student so that students can continue to reap the many benefits that fieldwork offers. While fieldwork is undoubtedly overall a very positive and worthwhile learning experience, it is not an educational Utopia as literature in this field often suggests. Some distinct challenges need to be addressed in fieldwork, and more research is needed to understand the pressures and challenges that students and staff face when it comes to fieldwork.

Despite these distinct challenges, fieldwork continues to be a worthwhile and a vital core component to the student learning experience of any geoscience degree. This Chapter has completed the first part of the first aim which was to enhance the understanding of the role fieldwork plays in learning about geoscience in higher education. What has not been addressed in this chapter, although alluded to during the history of fieldwork section, is how technology has advanced rapidly in recent years, as per the second part of objective one. Such rapid expansion in technology has affected and continues to affect the delivery and learning on fieldwork. Technology on fieldwork has been used to significant effect in both a positive but also a negative light. Therefore, the following Chapter IV: *Mobile Technologies in Fieldwork* discusses this advancement in technology and evaluates how such technologies are now used in fieldwork in relation to that discussed here.

CHAPTER IV: MOBILE TECHNOLOGIES IN FIELDWORK

The previous chapter discussed the history of fieldwork and the many advantages and disadvantages of it as a learning tool for students and staff. As alluded to in the previous chapter, technology has vastly altered the delivery of fieldwork and therefore, has affected learning in fieldwork in a variety of different ways. Fieldwork today has been influenced by technology use and this has changed how educators educate and how students operate on fieldwork. This chapter advances the discussion from the previous chapter to evaluate fieldwork through the lens of mobile technology use. This chapter will answer the second part of the first aim which is "*To enhance the understanding of the role fieldwork* ***and mobile technologies*** *play in learning about geoscience in higher education*". The chapter begins by outlining the development and introduction of mobile technology use on fieldwork. A small methods section will outline what questions were used to evaluate technology use in this research. This leads onto an exploration of mobile technology use in fieldwork by students assessing the advantages and disadvantages that such technologies have for learning on fieldwork a small concluding conclusion.

4.1 THE CHANGING NATURE OF LEARNING WITH MOBILE TECHNOLOGIES

With the rapid expansion of the internet from 1989, technology has followed suit to keep pace with its advancements (Peter, 2004). Due to this rapid increase and changes in technology, there is a need for educators to keep pace also (Cornelius, Marston & Gemmell, 2011). The need for this upkeep in pace is because students today have access to mobile devices that are more powerful and more resourceful than traditional desktop computers (Guy, 2010). Examples of mobile technologies are smartphone, tablet computers and small laptop computers (Shih & Mills, 2007).

Mobile technologies such as smartphones and tablet computers have rapidly developed to meet the ever-growing demand from consumers of which students are a key market (Caudill, 2010). There has been a plethora of different makes, models, purposes, designs, and prices of such items (Cornelius et al., 2011). This has led to a vast array of technologies to choose from with every budget catered for (Ovens, Garbet, Heap &

Tolosa, 2013). The reason that mobile technologies are so important to fieldwork is that they have immense pedagogic potential if employed correctly in an education setting (Norris, Akhlaq & Soloway, 2011).

Technology is rapidly improving in both usability and affordability and this provides a basis for their inclusion in fieldwork (France & Ribchester, 2004; King, 2011). Mobile technologies have been demonstrated to good effect in fieldwork through the use of podcasting, digital videos, remote sensing from tablets, geo-tagging and annotations, to list but a few (Jarvis & Dickie, 2010; Fearnley & Bunting, 2011; Welsh, France, Whalley & Park, 2012). Fieldwork is starting to move beyond the traditional methods of data collection in both the physical and the human aspects of geoscience (Medzini, Meidshar-Tal & Sneh, 2015). There has also been an abundance of new educational applications and software for students to use on both the desktop computer and their mobile devices. From the technical aspecsts such as ArcMap and portable GIS software, to more basic online tools such as Digimap and Ordinance Survey online maps (Spronken-Smith et al., 2016).

4.1.1 E-Learning

The introduction of mobile technologies have given rise to the term 'E-Learning'. E-Learning can be defined as "*electronically mediated asynchronous and synchronous communication for the purpose of constructing and confirming knowledge*" (Garrison, 2011, p. 2). E-Learning opens up the use of technology to mediate and communicate knowledge through a three way connection between the wider global community, the students themselves and the learning material, all while not being tied down to a fixed location (Cornelius et al., 2011). E-learning means that students can access information and learn outside of the traditional paradigms of the classroom environment (Sung, Chang & Liu, 2016). This has proven to be particularly beneficial to off campus students either through work arrangements or through disability (Dahlstrom & Bichsel, 2014). E-learning further allows the tutor to be creative in their delivery of the learning material through interaction and bringing the material to life (Castillo-Merino & Serradell-Lopez, 2014). The reason this teaching method is important to employ is that today, 95% of students aged 16-24 in the UK in 2018 have a smartphone device (Statista, 2018). However, due to this increase in mobile technology of students, *M-Learning* has started to replace E-learning.

4.1.2 M-LEARNING

Mobile Learning or commonly referred to in literature as M-Learning is a form of distance education where learners access a variety of educational tools for learning through a mobile device (Park, 2011). M-learning is a relatively new and emerging way for mobile technologies such as smartphone and tablet computers to support and enhance the continuing learning process of students (Motiwalla, 2007). M-learning as discussed by Georfiev, Georgieva & Smrikarov (2004), is an extension of E-learning as discussed in the section above and can be defined as "learning across multiple contexts, through social and content interactions, using personal electronic devices" (Cochrane, 2013. p. 24). M-learning has emerged due to the increase in availability of mobile and wireless communication devices, which has created the ability of 'just in time' learning (Peters, 2007). This is due to as described by Klopfer, Squire, Holland & Jenkins (2002) the five educational benefits of mobile technologies being Portability, Social interactivity, Context sensitivity (the ability to collect real time and simulated data), Connectivity (sharing of data between devices or networks) and Individuality (a unique scaffolding of learning that is customisable by the learner).

While E-learning is the creation and access of educational information online, typically this involves access via a laptop or desktop or in some cases, still used as blend of the traditional and technology based classroom environment (Evans & Fan, 2002). M-learning, has many different definitions in literature, however, one central reasoning of M-Learning is that it takes the ideas of E-learning such as continued learning access, the students ability to pick and choose when and how to access such learning, and the ability for peer interaction but M-learning enables this to be done on the move (Evans, 2008). M-Learning has developed new ways of learning that are different in part to that of E-learning due to the increase in mobility of students and increasing informal education opportunities in higher education.

Danaher, Gururajan & Hafeez-Baig (2009) proposed that M-Learning has three core principles, *Engagement, Presence,* and *Flexibility.* M-learning has had various models and proposals of how it fits into the learning experience of students. From three-level framework by Vavoula & Sharples (2009) which focused on the macro level of the institutional issues of mobile technology, the meso level of the learners experience and lastly, the micro-level of usability. Conversely, Parsons, Ryu & Cranshaw (2007) offered a more complex framework that looked in four key aspects of M-Learning they are; (1) Learning Objectives, (2) Learning Experiences, (3) Learning Contexts and finally, (4) Generic Mobile issues. Nevertheless, research in this area has often focused on how the device can enable and enhance such learning in students not only in education but also in the workforce (Wagner, 2005).

4.1.3 Advantage of M-Learning over traditional and E-learning

Where M-Learning comes into its own is when the traditional aspect of learning is viewed through the lens of time and space (Kearney, Schuck, Burden & Aubusson, 2012). Learning traditionally has been defined and understood through the formal learning that takes place in a physical location, a classroom (Park, 2011) or E-learning where the learner is tied down to a desktop or laptop computer (Corbeil & Valdes-Corbeil, 2007). Often, this traditional view of learning has a temporal setting to which formalised learning occurs during time slots for example from a standard school day to one-hour lectures (Traxler, 2009). M-Learning, however, is not bounded by this physical location, nor the same temporal restrictions as E or traditional learning (Ling & Donner, 2009). As advocated by Luckin (2010), M-learning promotes different levels of informal learning from self-regulated student learning in their own time to more structured educator led experiences.

It can be argued that M-learning has further been developed in three stages (Sharples, Arnedillo-Sánchez, Milrad & Vavoula, 2009). As mentioned previously, there has been a focus on the mobility of the learner that is no longer fixed to a geographical space such as the traditional classroom (Pachler, Bachmair, Cook & Kress, 2010). There has been an increase in focus on learning outside of the classroom environment (O'Malley, Vavoula, Glew, Taylor, Sharples & Lefrere, 2005), and a focus on the development of mobile technology devices enabling such new avenues of learning to occur (Traxler, 2009). As such, M-Learning has benefits for educators in the classroom but also for their learners.

M-learning examples in the classroom can be from the use of mobile devices to be used during a lecture to enable group participation, individual learning motivation and provides a virtual environment to get immediate feedback and discuss ideas (El-Hussein & Cronje, 2010). M-learning has been shown to have many advantages (Baran, 2014). The main benefit of M-Learning is the learners' ability to access their learning at any time and location, which increases motivation and attainment (Sharma & Barrett, 2007). The ability for mobile devices to hold and access a variety of data such as videos, audio and images makes the learning process more engaging for the learner (Herrington, Herrington, Mantei, Olney & Ferry, 2009). Finally, as discussed in Chapter III, there is an increasing pressure on students, many of them have to fit their university degree around work, and therefore this offers them the opportunity to do so. M-Learning, however, can become a distraction in the learning process, there is a reliance on technology and issues around affordability and technical issues (Ozuorcun & Tabak, 2012), all of which are discussed in this chapter in relation to mobile technologies on fieldwork.

4.2 METHODS

Now that a brief overview of mobile technologies in fieldwork and education have been explored, the rest of this Chapter will evaluate a number of aspects of the data collected in this study compared to established literature. This includes what mobile technologies are used in fieldwork and an exploration of the advantages and disadvantages of their use for staff and students.

In order to investigate this, data is primarily used from the questionnaire and focus group with students. Staff interviews are also used in this section although their inclusion is limited. Questions were used in the questionnaire to establish a number of aspects of students' use of mobile technologies on fieldwork. For the advantages and disadvantages of fieldwork, the open-ended questions were most useful for the analysis and this is supported by quotes from the focus group and interviews. For breakdown of the sections of questions used can be found in Table 4.1.

Table 4.1: Questionnaire Questions to Evaluate Mobile Technologies

Question Category (n= number of responses)	**Question Type**
Mobile Technology Use	
(8) Do you own a smartphone? (n=91)	Dichotomous
(9) Do you currently use your smartphone for educational purposes i.e. for lectures or in fieldwork? (n=91)	Dichotomous
(9.a) How do you use your device for educational purposes? (n=91)	Multiple Choice
(10) Do you own a tablet device? (n=91)	Dichotomous
(11) Do you currently use your smartphone for educational purposes i.e. for lectures or in fieldwork? (n=91)	Dichotomous
(11.a) How do you use your tablet for educational purposes? (n=58)	Multiple Choice
Opinion	
(12.1) "I have a high level of competency with technology" (n=91)	Likert
(12.2) "Using new technology in fieldwork increases my skills and employability" (n=88)	Likert
(13) How likely are you to use your mobile technology device in fieldwork? (n=90)	Likert

(15) Would you encourage the use of institutionally owned mobile technology devices in fieldwork? (n=90)	Dichotomous
(16)How do you think mobile technologies can enhance your learning experience in fieldwork? (n=91)	Open
(17) How do you think mobile technologies can hinder your learning in fieldwork? (n=91)	Open
Concerns of Mobile Technology use	
(14) What concerns/issues do you perceive there to be when using mobile technology in fieldwork? (n=91)	Open

Throughout the following discussion in this chapter, quotes are used to support the data and the narrative. However, these quotes come from two sources, the open-ended questionnaire data and the interviews and focus groups. Therefore, in order to separate these a number of identifiers will be used to differentiate between them. Interview and Focus Group quotes will be displayed as per Chapter III, (Position A-E, Discipline) while open-ended questions will be displayed (Gender, Discipline, Level). A key is located in Table 4.2.

Table 4.2: Quote Key

Identifier	Meaning
Q	Questionnaire Quote
M/F	Male/Female
OE	Outdoor Education Student
G	Geography Student
GC	Geography Combined Student
4	Level 4 Student
5	Level 5 Student
6	Level 6 Student

4.3 SMARTPHONE & TABLET USE IN EDUCATIONAL AND FIELDWORK

This section sought to discover if students not only use mobile technologies in education and or fieldwork but to discover what devices are used and how.

4.3.1 SMARTPHONE USE

Mobile phone technology has increased rapidly since 2005 and as such, prices have fallen, yet technological enhancements have increased in terms of memory size, battery life, computer power and sensors (Pew Research Center, 2013). Such advancements have changed the way in which smartphones are used today and are used differently than the uses of a desktop or laptop computer (Norris et al., 2011). Smartphones offer a great potential for fieldwork and teaching due the high computing power versus their small size and weight (Oost, De Vries & Van der Schee, 2011). Today's smartphones have an array of applications and sensors built into them as standard. Today's smartphones will typically possess;

- Built in memory (which can often be expanded with an SD card)
- Connectivity (3G/4G, Wi-Fi, Bluetooth)
- Operating system IOS or Android (customisable)
- Internet browser
- Forward facing and rear facing camera to capture still and video pictures
- Gallery and editing software for the camera
- Built in accelerometers
- Built in accurate GPS

Due to this vast array of standard equipment on smartphones it has allowed a new way of learning that has not been present before (Kalyani, 2012). Smartphones are adaptable due to the vast array of free and paid applications that can be downloaded onto the device. Such applications have been designed to work with the devices to create a much more effective learning tool (Gikas & Grant, 2013). Many smartphones today come with some form of office suite, which allows word documents, note taking and even data inputting into a spreadsheet to be done in the field (Gallagher & Ihanainen, 2016). This saves time, is more efficient, and alleviates some issues with the weather and traditional paper notebooks.

Many other applications can turn the phone into a data collection device. Photographs, videos and audio recordings can all be collected on a smartphone. Yet, they can do much more with apps turning the phone into a pedometer, distance measurer, altimeter, weather station and even noise and pollution level recorders (Medzini et al., 2015). Smartphones are fundamentally a communication device, with such connectivity it is no surprise that one of the benefits of smartphones in fieldwork is the ability to communicate with other devices and to share information (Cornelius et al., 2011; Gikas & Grant, 2013). This can be done either via the internet, short field communications such as Bluetooth or through the sharing of social media and cloud storage (Goggin, 2012).

In this study, 100% of students stated they currently had a smartphone device. The most popular smartphone manufacturers with students are Apple (56%) and Samsung (24%). The two manufacturers are currently the market leaders in smartphone manufacturing. This means that for this sample, 56% had an IOS operating system and 44% had Android.

4.3.2 How Do Students Use Smartphones For Educational Purposes

While student ownership of mobile devices has increased rapidly, previous research suggested that student uptake and their use in their studies with smartphone devices was limited. Authors often cite a reluctance by students to use personal devices for education fieldwork (Fuller & France, 2014). However now in 2018, 88% (n=80) of the respondents use their smartphone device for educational purposes. Students use their mobile devices for a number of ways in education as indicated in Fig. 4.1.

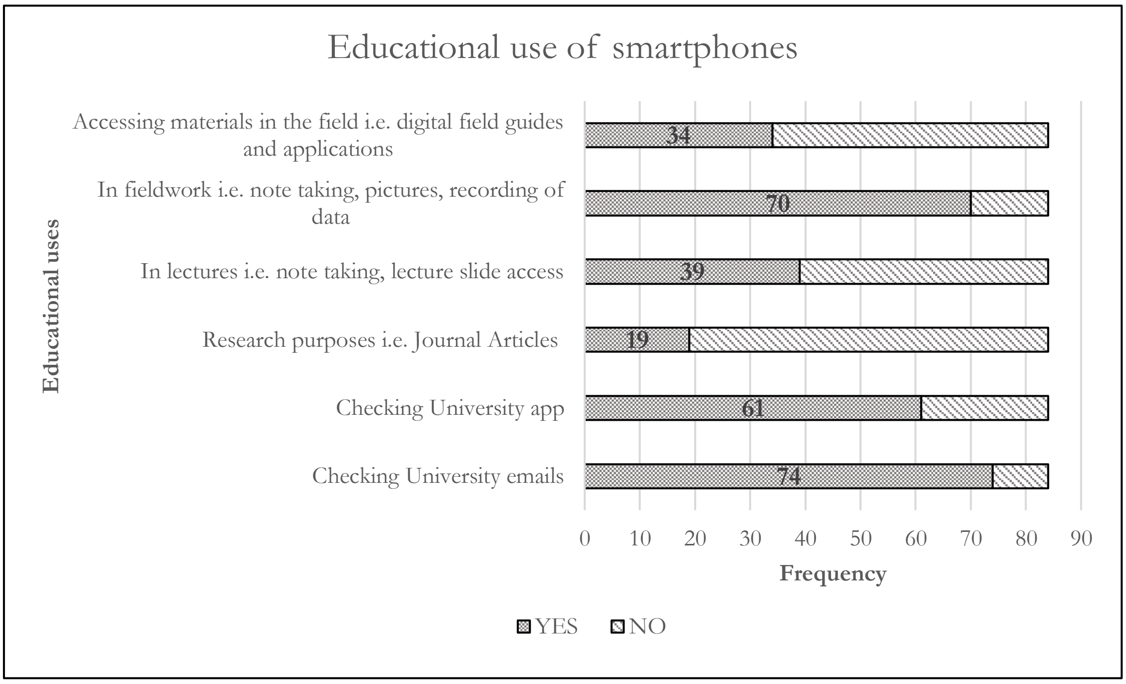


Fig. 4.1 - Educational use of smartphones

Two of the most popular reasons for using smartphones for education in Fig. 4.1 is for quick and easy access to a student's email account on the go 88% (n=74) while 83% (n=70) use their mobile devices on fieldwork to take notes and record pictures. This is encouraging as this is one of the main reasons for implementing mobile technologies on fieldwork. Despite their use in fieldwork, they are less commonly used for accessing materials in the field. Despite their use in the field as a collection tool, just under half of students 46% (n=39) use them in the lecture to take notes or access lecture slides. More investigation is needed to see if students use traditional methods such as notebooks to make notes or if they supplement their mobile device with laptops or tablets to make notes. Nevertheless, Outdoor Education students were less likely to use their devices to make notes in lectures compared to Geography and Geography combined students.

A chi-square test for association was conducted between student disciplines and using smartphones on to make notes in lectures. All expected cell frequencies were greater than five. There was a statistically significant association between Outdoor Education students and using smartphones on to make notes in lectures compared to Geography and Geography combined students, $\chi 2(2) = 7.717$, $p = .021$.

From this sample, students do not tend to use their devices for research purposes, despite them having access to the internet. While there was no significance reported on the use of smartphone devices being used on fieldwork across the variables, there is a significance reported with access to supporting materials on fieldwork by students.

A chi-square test for association was conducted between levels of study and using smartphones on fieldwork to access digital fieldguides and applications. All expected cell frequencies were greater than five. There was a statistically significant association between Level 4 students and them accessing digital field guides and applications compared to Level 5 and 6 students, $\chi 2(2) = 10.686$, $p = .005$.

4.3.3 Tablet Use

As good as smartphones are, they are limited by their relatively small screen size and poorer battery life (Welsh et al., 2015). The smaller screen is a major disadvantage to the use of smartphones in fieldwork compared to tablets. Tablets with a larger screen allow the user to type more easily and allows more room for annotation on the touch screen using a Stylus pen (Godsk, 2013). Tablets operate on a similar basis of smartphones and often have the same or very similar operating systems meaning a commonality for the user between smartphone and tablet devices (Thorn, 2014). Tablets traditionally have more computing power than smartphone devices and therefore can run rudimentary but more computer intensive applications such as ArcGIS mobile and more familiar applications such as Google Earth (Jones, Alston, English, & Gayle, 2013).

Tablet computers often have Word, Excel and PDF readers installed, meaning that students can do away with paper copies and can use the tablet to carry everything they need for the fieldtrip (Tilton, 2016). As mentioned by Welsh et al (2013) mobile technology has its greatest impact on fieldwork through the data collection and analysis in the field. Tablet computers allow for this data collection in the field to be completed. While data can be collected on smartphones, the larger screen size is a better facilitator for this (Tilton, 2016).

In this study 44% (n=40) of students owned a tablet device in this study. Level 4 students in this sample where significantly more likely to own a tablet (62%) than level 5 or 6 students.

A chi-square test for association was conducted between levels of study and tablet ownership. All expected cell frequencies were greater than five. There was a statistically significant association between Level 4 students and owning tablet computers compared to Level 5 and 6 students, $\chi2(2) = 7.117$, $p = .028$.

For those who did own a tablet device, 67% owned an Apple iPad, Fig. 4.2. This is unspringing due to Apple being the market leaders in tablet computers with 25% of market share in Q1 2017 (Statista, 2018). The second market leader is Samsung (17% market share Q1 2017) and this is reflected with 13% of the share of respondents. Of the 39 who own a tablet device, 56% (22) of them use their tablet for educational purposes.

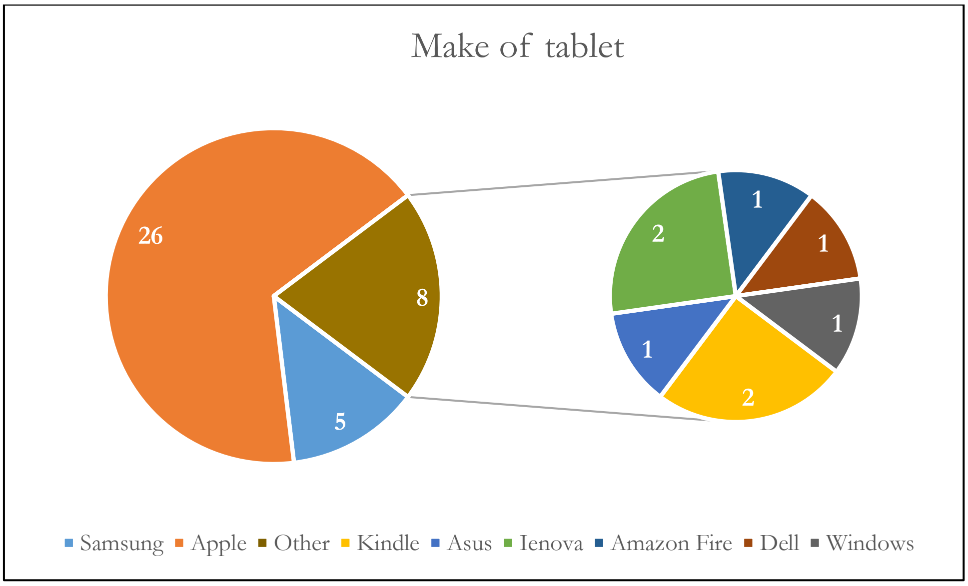


Fig. 4.2 - Tablet make of student ownership

4.3.4 How Do Students Use Tablet Devices

Thirty-nine students in this study used their tablet devices for educational purposes of which only 2 using this as their sole mobile technology use in education. 92% of those who use a tablet device for educational purposes also use their smartphone devices for the same purpose. Overall students used their tablet devices evenly across the educational uses, Fig. 4.3.

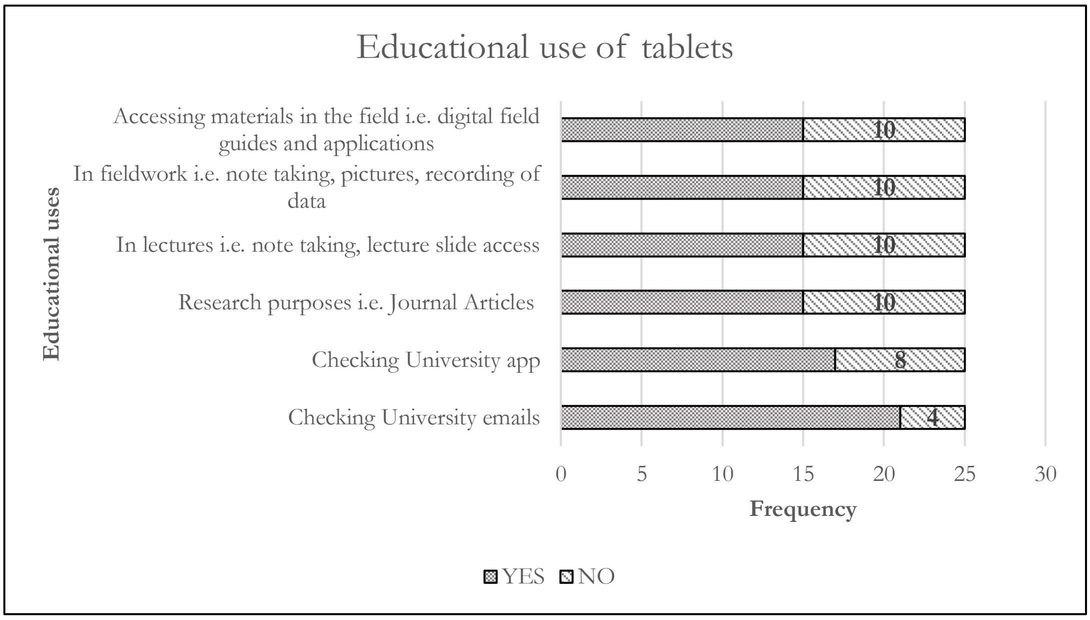


Fig. 4.3 - Educational use of Tablet Devices

4.3.5 Likelihood of Using Mobile Technologies in Fieldwork

While a high percentage of students indicated they use their devices for educational purposes, there was a high likelihood that students would use their devices on fieldwork, Fig. 4.4.

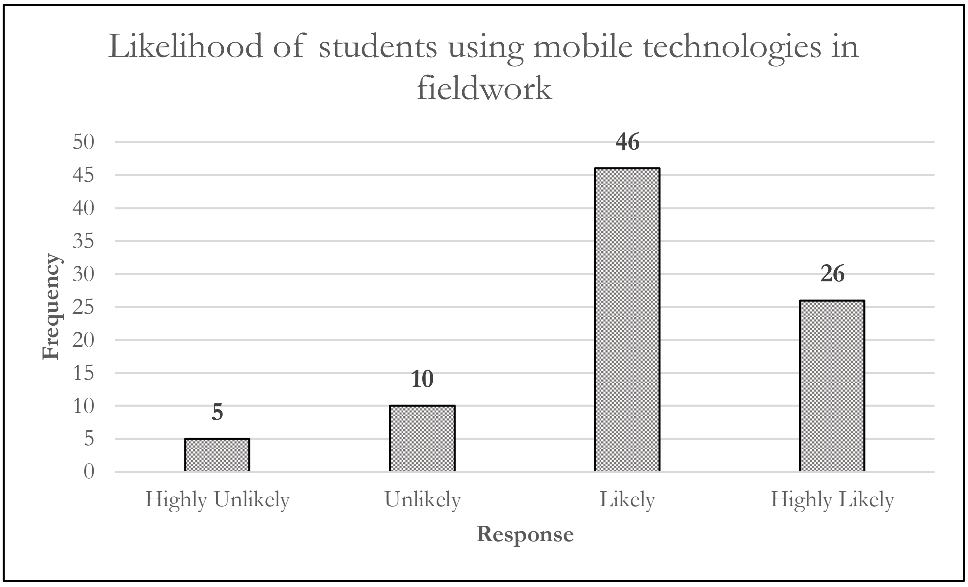


Fig. 4.4 - Student likelihood of using mobile technologies in fieldwork

This is positive as if students were unlikely to want to use their mobile devices on fieldwork then any attempt to use different methods would be limited if students were engaged with their use on fieldwork. With such a high percentage of students indicating a likelihood of using their devices, the researcher investigated possible reasons for this in the section below. Despite such positive likelihood of their use by students, the researcher wanted to investigate if this was across all variables in this study. While there was no significant differences between gender, level of study or university, Outdoor Education Students were statistically significantly less likely to use their devices on fieldwork than Geography Single Honours students p.001.

H0: There is no difference in likelihood of using mobile technology in fieldwork across student disciplines. A Kruskal-Wallis H test was run to determine if there were differences in Likelihood of using mobile technology on fieldwork score between [three student disciplines]: "Geography Single Hons" (n=33), "Geography Combined" (n=19) and "Outdoor Education" (n=38). Distributions of Likelihood of using mobile technology on fieldwork score were not similar for all groups, as assessed by visual inspection of a boxplot. The distributions of Likelihood of using mobile technology on fieldwork scores were statistically significantly different between groups, $\chi2$ (2) = 13.838, p = .001. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented. This post hoc analysis revealed statistically significant differences in Likelihood of using mobile technology on fieldwork scores between Outdoor Education Students (mean rank = 35.97) and Geography Single

Hons Students (mean rank = 57.03) (p = .001). There was no significant difference between other combinations.

Reasons for this difference has been explained in Chapter 3 section 3.4.3, where outdoor education students enter employment into practical and hands on professions such as mountaineering instructors. Due to this, they are less likely to need mobile technologies and therefore indicate more traditional hands on approach to fieldwork. Single Hons Geography students however do not share this view and instead have embraced technologies in their fieldwork. Nevertheless, both sets of students outline below how they feel mobile technologies can aid their fieldwork learning.

4.3.6 Technology Competence

High levels of competence were shown across the sample with 91% of students agreeing or strongly agreeing that their competency with technology was high, Table 4.3.

Table 4.3: Student agreement to the statement "I have a high level of competency with technology"

	Frequency	Percentage
Strongly Disagree	2	2.2
Disagree	6	6.6
Agree	51	56.0
Strongly Agree	32	35.2
Total	91	100

Of those who disagreed or strongly disagreed two where males and four females with two geography combined and 4 outdoor education students.

4.4 The Advantages Of Using Mobile Technologies On Fieldwork

> Mobile technologies are a gateway to a world of information, they have an app for any situation and are effective in a bunch of those situations, some more than others but I believe mobile devices make everything much more easy.
>
> (Male, Level 5, Geography student)

As summed up in the quote from a student above, mobile technologies can offer students many different ways to enhance their learning. Through the open-ended questionnaire which asked students how they perceived mobile technologies could enhance their learning, the most prominent enhancement was in their ability to be used for data collection (n=74). This was followed by their ability to access information in the field (n=27), the ability to store data securely and to share the data (n=27), along with perceived learning benefits to students such as making the fieldwork easier (n=27).

4.4.1 OLD METHODS, NEW TRICKS: ENHANCING DATA COLLECTION

Learning theories about technological use and the changing way in which students learn can often be complex and difficult to observe. Mobile technologies are updating old methods of teaching. A prime example of this in action, is how mobile technologies can enhance the traditional tool of fieldwork teaching, for example, the field notebook. The field notebook is a staple to any geoscience field trip, a tried and tested method of recording observations of a landscape (Kent et al., 1997). Field notebooks are important to hone the observational skills of students and for them to be critical in what they sketch or annotate for future reference (Kneale, 2014). The field sketch and the field notebook is one of the first fundamental skills a student on fieldwork will learn and it has been proven affective for many years (Kneale, 2014).

There are issues around this technique despite its popularity of use in fieldwork, such as a student's lack of drawing ability, missing vital information on the sketch and finally, one of the fundamental drawbacks is it does not capture the exact moment or scene in full detail for future reference (Haigh & Gold, 1993). This is where mobile technologies can come into play (Wills & Earley, 2013).

Mobile technologies makes this data collection process easier through the ability to take photographs, with 19 mentions of using photographic evidence by students on their fieldwork using such devices. Mobile technologies today often have sophisticated built in cameras (both still and video) with some exceeding the megapixels of bridge and handheld cameras (Hoang, 2010). Even the drawback of a lack of sufficient zoom on mobile devices has been alleviated by relatively cheap zoom add on lenses (Banerjee, 2016). Instead of a student sketching the immediate environs they can simply take a picture on the device. Photography has always been a core technique in Geosciences (Latham & McCormack, 2007) in both teaching (Sidaway, 2002) and research (Schwartz & Ryan, 2002). This photographic evidence is used by students to "*go back to again and again*" (F-OE4) and it allows a student to "*save time i.e. taking pictures to refer back to instead of sketches*" (F-G6).

Once on the device, the student can annotate the picture using a variety of different applications. A student can therefore add Geo-location data (e.g. Matiash, 2015), pin the image to a map (e.g. Welsh et al., 2012), include weather observations, timestamps, add video snippets and even add voice-recording overlays to the image (Kuzenkoff & Titsworth, 2013). The benefit to this is now it brings the traditional field sketch to life. A student still has to annotate and critically think about what observations to record, except now it is more data rich and accurate. One student elaborates on this point about the advantages that such technologies enable her over traditional field sketches as she explains that;

> If I could draw and had the time, I'd love to sketch a scene rather than take a photo but actually it's not as accurate and my photo tells far more words than any writing I could do.
>
> (Female, L5, Outdoor Education Student)

If the field sketch is still a vital part of the undergraduate fieldwork experience, then sketching can still be completed on mobile technology. Many artists today and especially graphic designers use mobile tablets as an effective way of creating images (France, Powell, Mauchline, Welsh, Park, Whalley & Rewhorn, 2016). Mobile devices can have drawing applications downloaded with many of them free or for a relatively small cost. By using either a finger or a more accurate stylus (a digital pen), a traditional field sketch can be created digitally. This means a student can share this between peers or devices and can be placed into a student's essay without the need for additional steps such as scanning.

Students are often required at a minimum to bring with them a paper field guide and a notebook. Using paper can be a challenge in inclement weather, which is often the case on UK based fieldwork (Earley & Wills, 2016). Some observations or data collection may be damaged or simply not completed due to having wet paper field guides and notebooks (Welsh et al., 2015). By using mobile technologies, it promotes a reduction in paper copies, their wastage and their cost to produce. Mobile technologies alleviate this problem through the ability to access the paper copies digitally. While 83% of students in this research use their mobile devices on fieldwork they indicated that one reason for this was for the purpose of note taking. Mobile devices makes for "*quick and easy note taking*" (M-G4) and allows other forms of written notes such as videos to be taken. This was supported by one student who explains the practical challenges of paper notebooks on fieldwork compared to the use of mobile technologies.

> …you can take notes and its rainy, wet, windy, whatever, having a piece of paper flying around trying to write is very difficult, plus you need something to lean on. So if

> I have a real flimsy book it's so difficult to write on whereas my phone I can type really quickly, has spell check and everything done for you.
>
> (Female, L4, Outdoor Education)

What this in turn allows is the ability for students to be more efficient in the field and more productive with their limited time on fieldwork. Students on the whole in this research believed that mobile technology enhanced their data collection techniques due to the ease and usability of the devices. Mobile technology "*enables data collection to be made easier*" (F-GC5) and this was highlighted by Welsh (2013) as one of the main drivers of implementing mobile technologies in fieldwork.

As discussed in the previous chapter, time constraints and maximising the time out in the field was the number one concern by staff on fieldwork. Therefore, mobile technologies are a useful tool in helping lecturers to maximise their time in the field to make students more efficient as using mobile technologies allows for "*instant research*" (F-G4) and can help students to "*develop and quicken the methods of some forms of fieldwork and data collection*" (M-G5). Mobile technologies can complete many different data collection tasks on fieldwork such as "*We didn't have to take loads of different equipment out into the field...students could analyse data when out in the field so that they could save time*" (Lecturer [E], Geography). While efficiency for data collection is a key benefit to using mobile technologies in fieldwork, as explained below it can make data for students more accurate and for them to make decisions in the field about their data, which they would not have been able to do without such technologies.

> [Mobile Technologies] saves a step for data entry when you get back to the lab…you know it's really useful doing it that way because you can have all of your information on there, your data collection spreadsheets. It can calculate your beach profiles as you go along…so you can see how your data looks in the field as opposed to having a series of measurements and not knowing till they get back to the lab whether that actually looks accurate or not and for supporting information as well you can put a PDF or a PowerPoint slide on there that will give them guidance on what they're doing what to look out for how to take their measurements.
>
> (Lecturer [A], Geography)

Saving time while data collection and particularly saving time post fieldwork in terms of data processing makes the fieldwork experience more efficient. Less time is spent processing and more time is spent learning. Having instant access to data on fieldwork through such technologies facilitates this increase in efficiency that traditional methods do not.

4.4.2 Information Access And Storage

One of the major benefits of using mobile technologies in fieldwork is for the ability of the student to access information immediately. While students use this information to "*get instant answers to questions*" (F-GC5) it allows deeper learning in the field through the "*ability to look things up and check them as you go to add more relevant information which you may not be aware of in the field*" (F-GC4). While access to information is easier through mobile technologies, it allows a student to store such information they have collected more securely.

Students referred to data collected on mobile technologies being "*harder to lose or damage*" (M-OE6) than traditional methods and to "*gather data and information while also being able to back this up, i.e. on the cloud*" (M-G4). The cloud is a network of remote servers hosted on the Internet and used to store, manage, and process data in place of local servers or personal computers (Mell & Grance, 2011). This use of the cloud is now common practice for smartphone users who often upload pictures and data to the cloud, most notably to OneDrive or Google Drive. The latter has been shown to be effective in education for students sharing data and completing assignments (c.f. Sadik, 2017). Not only does this have the benefit of being safer, it can be accessed from numerous devices rather than one thus, it allows students to share this information between others much more efficiently and safely than traditional methods. Again, this makes fieldwork more efficient for students not just on fieldwork but also post processing.

The application of cloud-based storage in conjunction with mobile technologies is changing the way in which some lecturers are going about their delivery of fieldwork. In the extract below, one lecturer describes plans to use cloud-based functions of mobile technologies to monitor students on fieldwork through their data collection phases. This can potentially replace the need for the tutor to be physically located onsite and opens up new avenues for fieldwork delivery and monitoring as they explain below.

> We're looking at doing something around campus and the student can update their [digital] field notebook and the member of staff actually, you know, we would go out into the field with them but there is an option where you can literally check up on Evernote on your desktop computer...so they send their field notebooks back to you and they will update and all the data goes through back to your main computer which I think is quite a nice thing.

(Lecturer [E], Geography)

Traditionally, students would share this data on paper copies with other students and staff members. Technology now, as shown in the extract above has the potential to radically update old methods of fieldwork practices.

4.4.3 Enhanced Learning

What the above can be summarised into is in mobile technologies enhancing student's learning through a number of ways. It has shown to make fieldwork easier, enhances student's situational awareness, knowledge creation and dissemination and can quicken up the whole experience. 27 students made direct reference to mobile technologies enhancing their fieldwork learning experience. One student believes mobile technologies make fieldwork "*more fun and interesting*" (F-G6) while another refers to how mobile technologies have allowed students with specific learning difficulties, to feel more inclusive and less hindered as it "*creates the ability [for a] student with dyslexia the chance to have a more interactive learning experience, even possibility could be classed as multi-sensory learning*" (M-OE6). As discussed in Chapter III, this inclusion of an increase in disabled students be that physical or mental is important for the discipline. Mobile technologies therefore have far greater accessibility reach for learning than the efficiencies outlined so far.

As mentioned by one lecturer in Chapter III was their goal is to develop students to be able to become independent in the field and to solve problems. One student alludes to technology helping them to achieve this as she comments that, "*I think mobile technologies enhance my learning in fieldwork as I am already familiar with the device and due to its easy accessibility, there is a higher chance I could complete fieldwork independently*" (Female, L5, Outdoor Education Student).

While independent learning is important, as mentioned in this chapter, mobile technologies can be beneficial for collaboration. This feeds into the positive skill development of teamwork and communication skills that already exist on fieldwork. Mobile technologies are taking the traditional fieldwork skills from interpersonal interactions to online. Despite students most likely to talk to their peers directly and the tutor to solve issues on fieldwork, 34% stated they seek this advice via social media.

Mobile technologies can make students more engaged in learning as "*sometimes students just having a laugh trying new things...their phone is and extension to their hands so if it is like* *that why not use it? So I think they engage well with it*" (Lecturer [C], Hazards). For others, it opens up new ways to engage students as "*we can use lots of different things…to engage students to make learning a bit more fun*" (Lecturer [E], Geography).

4.4.4 Increase In Employability Skills

As investigated in section 3.4.4 of Chapter III, fieldwork develops many skills that employers deem to be employable. Employers increasingly demand recent graduates to be technologically savvy (Mason, Williams, & Cranmer, 2009). Geoscience students are at an advantage already due to the many different specialist technologies used in their education (Owen, 2001). The ability for fieldwork to continue to facilitate the use of new and innovative technologies in fieldwork is acknowledged by students as being beneficial for their employment opportunities. For students, 41% (n=36) strongly agree that using mobile technologies in their fieldwork increases their employability skills, Fig. 4.5.

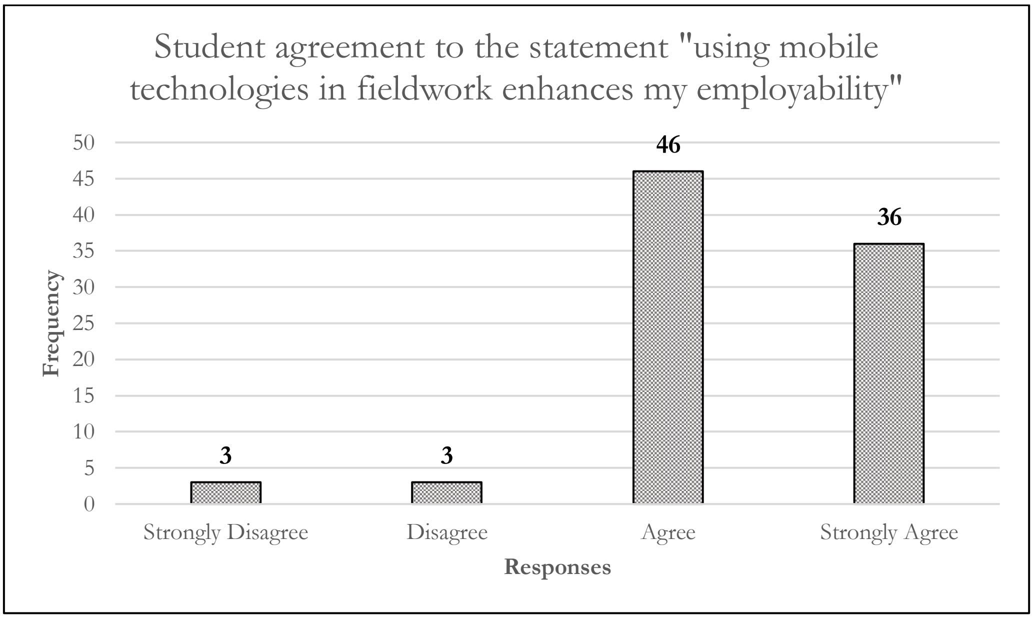


Fig. 4.5 - Agreement of students to the statement "mobile technology enhances my employability skills"

Despite the vast majority of agreement to mobile technologies enhancing fieldwork skills, the researcher wanted to investigate if Outdoor Education students who were significantly less likely to use mobile technologies on fieldwork did not do so because they did not see any employability benefit. If they did not, this would support the notion that such students are very hands on and practical in their career and fieldwork aspirations.

H0: There is no difference in agreement of using mobile technology in fieldwork enhancing a student's employability across student disciplines. A Kruskal-Wallis H test was run to determine if there were differences in agreement of using mobile technology in fieldwork enhancing a student's employability score between [three student disciplines]: "Geography Single Hons" (n=33), "Geography Combined" (n=19) and "Outdoor Education" (n=36). Distributions of agreement of using mobile technology in fieldwork enhancing a student's employability score were not similar for all groups, as assessed by visual inspection of a boxplot. The distributions of agreement of using mobile technology in fieldwork enhancing a student's employability scores were statistically significantly different between groups, $\chi 2$ (2) = 7.263, p = .026. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented. This post hoc analysis revealed statistically significant differences in agreement of using mobile technology in fieldwork enhancing a student's employability scores between Outdoor Education Students (mean rank = 37.54) and Geography Single Hons Students (mean rank = 52.27) (p = .021). There was no significant difference between other combinations.

As shown, Outdoor Education students in this study were less likely to agree that mobile technologies can enhance their employability skills. Outdoor Education students while Geoscience based are clearly different in their approach to fieldwork and technology than their mainstream geoscience peers. Therefore, such anomalies in the data of outdoor education students going against the trends of Geography and Geography Combined students can potentially put down to this different outlook on employability as discussed in section 4.2 of Chapter III. However, while results thus far confirm this, more empirical research is needed to fully understand the differences between these cohorts of students.

4.4.5 Summary Of The Advantages Of Fieldwork

Mobile technologies as supported by literature and the data in this study have many advantages to students and staff on fieldwork. Most notably in practical terms this has been demonstrated in the updating of traditional fieldwork skills and practices such as field sketches and note taking. Students have displayed a mostly positive attitude towards mobile technologies on fieldwork believing that they make fieldwork more efficient, makes data collection easier and for some, it has enhanced their perceived enjoyment and learning on fieldwork. Nevertheless, despite the positives of mobile technologies on fieldwork, there are some challenges as explained in the next section.

4.5 NEGATIVES OF USING MOBILE TECHNOLOGIES ON FIELDWORK

Students had many different concerns about using such devices on fieldwork. Concerns for students often varied but the four key areas that students identified as issues were, distraction, weather related issues, technology issues and finally, some practical challenges.

4.5.1 STUDENT'S CONCERNS OF MOBILE TECHNOLOGY

Students were asked to select which concerns they had about using mobile technologies on fieldwork, as predetermined from the literature. Their main concerns were around the practicalities of using such devices out in the field, specifically in inclement weather. 85% (n=77) stated that weather damaging the device was their number one concern (Fig. 4.6); this is a concern that was echoed by Welsh (2012) in her study of mobile technology use on fieldwork who found a similar concern from students. The students also voiced concerns around dropping or damaging the devices when out in the field with 85% (n=77) of students also stating this to be a concern. This was indicated in the study by Beddall-Hill, Jabbar & Al Shehri (2011) who evidenced student's reluctance to use institutionally owned mobile technology devices in the field due to the potential of damaging them. Females in this study were significantly more likely to state they had a concern of dropping the device than males.

A chi-square test for association was conducted between gender and concern of dropping the device. All expected cell frequencies were greater than five. There was a statistically significant association between female students and a concern of dropping the device compared to male students, $\chi 2(1) = 4.662$, $p = .031$.

Possible reasons for this can be that potentially females are more aware or concerned about dropping such devices compared to males. Interestingly, in the focus group with students one male student talked about and showed the researcher how he has developed his own makeshift device (a small elasticated material band that connected to the phone but also to two fingers) to ensure that he does not drop his device on fieldwork.

A quarter of students showed a preference for traditional methods rather than to use mobile technologies. Despite their common use and the suggestion in literature that all students are for and on-board with mobile technologies, this research suggests that this may not be the case that all students are keen on their inclusion. Unsurprisingly given Outdoor Education students reluctance to use mobile technologies on fieldwork, they were significantly more likely to prefer traditional methods than their geography counterparts, with 50% of outdoor education students showing to have this preference.

A chi-square test for association was conducted between student discipline and preference for traditional methods. All expected cell frequencies were greater than five. There was a statistically significant association between Outdoor Education students and a preference for traditional methods than Geography and Geography Combined students, $\chi 2(2) = 21.22$, $p = .000$.

Other concerns that students noted on this question for what concerns they had were more practical based, such as signal loss to using the devices with cold fingers, Fig. 4.6
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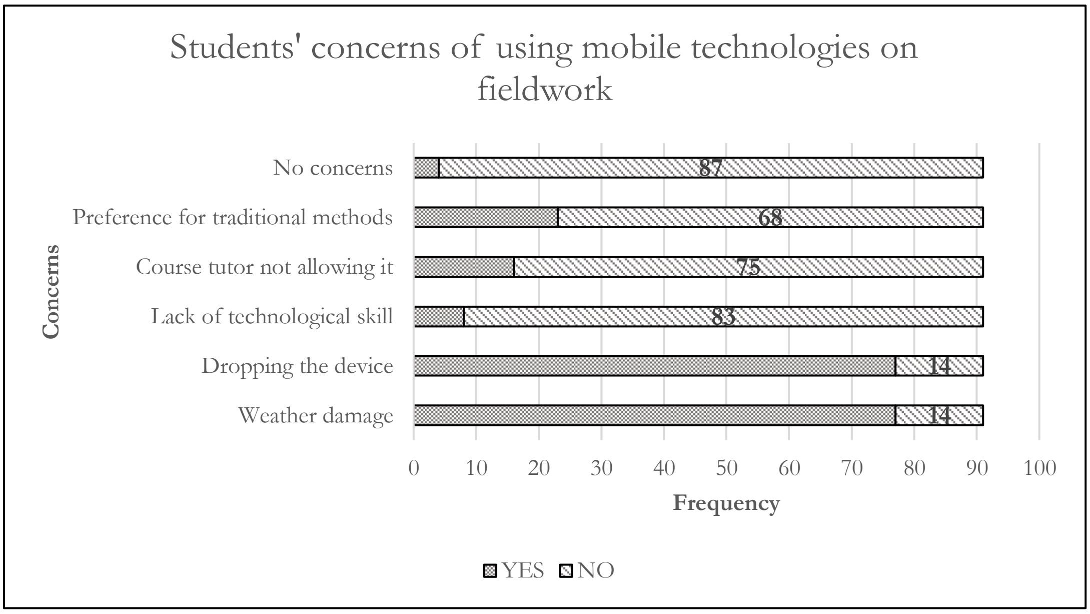


Fig. 4.6 - Student concern of mobile technologies on fieldwork

While students in the questionnaire indicated a variety of concerns, it was the open ended question of "*how do you think mobile technologies can hinder your learning*" which gleaned the most useful data about the true concerns of students. Students indicated that using mobile technologies in their fieldwork could offer the potential to be a distraction to them with 51 references made to this. Particularly this was in the form of social media on the device hindering their learning. The issue of technical issues be that damaging the device be that via dropping or external issues such as weather or battery life was the next most populous (n=48). An interesting caveat to explore is that although mobile technologies provide a benefit to fieldwork such as speeding up the data collection, there is a worry by some that it would reduce their hands on practical skills due to a reliance on technology with 10 references made to that.

4.5.2 Distraction On Fieldwork

Distraction of mobile devices is often one of the concerns for their use in education as a whole and on fieldwork (Mehdipour & Zerehkafi, 2013). Lecturers also know that mobile technologies "*can be a distraction, of that there is no doubt*" (Lecturer [C], Geography). Distraction concerns are often due to students being distracted by social media and this was acknowledged by students that such distractions do occur. Research into social media has typically focused on the use of social media in the classroom rather than in other learning contexts such as a laboratory or during fieldwork.

Fifty-One students mentioned distraction by social media as a concern. Lecturers while aware of the potential to be distracted, they seemed less concerned about how much mobile technologies distract their students on their fieldwork. For one lecturer, they support this notion by reflecting on their own experience and their own empirical studies into this issue:

> I've done a few interviews and questionnaires with students about this and the feeling I get from it is that they aren't as distracted in the field….because they are engaging in active learning, their mind is much more on 'right we need to get this done, what do we need to get?' so they're focused more in the field than if they're just sitting passively listening to someone lecture.
>
> (Lecturer [E], Geography)

While the above experience believes distraction isn't such a big issue, students were however keener to explicitly state this as being their number one concern of using these devices on fieldwork. Students expressed that they can themselves "*easily be distracted by other things on a mobile. E.g. Facebook*" (F-G6). While Lecturer E believes that students are focused on active learning in the field, students expressed that it was the act of using the device on fieldwork for purposes of the fieldwork and the ease of then being distracted by for example incoming messages than being distracted outright by the device itself, as discussed during a first year outdoor education focus group below:

> A2: … if something pops up on your phone you get distracted by that and next thing you know you're not paying attention.
> Interviewer: Do you think that happens quite often?
> A2: Probably.
> A4: It can do, it can do for many others too not just ourselves.

> A3: Because it's easy to just for me to go onto notes on my phone, I can just then pop onto Snapchat, check messenger...I'm bad at that!
>
> (Outdoor Education students)

Students it seems that while their main concern is distraction of social media, it is a concern that they have the power to mitigate themselves. In the discussions, there was no evidence that students were making any steps to reduce this distraction for themselves on fieldwork. This could be achieved relatively simply through having the *Do not Disturb* function enabled on their devices. Such a setting does not allow notifications to appear on the device while engaged. It is unknown whether students are unaware of such a function and if so, perhaps educators should highlight this function to their students to potentially mitigate the distraction of social media on fieldwork. However, conceivably this is a concern that students can live with and manage. While it was the most populous concern by students in this study, it became clear that to them, it was not the most detrimental concern compared to for example, damaging the device or losing the data.

Distraction from social media while detrimental to learning and can be seen as a slight annoyance, for one student they believe that "*mobile technologies may distract students and make them more prone to the risks around them*" (M-G4). While this is hoped to be an unlikely event that a student would be so distracted to injure themselves or others, it is a plausible concern.

4.5.3 Technical Difficulties

As with mobile technologies, there is always a concern around their robustness and technical issues they may have (Martin & Ertzberger, 2013). One of the main concerns with using mobile technologies on fieldwork is that if the device breaks "*you have no backup options data/information can be lost*" (F-GC5). A concern for some students is the battery life of some mobile devices "*if the device were to run out of charge/ get damaged it would be rendered redundant*" (M-G4). Students further expressed concerns about damaging the device as supported by the main concerns as outlined before from the questionnaire. While damage to the device is undoubtly a main concern for students, they did recognise that they could take steps themselves to mitigate such an issue. While not as resourceful as the account by the male student, one female student outlines that students can protect their own devices:

> So you can get cases, you can get waterproof carriers and that's the other thing really I don't think people have respect for it. They cost a lot of money and they just throw

them around and let them break whereas I'm going to be so proud of the one I've bought [Laughs].

(Female, L5, Outdoor Education)

There are other concerns from students such as the devices "*can become complex*" (M-GC5), it can "*possibly overcomplicate fieldwork*" (F-G6) and can in fact "…*take longer to collect data if [you're] spending too much time getting the technology to work*" (F-GC6). While some students mentioned the practical issue of using the devices in weather such as when it is raining "*as the touch screens won't work well*" (F-GC6). Other issues around their use include issues such as "*cold fingers from taking gloves off*" (M-OE6) to use the device. Such concerns are also prevalent with traditional methods also and are not unique to using such devices.

Weather and waterproofing is an issue, whist many smartphone devices today have water resistance or complete waterproofing such as the Samsung S9 which has an IP68 rating in their design. In practical terms this means that the device can be submerged in 1.5 meters of fresh water for 30 minutes (Samsung, 2018). In conjunction with the purchase of inexpensive waterproofing cases can alleviate the concerns of damage and particularly water damage to devices. Nevertheless, it became apparent from the focus group that such waterproofing does not alleviate students concerns due to their personal experience of a disparity between the usability of such devices depending on if they're waterproof or not. As recalled below even when manufacturers state they are waterproof there are still some issues which may lead some students to be reluctant to use them on fieldwork:

Interviewer: … [Students'] concern so number one was weather damaging the device, in fact 83% said that. Is that a concern that you would have if you went to use it?
A1/A2/A3: Yeah.
A4: Not for me because mine is water-resistant the phone, so that's good.
A3: Mine was supposed to be but ever since we went climbing, since then, the little scroll and the tabs haven't been up there, I have to go onto settings so it does damage it.
A2: Yeah mine said it was waterproof and I went walking in the Lake District [in the rain] and took a photo and it was its downfall!

(Outdoor Education, L4 students)

While phones may be water resistant, the practicalities of using such devices in inclement weather remains a challenge. For some, the lack of connectivity is a barrier to the inclusion of mobile technologies on fieldwork. One of the main positive points is in the devices ability to access information and share information instantly however this can only occur if the device has access to the internet via either Wi-Fi or a mobile signal. When out in remote parts of the UK on fieldwork, particularly down in Valleys then connectivity may not always be available and therefore one of the positive aspects of using such technologies is made redundant.

4.5.4 PRACTICAL ISSUES

Mobile technologies as shown above can be a distraction to some students and have their technical issues and weather concerns. While mobile technologies have their benefits to fieldwork such as increasing efficiencies in data collection, some students have outlined a learning concern that mobile technologies may pose. Some students believe that mobile technologies can in fact create a reduction in their skill levels. Students showed a degree of concern about mobile technologies "*reduce[ing] skill level as dependence on technology increases*" (M-GC6). Some student's showed a concern that mobile technologies could reduce their skill levels due to mobile technologies "*trying to pull away from being hands on*" (F-G5) which in turn they "*may become lazy [and] rely on it too much*" (M-OE5). This reliance can introduce such 'laziness' due to the "*technology doing the calculations*" (M-OE6) for them and "*too much reliance on them can reduce the potential of working out a problem mentally"* (F-G6). This was expressed by one student as she details those concerns below.

> The only thing that worries me is … I think the tendency will be "oh I'll just look it up, Wikipedia will tell me" and you have no idea whether that's true or false whereas you can come to your own conclusions by investigating and I think it would just take that little bit away.
>
> (Female, L5, Outdoor Education Student)

Luckin, Clark, Graber, Logan, Mee & Oliver (2009) when discussing educational use of students personal social media accounts suggested that students may well struggle to adapt or simply refuse to engage when their personal online space is used for education purposes. There does seem to be some evidence of some students showing a concern about the use of their personal devices for educational purposes:

> I don't know a part of me is always in the mind set of I've always...University is a bit like work in a kind of way, my phone is for personal use rather than anything for University, I do it [university work] on my laptop...

(Female, L4, Outdoor Education)

This is echoed and acknowledged by a one lecturer who comments that there is a "*reluctance from students who think' hang on this is very much my phone or my iPad and you know we're not crossing the boundary for using this for education as well*" (Lecturer [E], Geography). While this is a challenge for students to use their devices for personal and educational purposes, such concerns can be alleviated through simple explanation to the student. As one practitioner comments that there is a reluctance to use such devices due to a lack of knowledge about their devices and how they can be used for educational purposes.

> I feel once they realise that they can use mobile technologies for educational purposes and actually, sometimes it's just educating them on 'this is what it can do, you can download this app, this app, this app, and this is what it can do and it can really enhance how you learn' and … although they're like the digital natives you know the tech generation, a lot of them come in and they're not actually that confident with technology, not all of them but a lot of them aren't as confident as you might think that they are.
>
> (Lecturer [E], Geography)

Access to the latest equipment can be a challenge for students on fieldwork to. While technical and specialist skills are often subject and fieldwork specific, they will use devices such as the use of handheld GPS equipment to more specialist equipment such as spectrometers. Whilst specialist equipment is used in fieldwork on a regular basis there is a limit of how in date and relevant such specialist equipment is depending on the institution and department. As indicated by one student, sometimes the most expensive and up to date equipment is reserved for research purposes only and students do not get access to such devices.

> "We got to play with a few different instruments but when we're given them we're already told that they're 20 years out of date. So we know that stuff we're using there are more advanced methods. So we're almost learning, you know, the pre-age learning [Laughs] if you can call it that? And they're like 'Well there are more advanced things available but they cost £30000 and we just don't have that and you're not allowed to play with them'! [Laughs]"
>
> (Female, Outdoor Education Student)

Access is a challenge and especially when such equipment is owned by the department which leads onto the final section of the results and discussion in this chapter, the debate of Institutionally Owned Devices (IOD).

4.6 The Use Of Institutionally Owned Devices

This chapter thus far has outlined some of the benefits but also the challenges that mobile technologies can have on fieldwork. For some institutions, they have tried to limit the perceived negative impacts of mobile technologies on fieldwork while controlling and enhancing the advantages through the introduction of institutionally owned devices (IOD).

While there are many advocates for Bring Your Own Device (BYOD) on fieldwork such as; students have ownership of data collection, they're familiar with their own devices and it's cheaper for the department (Welsh, Mauchline, France, Powell, Whalley & Park, 2018). There are many negative impacts of BYOD on fieldwork. Many have already been discussed here such as damage to their own devices and therefore a reluctance to use them, risk and insurance issues and different operating systems meaning not all applications can be utilised by all on fieldwork.

4.6.1 Would Students Use Institutionally Owned Devices?

Students were asked if they would use institutionally owned devices if they were to become available for their use on fieldwork. Students could select one statement that best reflected their thoughts about these issues as shown in Table 4.4.

Table 4.4: Encouragement of students to use institutionally owned devices

Encouragement of institutionally owned mobile technology devices in fieldwork	Frequency	Percent
"Yes, providing there was no penalty for accidental damage"	36	40
"Yes, it's a great idea"	23	25.6
"No, I prefer using my own device"	15	16.7
"Yes, if tutors encourage it"	13	14.4
"No, I am worried about damaging the device"	2	2.2
"No, I don't see the benefits of using mobile technology in fieldwork"	1	1.1

As shown in Table 4.4, the majority of students would encourage the use of institutionally owned devices however there are some caveats to this. Around 26% of students believe it to be a good idea and have no conditions attached to their use. However, 40% of students would encourage it if there were no penalty for accidental damage. 2% would not use it for a fear of damaging the device. This supports the very risk adverse nature and concern throughout this Chapter from students about damaging such devices. While another 14% would use it if it were positively advocated for by the tutor. Of those who did not want to use institutionally owned devices was due to a preference for using their own, which is a key driver in BYOD in fieldwork as outlined by (Welsh, et al., 2018).

This mixture of views is supported by the experience of one lecturer in this study who recognised that "*Some prefer to use their own, some prefer to use the institutions, so I think having both on offer is a good mixture*" (Lecturer [E], Geography). While having a mixture is useful if departments were to go and fully invest in their own devices what benefits would that bring to their students.

4.6.2 Advantages of Institutionally Owned Devices

Throughout the interviews, different lecturers, like students, had a preference for BYOD or IOD. For one Lecturer [A], was a keen supporter of IOD in fieldwork and in the following extract, outlined the many reasons why they were a supporter of this method. This discussion arose when Lecturer A was discussing how they used mobile technologies on fieldwork and referred to students using iPads. This led the researcher to investigate if these were IODs.

> Interviewer: So the iPads they're all departmental owned?
> Lecturer A: Yeah, yeah we've mostly done it that way, we've mostly not done the bring your own devices model of fieldwork.
> Interviewer: How come you've not gone down the BYOD route?
> Lecturer A: I think partly because we've had the iPads in the department for a while so I think partly you can see potential hassle...firstly in terms of making sure it's got the data on it because you've got to go the extra step to make the data available. You have to download it, so by using departmental devices we can make sure everything is there and prepared and also the standardisation in terms of getting it back off and processing it afterwards. People using their own devices, okay most of them are pretty standard but someone may hit an issue with getting the data off and there is a risk of something going wrong and people losing their data if we use our own device with our own set up we know it's pretty failsafe and set up the way it needs to be.
>
> (Lecturer [A], Geography)

As outlined in the extract above one of the main reasons for using IOD is about smoother and safer data collection processes. One concern of BYOD is about students having ownership of their data but should this data be lost or failed to be transferred, then the onus is on the student. Such a concern of data being lost is a major concern that was born out of the data from students in this research. By using IOD, the onus is on the department to ensure that the data collected is safe, secure and available. This can therefore alleviate this barrier for students who are concerned about using mobile technologies on fieldwork due to loss of data.

As alluded to by this lecturer, the different types of devices on fieldwork can be a challenge. This is due to the main different operating systems such as IOS (Apple) and Android. Not only do smartphones vary in their operating systems but also in their various incarnations of that software (Vazquez-Cano, 2014). Some applications are designed specifically for different operating systems and some will not work with an older version. This creates an issue when trying to select a suitable application to use for smartphone devices for the students on fieldwork, when often they will have very different types of devices (Viberg & Gronlund, 2015). Therefore, by having IOD specialist applications can be used across the standardised devices thus, students will be able to collect the data as explained below.

> Other things we've done and mostly using iPads but it's actually more linked to directly data collection and that's using apps like ArcGIS collector to collect photographs and take notes GPS points in the field which they can use to generate story maps and those kinds of things.
>
> (Lecturer [A], Geography)

4.6.3 Disadvantages of Institutionally Owned Devices

While the most common advantage was standardisation and the safety of the data, there are some disadvantages to IOD. This emerged from the interviews as three main issues, students concern of damaging the devices, the disparity of perceived value for students of their own devices compared to institutional ones and finally, it is costly for departments.

4.6.3.1 Damage to IOD and disparity in personal values

Damage of the device is a continual concern throughout this study of mobile technologies on fieldwork. While some students show an acceptance of damage as "*Everyone smashes their phone now though"* (Female, L4, Outdoor Education Student) others are more concerned. As shown by the studies of France et al (2015) students were often reluctant to use IOD on fieldwork due to damage or repercussions and this was reflected by the experience of one lecturer who states:

> You think they're not going to be concerned about institutionally owned devices but in some ways they're…more worried about institutionally owned devices because it's not theirs and if they break it 'am I going to have to pay £500 to the department'. The other side of the coin is well it's my device so I don't want to get it out in the rain and what happens if it gets soaked or of course universities just don't have bring your own device policies in place it's a very grey area in terms of who's liable if anything happens to a student's device so it's a tricky one really.
>
> (Lecturer [E], Geography)

This concern of damage of equipment was the number one barrier for students for not using IODs. As highlighted above, the '*grey area'* of BYOD insurance is an important point to consider. The researcher could not find any institution who had specific guidelines about insurance for BYOD or IODs nor is there any published work on this matter. It raises the concern of who is liable should the student damage their own device on fieldwork and the practicalities of dealing with this on fieldwork. Even for IOD while it is assumed by the researcher that these devices are insured by the department/institution, to what extent this insurance covers such activities is unknown.

Whilst concerns about cost and insurance is an issue, it became clear from the extracts that students perceived different levels of value to equipment and therefore acted accordingly. For example as explained in detail below, students are perceived to be more than willing to use IOD such as expensive GPS equipment without much hesitation. However, they are far more risk adverse when it comes to far cheaper iPad use as observed by one lecturer who explains that.

> Differential GPS you know they don't ever seemed concerned that they've got 25 grands worth of equipment in their hands. That's not the same level of concern as "oh my goodness I've got £500 worth of iPad in my hand".
>
> (Lecturer [E], Geography)

Perhaps students place far greater emphasis and value onto devices they utilise or aspire to have, as Lecturer E comments that "*I don't know if that's because they realise how expensive that is and maybe they look at the GPS and don't think anything of it but it doesn't mean anything monetary value to them whereas to them*". This does align to the idea that expensive equipment such as Differential GPS students are not concerned about so absolute monetary value is not the deciding factor. What seems to be the deciding factor is how much personal value a student attaches to that particular device as she continues to say that;

> An iPad is expensive … maybe that's not something achievable that they can own for themselves because it's too expensive whereas they've never really thought about owning a GPS.

Therefore lies a challenge in how to alleviate such a concern for students. While steps such as protective equipment and insurance or no punishment for accidental damage of IODs on fieldwork can be taken, it is far harder to change a student's personal value of a device.

There is no easy way to tackle this issue other than guaranteeing that steps have been taken to ensure students that IODs can be used, are protected, and no punishment for accidental damage will occur. Nonetheless, not every student is as risk adverse or as concerned by IODs. One female student showed no concerns at all about damaging IODs on fieldwork as the extract below demonstrates.

> I prefer using my own [device but] I think if they're giving it to us they know the risk so I would be as careful as I can...but if I broke it I'm so sorry but I wouldn't be as panicky if it was my personal device…but yeah they have the understanding that they've given it to us knowing the dangers.
>
> (Female, L4, Outdoor Education Student)

While the majority of students are concerned, there will be other students who hold similar views to the student above. In contrast to the student above, another female level 5 student who was a mature student held a contrasting view of the value of technology to her personally. In her account she recalls her view on how her peers may view the value of technology differently to her.

> I think people are almost numb to it. Technology is technology, they don't see it as different grades of technology and I think they're just so used to everything being safe because I'm not used to having, you know the clouds, and dropbox, and things like that... they kind of treat technology the same … whereas, I'm from the generation

> where it was a photo, and if that photo got lost, burnt, or a cup of tea poured onto it, well...that memory disappears and you are far more precious when you've had that. So, I do think there is definitely more, I don't know what the word is...don't take the same level of responsibility for things and not careful.
>
> (Female, L5, Outdoor Education Student)

In her account, she mentions she is from a generation before smartphones and therefore has a greater appreciation for cost and value than her younger peers have. This difference is shown in the L4 student who is from a different, younger generation who is unconcerned by damaging the device and the acknowledgement by another student who stated, "*Everybody smashes their phones nowadays*". More research is needed to investigate this but it is interesting that despite students of this generation being less risk adverse with their own devices, they still hold on the whole, a very risk adverse nature to IOD and so they have continuing conflicting values.

The challenge is how to find a happy medium between the very risk adverse students and the not so risk adverse for IOD use. As mentioned however, having a mix of BYOD and IOD allows a student to make an informed choice of what type of device to use on their fieldwork. While Lecturer A would prefer to use IODs on fieldwork for standardisation, should a student feel so concerned by damage then they have the option to BYOD and take responsibility for their own data. Students therefore have to weigh up the pros and cons of each.

4.6.3.2 Cost of IOD

Mobile technology devices are on the whole expensive from £500 phones to £25,000 and above for specialist equipment. If departments are to invest in IOD for fieldwork such as iPads and mobile phones then this will incur significant costs to departments. Today's smartphones in 2017 will on average cost £286. However, this is a significant reduction from 2013 when the average smartphone cost £419 (Statista, 2018). Yet, the highest end and newest models of smartphones are significantly more expensive as of September 2018 Samsung Galaxy S9 will cost £739 RRP (Marshall, 2018) and the iPhone X will cost £999 to £1149 depending on the model (Beavis, 2018). As outlined below the mixture of BYOD and IOD is important as sometimes BYOD can fill the gap when resources are limited in terms of IOD so that students can still complete the intended task.

> I encourage them to download a GPS app on the phone which allows them to do the same data collection that can be done by the handheld GPS and I think that's also quite good because it shows them if they also want to use them for their own data collection for dissertations you've got this you can do it on your phone it's quite capable of collecting what you need.
>
> (Lecturer [A], Geography)

4.7 CONCLUSION

Mobile technologies have developed rapidly in recent years and have found their way into fieldwork as overall a very positive new influence. As shown in this chapter, there are many advantages that mobile technologies can give students and staff on fieldwork. Most notably it allows students far greater and ease of access, makes the data collection process far more time efficient, and therefore allows what limited time that does take place on fieldwork to be as productive as possible. Students overall have embraced this new technology and have used it to good effect for their learning on fieldwork. However not all students are as pro mobile technologies as some established literature would suggest.

Outdoor Education students certainly are different in their outlook of mobile technologies compared to their Geography peers and within different cohorts, different generations and views exist. Technologies can be expensive and less robust than traditional methods with students citing damage and distractions as their main barrier to using them on fieldwork. While some of these barriers can be addressed as technology advances to include better damage protection or waterproofing, some barriers as shown with the debate of BYOD vs IOD are harder to change such as individuals holding different values to technologies.

Despite these challenges, mobile technologies have not only changed the world in which we live in today it has made a significant impact in education. While education has typically been slow to adapt and update methods to utilise these technologies developed (Cheon, Lee, Crooks, & Song, 2012) fieldwork has been proactive in using such devices. The main driver behind this is the ability for such devices to make the fieldwork experience more efficient. As fieldwork is forever more time pressured these devices unlock extra time for lecturers and students to maximise being in that landscape. This chapter along with the previous chapter has accomplished the first aim of this research which is to "*enhance the understanding of the role fieldwork and mobile technologies play in learning about geoscience in higher education.*"

As technology has progressed, a new and emerging mobile technology has recently become available for departments to use in fieldwork. This technology is a mobile technology that has the potential to bring together all of the many benefits of mobile technologies into one device to further enhance the fieldwork experience of students. This technology is the Unmanned Aerial Vehicle (UAV).

The following Chapter V will explore in-depth what further advantages this piece of mobile technology can bring to both staff and student on fieldwork along with the distinct challenges it poses.

CHAPTER V: UNMANNED AERIAL VEHICLES

This chapter explores a mobile technology that has been repurposed for new applications, one of which is investigated in this study, education. This mobile technology is the Unmanned Aerial Vehicle (UAV) or colloquially known as a 'Drone'. This chapter examines the second aim of this research that *is to investigate and document the regulation, the benefits and the challenges of using Unmanned Aerial Vehicles in Geoscience fieldwork*. This chapter commences with the history of UAV technology. UAV's are governed by strict laws and licencing requirements in the UK. Regulation and laws are one of the key challenges that both the researcher and the educators in this study faced with regards to their inclusion in education. Therefore, this chapter outlines the many often complex regulations that govern UAV flight in the UK to provide not only context to the educators' concerns but also to highlight this aspect of UAV flight to any potential new users of this technology in education. After outlining what research instruments and questions were used in a brief methods section, this chapter then evaluates the advantages and then the disadvantages that UAVs can potentially bring to teaching, learning and fieldwork before offering a conclusion.

5.1 A HISTORY OF UNMANNED AERIAL VEHICLES

Mobile technology has demonstrated the potential in benefitting today's fieldwork in geoscience as discussed in the previous chapters (Welsh et al., 2012; Medzini et al., 2015; France et al., 2016). One such mobile technology that has been around for a long time for military applications (Valavanis, 2008) but only emerged recently on the commercial market, is the rise of Unmanned Aerial Vehicles (Canis, 2015). UAVs are referred to in many different ways in literature and in policy and regulation. UAVs can be referred to as Remotely Piloted Aircraft Systems (RPAS), Remotely Piloted Vehicles (RPVs), Unmanned Aircraft System (UAS) used by the United States Department of Defence, Federal Aviation Administration, British Civil Aviation Organisation and the International Civil Aviation Organisation (SESAR, 2015), Unmanned Aerial Vehicles (UAVs) to which they will be referred to in this thesis and most commonly by the public, '*Drones*' (Cavoukian, 2007). The latter term, however, is contested and rebuffed by UAV manufacturers and aviation experts despite its popularity (Stanley, 2013). This rebuttal of the term is due to the connotation of warfare and implied the autonomy of such aircraft called drones, and therefore manufacturers prefer to use the number of acronyms as listed above (Gosztola, 2013).

UAVs are defined as "[a] powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide lift, can fly autonomously or be piloted remotely, can be expendable or recoverable and can carry lethal or non-lethal payloads" (Valavanis & Vachtsevanos, 2014, p. 2).

Since 2005, rudimentary UAVs were starting to use surveillance and live video streams for more civil and scientific roles (Koldaev, 2007). It was thought by advocates for such technology, that if such systems existed for military applications, the potential was there for the development for civil and scientific purposes (Liu, Chen, Haung, Han, Lai, Kang & Tsai, 2014). Early civil UAVs, however, lacked sufficient power, flight time, control and usability of their military counterparts (Gupta, Ghonge & Jawandhiya, 2013). The most significant disadvantage to civil UAVs over military UAVs was the lack of high-quality optics that were small enough to fit onto these smaller aircraft (Ro, Oh & Dong, 2007). Military UAVs that possessed such attributes were often very large heavy aircraft that had a significant running cost, which made them impractical for civilian use (Nonami, Kendoul, Suzuki, Wang, & Nakazawa, 2010).

It was not until the emergence of the Chinese firm DJI which developed the Phantom series, that UAVs became accessible to the masses for non-military applications in sufficient quality and usability (Harvey, Pearson, Alexander, Rowland & White, 2014). DJI is the leading manufacturer of civil UAVs with global sales of $500m in 2015 (Liu, 2016). This dramatic emergence of commercial UAVs on the market occurred due to the advancements in smartphone technology (Remondino, Barazzetti, Nex, Scaioni & Sarazzi, 2011). This advancement came through the combination of development in battery technology, lighter and stronger manufacturing processes, and the emergence of small enough sensors and high-quality cameras that could be fitted onto these smaller aircraft.

One significant contribution to this boom in small commercial UAVs is their ability to complete data collection tasks at a fraction of the cost of traditional manned aviation methods (Everaerts, 2008). For example, it costs $50,000 USD to operate a surveillance UAV with a qualified operator for a year compared to in excess of $1 million to operate a crewed police helicopter in 2007 (Cavoukian, 2007). As UAV technology improved and aviation fuel prices have increased, the potential savings have also increased. It can cost between one to three million a year for the purchase of the helicopter, fuel and pilot pay, in the USA whereas UAVs are used more commonly for law enforcement. Such an operation can equate to around $700 per hour (excluding crew salary) to operate a police helicopter, yet estimates are only $25 per hour (excluding crew salary) to operate a UAV (Hamann, 2018).

The UK government believes that commercial UAV usage will contribute £100bn by 2025 to the UK economy (UK Gov, 2017). According to a Department for Transport whitepaper on UAV use in the UK, they estimate that there could be 76,000 UAVs in UK skies by 2030 with more than a third of them used for public sector work such as defence, health, and education (Department for Transport, 2018). While sectors such as emergency response are already integrating such technologies and abundant literature and development of such systems for these purposes exists (c.f. Qi, Song, Shang, Wang, Hua, Wu et al., 2016; Bejiga, Zeggada, Nouffidj & Melgani, 2017; Cracknell, 2017), this is not the case for the education sector. The link between aircraft and benefit to sectors such as search and rescue are relatively clear and straightforward but not so for education. Due to a lack of literature and a clear strategy on the educational use of UAVs, this chapter attempts to uncover some potential uses of UAVs in education through the lens of fieldwork.

5.2 Laws and Licencing

This section is a detailed look at the UK specific rules and regulations that apply to any UAV that is flown (CAA, 2016). Different countries have different rules and regulations on the use of UAVs and these vary from no regulation to highly regulated. In the UK, in order to operate for commercial purposes such as research, the pilot must operate under a CAA approved operations manual. This licence is called a *Permission for Commercial Operations* or known in the industry as a *PfCO*. This manual is often up to 100 pages long and details in a legally binding way how the pilot will operate the aircraft and maintain it. The PfCO was vital and often a key area of discussion not only for the development of the model used in this research but also for those interviewed. This section outlines in detail the many rules and regulations but also outlines the lengthy process the researcher conducted in order to be fully trained and complete their own operations manual. This process was extensive, and the researcher wanted to go through the process to have the first-hand experience of what operators in Higher Education must go through in order to be able to fly a UAV.

5.2.1 Legality of Operations

In the UK any UAV over 250g (excluding fuel but including the UAV and anything else attached such as sensors/camera) is classed as an aircraft and must adhere to Article CAP 722 of the Air Navigation Order (CAA, 2015). This order is what all pilots of both manned and unmanned aircraft in the UK must follow (excluding emergency services and military). The CAP 722 is there to separate aircraft, UAVs, and people from potential confliction with each other (CAA, 2015). UAV pilots must follow the rules and regulations as set out in CAP 722; a simplified version can be found in appendix P as the Air Navigation (Amendment) Order 2018 (UK Parliment, 2018, p. 49).

As outlined, there are extensive regulations and laws that UAV pilots must operate within. More discussion of how this influences their use in education is discussed in section 5.6.1. For many people including students in this research, there was a distinct lack of knowledge that such regulations existed and were so extensive. Fundamentally, any UAV flying in the UK is governed by such regulations, and this either hinders or helps UAVs in education as discussed in this chapter. One part of the regulations that governed the data collection process of this research was the PfCO.

5.2.2 Permission for Commercial Operations

If any activity is for a commercial nature, the UAV pilot must hold a licence to operate issued by the CAA while conforming to the regulations, called a PfCO. The CAAs definition of commercial is "any operation of an aircraft other than for public transport which is available to the public or which, when not made available to the public, is performed under a contract between an operator and a customer, where the latter has no control over the operator in return for remuneration or other valuable consideration" (Civil Aviation Authority, 2018). This type of activity is illegal unless a Permission for Commercial Operations (PfCO) is obtained from the CAA. Regarding education and research, it is a current grey area in the law. For research, if a university or industry has exchanged money for UAVs to be used such as in grant form then technically money is being exchanged for the purpose of UAV flying.

Regarding education, students are paying a fee to attend a course, and if UAVs are offered as part of that course then again, it can be deemed to be commercial as money has been exchanged for a service. Of course, this is more subjective and less clear-cut than a standard commercial contract and exchange, and this has only added to the confusion in the UK higher education system with no set standard yet to be delivered. Nevertheless, it is important for those in education to pursue the PfCO process as it means the pilot is fully qualified, knowledgeable of the laws and licencing requirements and their aircraft, distances can be reduced for higher quality data outputs and finally, public liability insurance for UAV flight is only offered to those entities who hold a PfCO.

To gain a PfCO, the pilot has to undergo extensive ground school and flight training examinations to gain a licence, which in turn, makes a safer and legal operation. The pilot must demonstrate skill and knowledge of aircraft systems and policy that a non-PfCO pilot may lack. As described in article 95 2-part A, the distance a PfCO pilot can fly in a congested area is reduced from 150m to 50m. While this change may not seem so crucial for flying in open countryside, it is beneficial to reduce such distances in congested areas, which is defined as "in relation to a city, town or settlement, any area which is substantially used for residential, commercial, industrial or recreational purposes" (Civil Aviation Authority, 2018). Having a reduced operating distance makes more areas more accessible and more flexible for flying the aircraft for data collection on fieldwork. Reducing the distance allows the aircraft to fly closer to an object or site, which will increase accuracy and detail in the images and models that will be created.

5.2.2.1 Ground School

Before any commercial flying can be conducted, a pilot must attend a UAV ground school. In the UK there are around 20 CAA approved ground schools called National Qualified Entities (NQE). Each school offers different training packages and different materials for varying prices. The training packages range from two-week classroom intensive learning courses to longer duration distance online learning modules. Some NQEs offer a blend of the two approaches. For a pilot to gain a licence, they must complete two written examinations and a practical flying exam. Regardless of the delivery, all NQEs have their courses and teachings approved by the regulatory body, the CAA. For this research, the researcher used the longest standing UAV training provider for the CAA, called UAVair. For £1500, this included a 40-hour distance-learning course, followed by two days of classroom and examinations and then the practical flying exam on the third day. This was called their "*intensive fast-track*" course.

The researcher elected to use this approach for a variety of reasons. The company used was the first and most respected company by the CAA, and therefore teaching and materials were of the highest order. The distance learning option allowed the researcher to work on the online modules remotely while completing other aspects of this research. The company offered a Fast-Track course that condensed the exams into three days meaning that once the online modules were completed, the researcher could gain the licence to operate under another PfCO in three days. The drawback to this approach is it is the most intensive course that a pilot can do. The 40-hour online learning process had a high pass mark and two days of 12-hour teaching and examinations, followed by a flying exam on the third day. Adding to the stress and pressure is often the financial investment, with failure at any point the pilot needed to pay to recomplete that portion of the licence. For example, failure to pass the flying exam portion of the licence would cost around £500 to re-sit. This was considerable pressure for the researcher due to limited funds available for the project.

While this method for gaining the licence was chosen amongst the many NQEs who offer different schedules and training materials in their delivery, they must all cover the following modules; Air Law, Airspace, Navigation and Charting, Meteorology, Principles of Flight (General), Principles of Flight (RPAS), Human Factors and Airmanship, and Safety and RPAS Operations. Due to the extensive examination and the amount of workload required to pass the exams, pilots who graduate the ground school and flight examination and complete an approved CAA operations manual are awarded a ProQual Level 4 Diploma in Remote Piloting of Unmanned Aircraft Systems.

Prior to the three days of examinations, the researcher conducted the online 40-hour module course. Each module required reading via an online course manual, videos and through physical textbooks. Each student pilot had to complete an end of online module exam, with a pass mark of 80%. Once the researcher had completed all online modules and passed the online module exams, they were cleared to attend the assessment weekend. This assessment weekend was held over three days 29th April – 1st of May 2017 in York, United Kingdom.

The first test was a practical flight-planning exam that was conducted under exam conditions at which the researcher was given a fictional flight to plan. Using only paper charts and selected websites the flight had to be planned correctly, noting any hazards, dangers and airspace restrictions. The test is designed to see if the student pilots understand the associated hazards and how planned flights need to be altered based on these external restrictions. How this is achieved is outlined in Chapter VI, which discusses how the data was collected for the model. The flight-planning exam was a straight pass or fail and was not graded on a score. If the flight-planning phase was failed, then student pilots could not progress to the final ground school exam, which was the General Theory exam. This exam was an hour-long exam during which 50 questions were asked to the student pilots from any of the nine modules that had been covered previously. The pass mark was 75%, the researcher passed the exam with a mark of 94%. Out of the 15 student pilots, three failed at this examination and did not progress to the flight assessment.

5.2.2.2 Flight Assessment

The flight assessment exercise is a flying and procedure practical test for UAV pilots. The pilot is assessed by a fully trained and CAA approved flying instructor over a designated one-hour period. The assessment started as soon as the aircraft was removed from the carry case and only finished once the aircraft was stowed. Pilots are under constant evaluation from the instructor during this time. The flying exam has the following parts: Site Assessment, Flight Planning, Briefing, Assembly, Flying Manoeuvres, Emergency Procedures, Fail-Safe procedure, and Disassembly.

At each stage, the pilot is assessed on their safety, ability to use checklists, their flying skill, their knowledge of the aircraft systems, and their ability to mitigate emergency scenarios. The flying manoeuvres are designed to test the competency of the pilot and to ensure that they are flying in a safe and controlled manner. The entire flying exam is conducted in *Attitude* (ATTI) mode, which is the hardest mode for flying as all GPS, and pilot aids are disengaged. In ATTI mode, the aircraft will only use the internal barometer to maintain height and orientation but not a position in this mode. Global Positioning System (GPS) and Global Orbiting Navigation System (GLONASS) (the Russian equivalent and alternative to the United States of America run GPS) and Vision Systems are not used to maintain a hover. In order to maintain a position over the ground, the pilot must make continuous control inputs in order to keep the aircraft over the same hold point taking into account the wind. The flying exam is conducted in ATTI mode to expose the skill of the pilot but is also a CAA requirement to demonstrate that in the event of the GPS on the aircraft failing, that the pilot has the skill to fly the aircraft in winds safely without GPS or pilot aids. Pilots are allowed to repeat one failed manoeuvre but no more, if the pilot fails a manoeuvre twice or breaks the safety box (an imaginary boundary which within the flight must take place) then the examiner will fail the pilot, and they must resubmit for the flight exam. The researcher failed one manoeuvre but completed it at the second attempt, and no other fails were recorded and therefore passed the flying exam first time.

5.2.2.3 Operations Manual

Once the pilot had passed both the ground and flying exams they can now work for a company or University who has a PfCO in place already. The researcher could have operated under the host institutions PfCO however; they did not for two reasons. The owner of the operations manual at the time and their "team" were extremely hostile and difficult towards the researcher. While the researcher cannot say for sure exactly why such hostility was given, they can surmise that it was in-house competition between faculties, internal politics, and the researcher using newer UAV technology than they currently had. The second reason is the Operations Manual on offer was in the eyes of the researcher having completed the training, "beyond restrictive". The Operations Manual was overly complex, overly regulated, and this was compounded furthermore by the researcher owning their own aircraft and not the University due to a lack of sufficient suitable UAVs in the University at the time. An example of how this was an issue was in the host institutions Operations Manual; the aircraft must be taken apart after every flight to inspect the internal wiring and motors. Such a procedure would have (a.) nulled any insurance or warranty of the researcher's aircraft and (b.) The manufacturer only recommends this needs to be done after a significant amount of flight hours (50+) or after a crash and must be done by a manufacturers own mechanic. Lastly, the researcher wanted to understand and complete the full process to gain a holistic view of the challenges that new pilots face in the process of becoming a legal RPAS pilot. This process was important especially if this technology is to be used by others in education, they must know the challenges that are needed to be overcome to become legal.

After a sincere attempt to compromise and collect data under the hosts PfCO with continued resistance, the decision was taken for the researcher to complete their own operations manual and subsequently had it approved by the CAA. All flights, therefore, were conducted legally in the eyes of the CAA and under full-approved UAV insurance. All flights concerning this study were conducted in the researchers own time outside of University business hours (i.e. weekends).

The Operations Manual is a substantial document around 22,000 words that outlines everything from set procedures, legal information, to aircraft specifications. This document governs all flights that are to be conducted for commercial operations by the pilot and outlines how they will be conducted. This is a legal document approved by the CAA which then grant the pilot a PfCO based on them following the procedures outlined in the document. A copy of this extensive document created by the researcher can be found in appendix Q.

5.3 UAVs IN GEOSCIENCE

UAVs fall under the guise of mobile technologies and have seen an increase in development and usage as have their smartphone and tablet counterparts (Cai, Dias, & Seneviratne, 2014). One of the reasons previously discussed regarding the increase in usage of mobile technologies in fieldwork is how much more efficient they can make the data collection processes over traditional methods, with one device having a multitude of applications (Welsh et al., 2013). UAV technology and its potential introduction into fieldwork are for this exact reason. One device can be changed and altered to perform many different fieldwork tasks, and they are more efficient at collecting data over a large area than traditional methods (Haala, Cramer, Weimer & Trittler, 2011; Turner, Luiceer & Wallace, 2014; Tiwari & Dixit, 2015). UAVs can be used in fieldwork for aerial surveys, photogrammetry, field and vegetation mapping and 3D modelling which can be achieved through real-time video telemetry or can be downloaded and explored quickly at the end of a flight through dedicated software (English, Herwitz, Hu, Carlson Jr, Mulller-Kager, Yates, et al., 2013; Turner, et al., 2014; Jordan, 2015; Hammerle, Schutt & Hofle, 2016).

There is a significant gap in literature around the use of UAVs in fieldwork and a distinct gap in their educational use with students. However, there is abundant literature on the application of UAV technology for other applications of scientific research that can be transferred over into fieldwork. For example, UAV technology is often used to collect data from a large area or harder to access locations (Jordan, 2015). Examples of this can be in their use of coastal and offshore surveys (Einsenbeiss & Sauerbier, 2011; Darwin, Ahmad & Zainon, 2014), flood and disaster relief mapping (Niethammer, James, Rothmund, Travelletti & Joswig, 2012), dense rainforest (Remondino et al., 2011) and glacial landforms (Ely, Graham, Barr, Rea, Spagnolo & Evans, 2017) all of which are common areas for student enquiry in fieldwork.

One of the primary uses of UAV technology in research is in their use for aerial photogrammetry (Colomina & Molina, 2014; Siebert & Teizer, 2014; Harwin, Lucieer & Osborn, 2015). Photogrammetry has no universal definition but is, in essence, the science of taking measurements from photographs, often from aerial images. While this can to an extent be achieved today by satellite imagery, the resolution for finer details of a field site is lost with often 1 pixel representing 25m^2. Finer details can be collected by survey aircraft yet they are expensive to run and must be booked in advance, and if the weather is not suitable, then the process must be redone (Marshall, 2016). For fieldwork and particularly students, the resolutions, time and costs of this type of data collection are often unviable.

UAVs can be used primarily in fieldwork for mapping be this though still and video imagery which can be stitched together to create a 3D model environment through software such as 'Agisoft Photoscan' (Agisoft, 2018). UAVs can be fitted with more sophisticated Light Detection and Ranging (LIDAR) (Hodge, Brasington & Richards, 2009; Thoma, Gupta, Bauer & Klirchoff, 2005; Maltamo, Naesset & Vauhkonen, 2014). Advancement of technologies have allowed LIDAR scanners to become smaller and more affordable to the point where they are now attached to UAVs which can develop 3D visualisations and GIS data points of a field site in a few hours to a high degree of accuracy (Fritz, Kattenborn & Kock, 2013; Petrie, 2013; Gallay, Eck, Zgraggen, Kanuk & Dvorny, 2016; Wallace, Lucieer, Malenovsky, Turner & Vopenka, 2016). This technological advancement not only creates highly sophisticated maps for students but can also be inserted into VFGs and provides many skill sets for a student to master.

Following a methods section, this chapter explores the advantages and disadvantages of using UAVs in geoscience fieldwork as an attempt to fill some of this missing gap in the literature.

5.4 METHODS

In order to evaluate UAVs in geoscience fieldwork and the benefit of such a new technology, interviews and questionnaire data were used. Questions used in the questionnaire were from the UAV section of the questionnaire that consisted of a number of different style of questions to get a range of data. This data included dichotomous questions, Likert scales for opinions and open-ended questions as outlined in Table 5.1.

Table 5.1: Questionnaire Questions used to evaluate UAVs in fieldwork

Question Category (Question number on the questionnaire) (n= number of responses)	**Question Type**
UAV Experience	
(22) Have you used a UAV/Drone before? (n=91)	Dichotomous
Opinion of UAV	
(23) Would you encourage the use of UAVs in fieldwork? (n=90)	Dichotomous
(24) How comfortable do you feel about using UAV technology in fieldwork studies? (n=88)	Likert
(25) How useful do you believe UAVs can be in your fieldwork? (n=87)	Likert
(26) How beneficial can UAVs be as a collection tool, 1-5 with 5 being very beneficial (n=87)	Ranked
(27) To what extent do you agree with the following statement: "I think using UAVs in my fieldwork studies could help to enhance my interest and engagement with the subject"? (n=89)	Likert
UAV Applications	
(28) How would you like to see UAVs used in fieldwork? (n=87)	Multiple- Choice
	Multiple-Choice
(30) What skills do you think UAVs can bring to your fieldwork experience? (n=88)	
Concerns of UAV use	
(29) What concerns do you have around the use of UAVs in student fieldwork? (n=85)	Open

Throughout the following discussion in this chapter, quotes are used to support the data and the narrative. These quotes come from two sources, the open-ended questionnaire data and the interviews. Therefore, in order to separate these, a number of identifiers will be used to differentiate between them. Interview and Focus Group quotes will be displayed as per Chapter III & IV, (Gender, Position, Discipline) while open-ended questions will be displayed as per the key located in Table 5.2.

Table 5.2: Quote Key

Identifier	Meaning
Q	Questionnaire Quote
M/F	Male/Female
OE	Outdoor Education Student
G	Geography Student
GC	Geography Combined Student
4	Level 4 Student
5	Level 5 Student
6	Level 6 Student

5.4.1 Data Descriptive

In total 91 students answered the questionnaire questions although, as shown in Table 5.1, the lowest was Q29 with 85 respondents. The amount of UAV experience varied across the interviewees ranging from 25 years experience to no experience at all. Of those who had direct UAV experience [Lecturer A, B & C], the majority have flown a UAV for research purposes rather than for teaching. No participant to date had completed the full UK CAA UAV licencing requirement. However, three had completed the ground school element of the exam. Two of those participants [A&C] were waiting to gain more flying hours before taking the practical flying exam part of the licence. Some participants had indirect experience of UAVs through knowing some of their colleagues using them in research. On the student side, the experience of UAV flying was often related to their personal experience of seeing them being flown by members of the public. Only 17 students had ever flown a UAV before, and none of them had flown a UAV that was not a relatively cheap toy; therefore students overall were inexperienced with UAVs in this study.

5.5 The Advantages Of UAVs For Geoscience Fieldwork

There are many advantages that UAVs can bring to fieldwork that emerged in this research. These benefits often focused around the UAVs ability to capture large amounts of high-resolution images from inaccessible locations and this provided students with a different perspective of a landscape. This benefit, in turn, can potentially make fieldwork more efficient and safer for students.

5.5.1 Current Use Of UAVs In Teaching

All lecturers who use UAVs are more focused on their use in a research capacity rather than on their integration into their courses. All indicated that in the future once they become more familiar with the UAV and its capabilities, they have plans to introduce them directly into teaching. This is somewhat unsurprising with such a new technology in education and a lack of literature there is little to no guidance on how educators should use this technology for their students. Mobile technologies now have extensive literature about how and why educators should use such a technology, but this does not yet exist for UAVs. This research, therefore, is at the dawn of UAV use in education and hopes to outline some ways educators may use this technology in this chapter.

One lecturer uses the UAV as an indirect tool in education to make students aware of the latest technologies that are available to collect the data that they would use in their GIS and Remote Sensing module. While his uses of UAVs do not directly inform teaching, he uses the UAV as a tool to show its capabilities and to offer some information about UAV operations such as the DroneCode which is a simplified version of the laws and licencing as outlined previously in this chapter as he explains below.

> We have them [UAVs] in the department and take them out onto the hockey pitch and show them the basics of drone operation, you know the Dronecode and the things you're meant to think about and as they're very much an up and coming technology. If you're teaching about GIS and remote sensing, then you need to make students aware of drones, and their capabilities is a key part of it now.
>
> (Lecturer [A], Geography)

As shown in the account above, while this is a new technology, already in the eyes of this educator UAVs are now a key part in the area of remote sensing. This shows a progression in UAVs from being used for military purposes to now being an integral part of a subject discipline. This notion that UAVs are now important to the discipline is taken further in such modules by one lecturer using them as demonstration tools for such technologies in remote sensing as he clarifies below.

> The plan is to take the drone to Iceland in May. So one colleague who has the licence leads the Iceland field trip so the plan is to fly the drone across some open glaciated Icelandic landscapes and use that to capture data that students can use in projects or

> you know have some fun with the data. We plan to begin to implement that into the curriculum, but at the moment it's very embryonic.
>
> (Lecturer [B], Geography)

As alluded to by Lecturer A and B the use of UAVs in teaching is very superficial and only used as demonstration tool currently. This can be explained by it still being a new tool for educators, and so they are still testing and "*looking to find opportunities to go and do it within our modules, and that's going to take some time*" (Lecturer [B]). Lecturer B further expressed that he wished to use the UAV for more deeper teaching aspects, but he was limited in his department only having one UAV. As demonstrated in Chapter III and IV resource issues are a key barrier to fieldwork, and this is especially the case with IODs on fieldwork. This barrier comes across into the realms of UAVs, arguably more so as UAVs are far more expensive than standard mobile technologies. Therefore, limited resources for educators continue to be a barrier to effective technology use in fieldwork.

Despite this current superficial use of UAVs, there was recognition that UAVs could be used to their full potential in teaching by lecturers eventually. There is a sense of a willingness to implement such devices into their teaching at some point in the future, depending on regulation and resource availability. Through discussions, it became clear that they saw that the UAV is a "*great idea for teaching*" (Lecturer [E], Geography) and as such, educators highlighted some critical areas in which they believed that UAVs could enhance their ability to teach, as explored below.

5.5.2 UAVs Provide A Different Perspective

Lecturers often cited that the UAV could be a valuable tool in helping students to gain a different perspective of the field location. This was often referred to as a '*bird's eye view*'. How this benefits students is the detail this bird's eye view can offer students in their learning which they cannot get from any other means of technology and certainly not by visiting the location first hand due to the scale of the landscape. One lecturer (Lecturer B) believes that "*studying landscapes is really hard when you're stood in it because the landscape is massive and you can't see a lot of the morphological features because they are such a big scale*" he then goes on to say that "*you can see their form and shape and morphology more easily from above than you can on the ground*". Therefore, he believes that:

> A drone has the potential to utterly transform the way in which you teach and understand a landscape and how it functions and how it's shaped because you can get such amazing visual impression of it from a drone.
>
> (Lecturer [B], Geography)

This different bird's eye view perspective can be utilised for specific fieldwork environments. While Lecturer B talks about the generic use of UAVs offering this bird's eye view, one lecturer offers a specific fieldwork environment example where UAVs can offer a distinct advantage for students. This account talks about how UAVs can be used to great effect for river studies. As noted, it is often impractical due to time pressures of fieldwork to study an entire river profile; therefore, this lecturer argues that utilising a UAV allows students to gain that more in-depth understanding and context of a river system, which they cannot get currently on fieldwork.

> [UAVs] It's great [for] looking at channel morphology and looking at how morphology changes, all that is fantastic. I'm thinking particularly about the trip down the river Dee that's quite a dynamic area. There is a really straight section, and there is lots of meandering sections. So, to show the change [to] give them more than "it's just a bit of water here and it looks like a straight bit of river," you can get a long perspective which you can't get normally.
>
> (Lecturer [E], Geography)

This overview can potentially provide students with an extra piece of data to enhance their fieldwork experience. As shown in Chapter III, it is important for students to get out into the field to explore and solve problems by seeing a landscape in person, however as demonstrated here, there are challenges of scale and not being able to visualise the whole landscape. UAVs, therefore, offer students this additional situational awareness to help them solve such issues or to grasp the scale of the landscape while on fieldwork. This benefit is an extension of mobile technologies being used in Chapter IV for greater situational awareness via applications like Google maps.

When students were asked how they would like UAVs to be used on fieldwork, the two most populous answers were to collect pictures of field sites (n=81) and to collect videos and create 2D maps (n=70). Therefore, what lecturers wish to use UAVs for align well with what students wish to use them for, Fig. 5.1. It would seem that this bird's eye view and additional context of a site, which is valued by lecturers, is also an aspect that students seek.

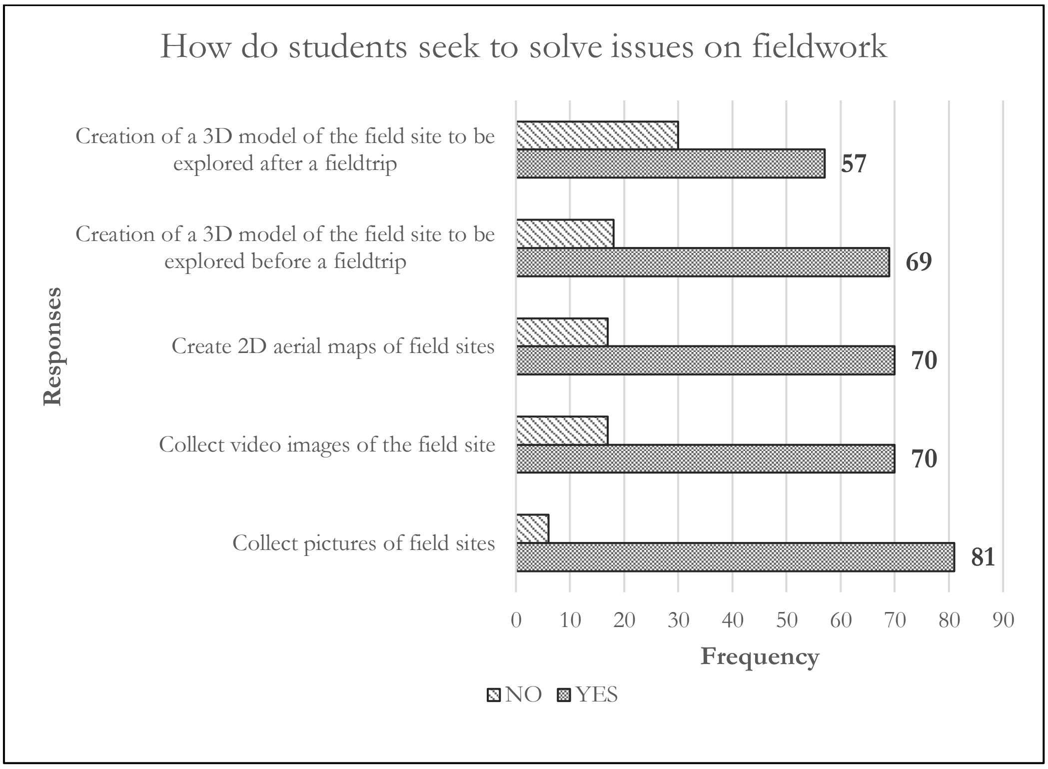


Fig. 5.1 - Students want UAVs to be used for

5.5.3 Accessing Data From Inaccessible Locations

As fieldwork is a vital learning tool by getting students to visit locations, sometimes due to health and safety and risk management, which is an increasing barrier for fieldwork, some locations cannot be accessed. What this means is that while students may be in an area important for their study, they are not maximising their time out in that location due to access restrictions. These restrictions can range from landowner permission such as private land or farms, or may simply be too dangerous for students to operate in. On fieldwork without UAVs, this area of land and any potential data from it would be inaccessible for student learning. This changes with the introduction of UAV technology. All lecturers mentioned the UAV being a valuable tool in being able to enter inaccessible locations to collect data. This discussion often focused around specific environments where UAV operations can play a vital role in this collection of data and the safety of students. One lecturer outlined how using such technology opens up far more learning and data collection opportunities for his students on his fieldwork.

> You can use it to observe places that you can't get to. So like in Iceland you can use it to fly over glaciers where students ain't going to go or terrain they can't access. From my point of view, I take students to coastlines and beaches, and you never go into the

> inter-tidal zone very far because there is an obvious danger sometimes and it's difficult to access but you can look at flying a drone over that no problem. So I think that's one of the advantages is you can get data from locations that otherwise you wouldn't be able to access.
>
> (Lecturer [B], Geography)

As mentioned in the learning theories of Kolb, students must be able to observe before they can reflect. While this is more effective seeing landscapes in person, using such technologies to access these locations from a different viewpoint allows the student the opportunity to observe the landscape in a way they traditionally would not get from the ground. Therefore, it can be argued that UAVs can have a potential learning enhancement over standard fieldwork due to observing locations they cannot access from a bird's eye view perspective.

5.5.4 Increased Data Collection

Closely linked to access of data from inaccessible locations, is the idea from educators that the UAV has the ability to collect data efficiently and quickly in such environments. Lecturers were keen to stress the importance of UAVs in enabling them to collect data that is of a high spatial and temporal resolution. UAVs are a useful tool that can complement both traditional satellite images and aerial survey photographs. Both of those methods of data collection often have good spatial resolution but poor temporal resolution. They can often be costly for departments to obtain, so UAVs can make obtaining this data more accessible, affordable and of better quality for their students. One lecturer mentions how using UAVs on fieldwork could make fieldwork safer and quicker for data collection, especially in changeable conditions such as the intertidal zone on coastal fieldwork.

> I think for coastal environments there is an ideal tool as again working with the tides you want something which is quite responsive that allows you to look at a reasonably large area, get out there and do it quickly and I think drones are ideal in that sort of situation because you can, you know, get it out there and get it ready as the tide goes out and make the most of that two hour window or whatever it is you've got to collect as much data as possible before it comes back in.
>
> (Lecturer [A], Geography)

As demonstrated here, this is another example of UAVs on fieldwork opening up the landscape for learning for which students traditionally on fieldwork would be restricted from accessing. UAVs also allow high temporal resolutions for students that cannot be achieved currently via any method. This access to such data gives lecturers a powerful tool to show students change of a landscape over days, weeks, months and years as he notes that UAVs "*fills a nice niche of that spatial and temporal scales that we want to look at and understand over reasonable large extent that nothing else can easily do at the moment*" (Lecturer A).

5.5.5 Positive Student Thoughts About UAVs On Fieldwork

There is a lack of research investigating the impact that UAVs may have on student fieldwork. However as noted previously, many benefits have been achieved from mobile technologies, and so it is envisaged that benefits, such as time-saving, more efficient ways of collecting and disseminating data on fieldwork will continue with UAV usage. Some of the learning benefits to the student have been outlined here, and there is abundant potential for student learning both pre and post data collection through UAVs (Carnahan, Crowley, Hummel & Sheehy, 2016).

While 90% (n=81) of students would encourage the use of UAVs in this study, overall they also believed that UAVs would be very beneficial for their data collection on fieldwork as echoed by the thoughts of the lecturers. Males, however, had a significantly higher agreement to the statement that "*UAVs will be beneficial for data collection on fieldwork*".

> A Mann-Whitney U test was run to determine if there were differences in benefit of UAVs on fieldwork score between males and females. Distributions of the benefit of UAVs on fieldwork scores for males and females were not similar, as assessed by visual inspection. Benefit of UAVs on fieldwork scores for males (mean rank = 52.03) were statistically significantly higher than for females (mean rank = 38.60), $U = 629.00$, $z = -2.533$, $p = .011$

Students overall believed that UAVs could help to enhance their interest and engagement with the subject with 42% (n=37) of students agreeing and a further 21% (n=19) strongly agreeing to this, Fig. 5.2. Fifteen percent of students were unsure about if the UAV could enhance their interest and engagement and this is to be expected when it is yet to be demonstrated or used on their fieldwork for them to make an accurate decision.

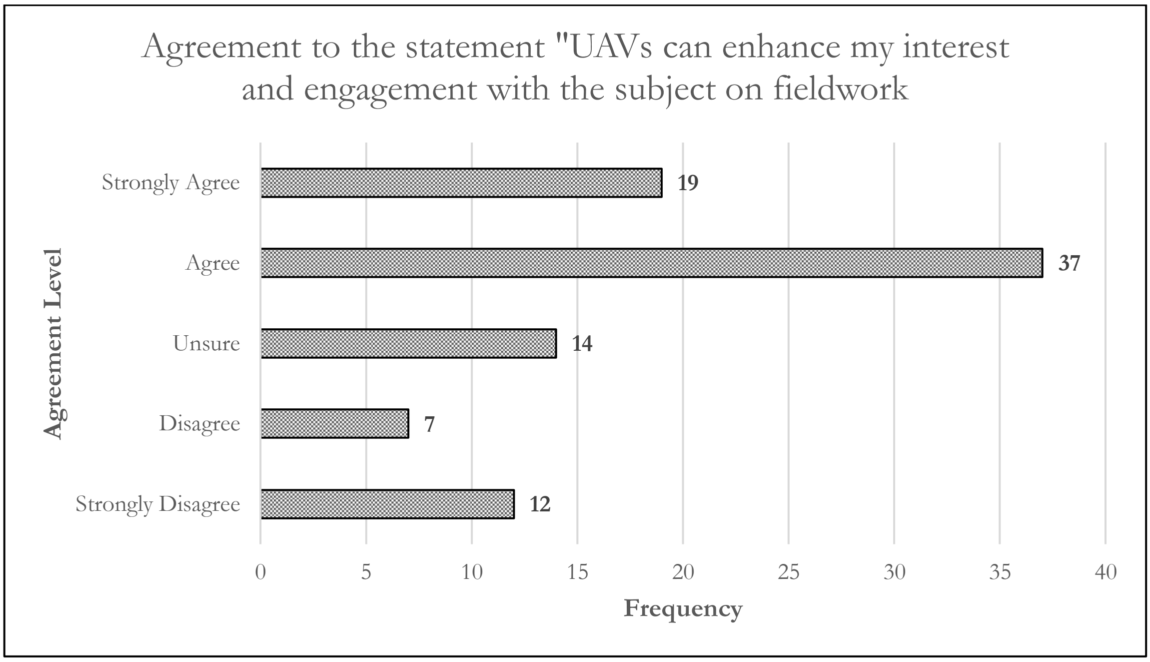


Fig. 5.2 - Agreement to the statement "UAVs can help to enhance my interest and engagement in the subject."

Students stated that they believed that UAVs would increase their data collection skills Fig. 5.3, and more complex technical skills such as photogrammetry (significantly more likely for LJMU students p.007), while male students were significantly more likely than females to want hands-on flying skills to be developed from UAV use on fieldwork, p.045.

A chi-square test for association was conducted between university and photogrammetry skill. All expected cell frequencies were greater than five. There was a statistically significant association between LJMU students and photogrammetry skill compared to UoC students, $\chi2(1) = 7.264$, $p = .007$.

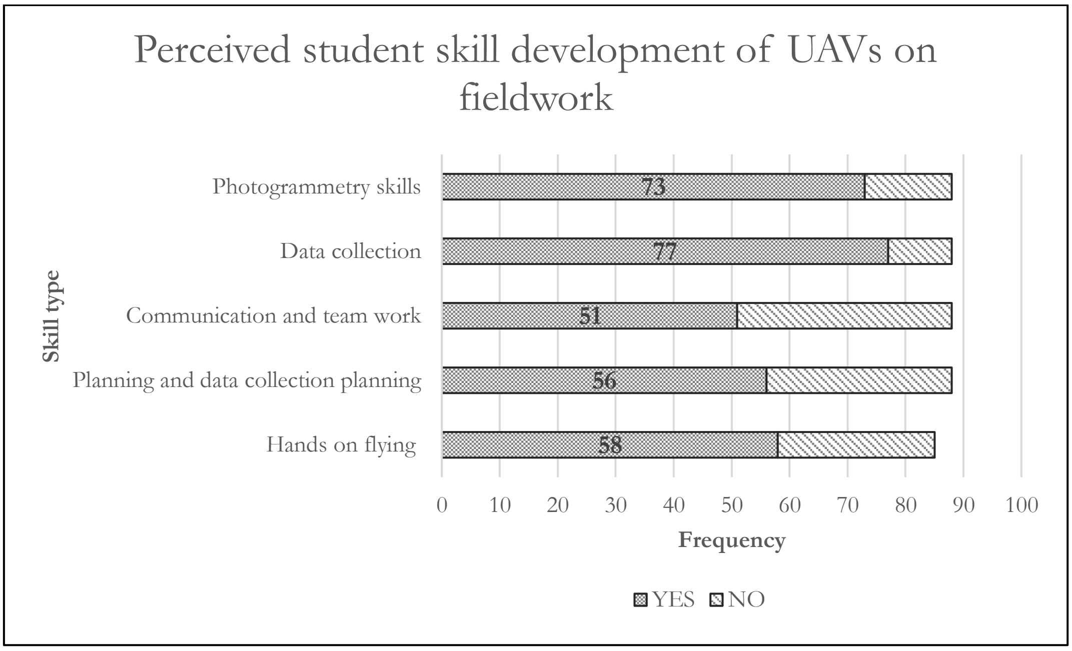


Fig. 5.3 – Student skills they believe UAV technology will enhance on their fieldwork

A chi-square test for association was conducted between gender and aspiring flying skill. All expected cell frequencies were greater than five. There was a statistically significant association between male students and aspiring flying skill compared to female students, $\chi 2(1) = 4.011$, $p = .045$.

Using UAVs on fieldwork can also foster teamwork and independence skills in students, especially in the designing of suitable data collection sites for UAV use that can enhance and deepen their learning by taking ownership of the project (Mitchell & Jolley, 2012; Kelly, Lesh & Baek, 2014). This is an important skill to consider as newer UAVs can fly on a predetermined flight path. This means that students can potentially design and implement a safe flight path to achieve their objectives, even if regulation means that they cannot fly the vehicle itself. There are many tools available to practitioners and students for mission planning of UAVs from negotiating airspace restrictions to obstacles such as power lines.

With UAVs becoming increasingly popular in the commercial world, this graduate attribute may well prove beneficial to future geoscience student employment. Further graduate attributes are also created by using UAVs in fieldwork. Not only are the students' critical thinking, analysis, and decision-making tested in all parts of using the UAV from planning to operating, teamwork is a vital skill needed for UAV flight and is one of the key skills to develop on fieldwork. Regulations suggest that one or more 'spotters' are present during every flight (CAA, 2015) this is to ensure that while the pilot is flying that a spotter communicates any obstacles, changes in weather or any infringements that could affect the safety of the flight. The spotters have a responsibility to communicate and work in a team in order to secure the safe completion of a UAV flight. As such, while normally students cannot fly the UAV there are opportunities during the flight process to still be involved and to enhance their skills. As shown there are many potential ways that UAVs can enhance the learning experience, be that through access and data collection to the development of a variety of skills. UAVs are a mobile technology that can enhance time-saving, data collection and efficiency in learning on fieldwork. However, like all mobile technologies, they have their limitations.

5.6 Barriers to UAV Use In Education And Fieldwork

While lecturers and students were positive about the numerous advantages that UAVs can bring to fieldwork and their teaching, some significant challenges were raised in this research. Some of the challenges outlined are challenges that align to those already observed with mobile technologies on fieldwork such as resources, cost, and concern of damage, yet UAVs offer some unique challenges and hurdles such as regulation and laws. Students in this study had a wide range of concerns when it came to using UAVs on fieldwork.

5.6.1 Laws and Licencing

Laws and licencing concerns were the most often spoken about concerns from lecturers and alluded to by students. While an inconvenience to some, for others, it was the number one barrier preventing UAV technologies being used in their teaching. One of the fundamental issues of UAV regulation, laws, and licencing, is a more systematic issue of UAV laws in the UK being shoehorned into existing manned aviation regulation. UAV regulation is changing rapidly at present in the United Kingdom. Since this research started in the autumn of 2016, there have been three significant changes to UAV regulation in the UK, these changes are set to continue in the near future, and beyond including registration of aircraft, a national system to log UAV flights and age restrictions on those allowed to fly. Nevertheless, until such regulations are created for UAV only purposes outside of traditional aviation law and stabilise into a workable format. Confusion and barriers of regulation will continue to be an issue for those who wish to use UAVs as echoed by one lecturer.

> I think the various aviation authorities haven't quite got their heads around how to handle it and trying to shoe-horn it into existing regulation. Eventually, someone will have time to look at it properly and come up with a sensible way to deal with it, but it's not quite happened yet!
>
> (Lecturer [A], Geography)

A supplementary concern around UAV regulation for fieldwork purposes is that while UAV regulation can be complex in the UK and a challenge, as one practitioner mentioned, regulation globally varies vastly between countries. Such variation poses a distinct challenge if there are plans to use the UAV outside of the United Kingdom on residential overseas fieldwork; this provides confusion and extra time to understand for lecturers.

> Overseas countries some of them are unregulated but a lot of places are quickly becoming regulated, and that's inconsistent across international borders so you can't just assume that you can go to South Africa and fly a drone because I don't know whether you can, but you need to check all of that sort of stuff. So, there is certainly tighter, and tighter legislative requirements that you know could potentially be a hindrance.
>
> (Lecturer [B], Geography)

One potential way to alleviate such an issue is if every country had a blanket set of rules. This seems unlikely however considering the vast array of laws and licencing requirements of each country currently. While there have been some whitepapers and discussions around regulations for European countries adopting a blanket rulebook, this is still a few years away, and this would not be applied to non-EU countries. How this affects the UK in relation to the aviation laws post-Brexit, is still uncertain at present. Therefore, this challenge is unlikely to disappear or become clearer for pilots and operators anytime soon.

Focusing on UK based regulations; as discussed previously is the added complexity of the PfCO and operations manual which adds another layer of regulation and restriction in some aspects to UAV flying. For example, how this can affect fieldwork in a practical sense is that a UAV may have a maximum wind limit set by the manufacturer of 20 knots, but an operations manual may build in a safety margin and set the maximum at 15 knots. While a reduction in five knots may not sound too much of an issue, on fieldwork this could be the difference between collecting data or not. Operations manuals from Universities can often be complicated as experienced by the researcher, and this was alluded to by one interviewee as shown in the exchange below.

> Interviewer: We looked at flying under the [University] ops manual, and we found it quite restrictive.
> Practitioner: Oh, god yeah tell me about it! I think it's in the process of being kind of updated its now in the hands of the health and safety unit. It's not engineering as they used to hold it…so yeah it is very restrictive actually, but it's now not in the hands of an academic it's in the hands of a team which is how it should be.
> (Lecturer [B], Geography)

The issue of operation manuals can be a final hurdle that must be considered for those who wish to take UAVs into their research or for teaching. A restrictive and overly complicated operations manual can be an added barrier; therefore, operation manuals should adhere to all regulations but have a degree of flexibility for the end user.

This issue of regulation for one lecturer was a significant barrier as to why they decided not to pursue UAVs in their teaching as the "*laws and the licencing that completely put me off*" (Lecturer [E], Geography). While those lecturers who had been on the CAA course understood to a passable standard about laws and licencing, the interviewees who did not fully understand the laws and licences had concerns about UAV regulations but for a different reason. While qualified practitioners suggested that regulation could be more transparent or less cumbersome in places, for those who were not qualified, they showed concern in their perception that there was little to no regulation present for UAVs as expressed by one who comments that;

> I can't believe that there isn't a register. I know that it's coming in or it is in now but the fact that it hasn't been one for so many years is just unbelievable. You know literally any man and his dog can fly one, so it's a bit scary if I'm honest.
> (Lecturer [E], Geography)

This issue of regulation was discussed in detail with one student who had reservations about UAVs in general. Throughout the interview, she referred to people using UAVs for purposes of invading privacy and mentioned before the interview that she had looked up the *DroneCode*. The Dronecode is a code developed by the CAA to inform recreational and hobbyist UAV users of the laws that govern UAV flight and can be accessed here: http://dronesafe.uk/drone-code/. When discussing the regulation of UAVs, she was '*surprised at how loose they are*' and believed that the set distances were '*just too whimsical*'.

The perception that the student showed is a common perception held by those who are not involved in UAV operations. This public perception can potentially be influenced by recent media articles about near misses with UAVs and aircraft, especially in light of the drone incident at Gatwick airport in December 2018. There are personal issues too that generate negative perceptions, such as the student who referred to people flying them in her local park illegally.

5.6.2 UAV MALPRACTICE AND DAMAGE

The issue of malpractice by individuals who use UAVs illegally or inappropriately is a concern that is shown by some lecturers and is one of the main drivers in increasing regulation in the UK (UK Gov, 2017). A view by one lecturer is the fear of "*some idiot flies one of these into an aeroplane [and] all of a sudden it's banned*". Therefore, introducing UAV technology into their teaching they are a "*bit reluctant to go whole scale [of using them in teaching] because if something goes catastrophically wrong, the consequence will be grounded until further notice*" (Lecturer [B], Geography). For them, this posed a problem if modules were reliant on data captured from the UAV or promises had been made to students that cannot be kept.

In the questionnaire response to '*What concerns do you have about UAVs being used in your fieldwork*' there were 30 references made by students to damage to the UAV either direct damage or the UAV "*may get damaged if students with no experience were to operate them*" (Q-M-G). Many references are made to the students' concern of damaging the UAV, a common theme as discovered with mobile technologies in Chapter IV, that students show considerable concern about damaging such devices. While some students raised a concern of the cost of the UAV being such a piece of "*expensive equipment*", (Q-M-OE), there is more concern about the student "*having to cover the cost of repair*" (Q-F-OE). Students perceived that UAV equipment is expensive and therefore exercised a degree of caution in their usage, as supported by students in relation to other mobile technologies in this study.

5.6.3 TIME INVESTMENT

To complete the required training and licencing requirement including the creation of the operations manual takes considerable time. As an example, it took the researcher seven months from buying the aircraft, to completing training, developing an operations manual to becoming fully licenced by the CAA by gaining a PfCO. One lecturer explicitly stated that time or their lack of it, was a significant barrier for them to pursue UAVs in their teaching. Time vs reward was a concern expressed as she saw that UAVs were more beneficial for research purposes than for teaching.

> I think they'd [UAVs] be really good for teaching and they are but it has put me off doing the CPD course and listening to your talk as well in September [Enhancing Fieldwork Learning Conference 2017 presentation on UAVs in fieldwork] that really sealed the deal for me just because the amount of work I'd have to put in and I don't feel like I'd get enough out of it at the end really. (Lecturer [E], Geography)

Time is often a limited commodity, as is finance in Higher Education. Departments may well struggle to justify the cost and time taken by lecturers to become fully qualified. While the introduction of mobile technologies has been made to save time and increase efficiencies on fieldwork, while the act of using a UAV does indeed facilitate this, to get to that point takes a significant investment of time. Not only does it take time to become qualified but also to plan a flight legally and obtain permissions for sites can be anywhere from half a day to 6 months for permissions. UAVs are not a quick to use method such as smartphone devices on fieldwork, while they are more efficient at data collection they are not as time or user-friendly as such devices and therefore operators must factor this in if they are to use such devices on fieldwork.

5.6.4 Operational Issues: Weather, Permissions & Privacy

Other operational concerns that practitioners mentioned were weather and permissions. Weather is one of the key operational factors that limit any UAV flying in the UK. It is said that there are around only 125 days of suitable flying in the UK for UAVs. UAVs for commercial operations are limited somewhat by their usage in inclement weather (DeGarmo, 2004). Many commercial UAVs are not waterproof and so cannot be used in such weather (Valavanis & Vachtsevanos, 2014). The primary issue around the safe operation of a UAV is wind speed. Many manufacturers will have a wind speed maximum for the safe operation of the UAV (Langelaan, Alley & Neidhoefer, 2011). Wind is a particularly difficult issue for the flying of a UAV due to the small weight of the UAV it can cause instability and lead to difficulty in conducting the safe operation of a flight (Rysdyk, 2006). In order to comply with CAP722, the flight must be deemed safe to operate which includes the accurate assessment of the weather conditions by the remote pilot (CAA, 2015). For example, the DJI Phantom 4 Pro used in this research had a manufacturer's maximum safe wind speed of 20 knots, which is frequently exceeded in the UK.

If a field course is a single day trip due to restrictions on funding, and planning / timetabling (i.e.) students need to know of a field trip several months in advance) then if the weather is unsuitable that one chance to collect sufficient data is lost. This problem is not unique to UAVs but all fieldwork, especially with mobile technologies unless data from the previous year has been collected as a backup. This weather concern can be alleviated somewhat by longer residential field courses. However, the very nature of UAV technology means a very short set up time that on fieldwork is vital to make the most of any breaks in the weather.

Permissions are another challenge that some may find when trying to introduce UAVs into their teaching or research. UAVs currently do not need permission to fly over land, but they do require permission to take off and land as per the Air Navigation Order (CAA, 2015). Such permission can be difficult to obtain or in some cases can be restricted in a Site of Scientific Interest (SSI) and can take months for clearance. As one practitioner outlined, even when permissions are granted, the restriction can often make it almost impossible to fly.

> I got permission, and I flew there [in an SSI], but it was a very drawn out process to get permission. Lots of paperwork with Natural England and we got permission but in the end that limits our flying time because the ideal time as to not intrude on the public would be early morning. So in the summer at 4 o'clock, it's a beautiful time however they came back and said "No. That's when the birds are feeding and taking off, so you have a chance of hitting them. So can you fly in the middle of the day when the birds aren't flying about?"
>
> (Lecturer [C], Hazards Combined)

Some students saw UAVs as disruptive due to '*the implications of noise and privacy*' (Q-F-OE) while five students mentioned concerns about the '*potential intrusion of privacy*' that the UAV may cause (Q-M-OE). This was a concern raised by two lecturers whom both mentioned stories of members of the public, not understanding UAV operations and privacy:

> I think one of the biggest barriers generally is public perceptions. I think some people just have a big issue with drones for no reason and they don't really know what they're doing and you know you hear all sorts of stories of people out collecting data for perfectly innocent reasons, and they assume that they're spying on them and comes

> over yelling and whatever. So at the moment, it is that public perception and the insurance and safety element that links into that, that is a real barrier to their use.
>
> (Lecturer [C], Geography)

Privacy, as shown above, is still a major concern that the public has when it comes to UAVs for both military and civil uses (Cavoukian, 2007; Calo, 2011; Jenkins, 2013; Finn & Wright, 2016). The issue around privacy for UAV usage is still a contested and a contentious grey area of legislation. There is a debate not just in the UK but globally about what constitutes private or personal space, such as a property (McCosker, 2015). Although the homeowner or landlord own the physical ground around a house or building, the airspace above a building is less defined. In UK law, the airspace above a property and the area below a property is under a 'legal presumption' which means it is undefined unless in the deeds of the property. However, under the legal presumption it states, "Where division is vertical, there is a presumption that the land includes … the airspace above to such height as is necessary for the ordinary use and enjoyment of the land" (UK Government, 2015). However, this assumption of just what height constitutes "as is necessary for the use and enjoyment of the land" being undefined has meant many issues of using UAVs in operation when people and property are involved. Although in the UK a UAV must not be flown within 150m of a property (50m with a PfCO), it does not stop a UAV being 151m away and thus encroaching on individual's privacy.

At present, private property may not be walked on, however, unless a restricted airspace cordon is placed around the property a UAV can fly over it, providing it is following the regulations set out in CAP 722. There have been incidents of people shooting down or disrupting the use of UAVs because they have flown over their property or feel that they are invading their privacy (Cavoukian, 2007). This is a serious offence as to attack or disrupt the flight of a UAV can lead to hefty fines and imprisonment as it is the equivalent of attacking a manned aircraft. Further to this, large parts of the UK such as National Trust land, have a complete ban on UAV flights on their land. In a positive light, this is to protect the privacy and tranquil setting of their land, attractions and any protected habitats. In a cynical mindset, it is an entity 'cashing in' on UAVs as to fly on their land requires a substantial amount of money (upwards of £200 per flight) for permission to fly on their land. This can add cost and limit the areas in which flights on fieldwork can take place.

One student held a specific concern around the UAV affecting animal welfare and privacy due to the noise emitted from the aircraft. Under UK regulations, any UAV should not be flown below 50m above any livestock or animal. However, her concern was as follows about using UAV technology in fieldwork:

> I think out in the wilds we don't know how that's [UAV] going to affect animal life. Either you've got tiny animals on the ground they're just going to think its a hawk, a hawk is going to think its a hawk, so even in the smallest way you're changing the diversity of that landscape you're in a place completely devoid of man, and there are not that many of them left, you're introducing just another element.
>
> (Female, L5 Student, Outdoor Education)

5.6.5 Student Use Of UAVs On Fieldwork

While one lecturer mentioned students flying the UAV on fieldwork for a short period, most lecturers have stayed clear of that. Most indicated that they would have liked to have students operating the UAV but due to regulation, insurance, and safety concerns deemed it to not to be feasible. However, that does not mean that students cannot be involved in some element of the UAV operations on fieldwork as outlined by one lecturer below.

> I must admit I was naive and I did think in the inception of this idea that we could have a drone and they [the student] could have a go at flying it, and I realise now that that is not going to happen now [Laughs]. I can see that I was naive and that's probably the right thing here. Would you really want a couple of students buzzing around with these things? However, that doesn't mean to say that they can't be involved like I have, being an observer for other people using them, learning from the process.
>
> (Lecturer [D], Outdoor Education)

There is a concern by some that students would expect to fly the UAV at some point in their course as reflected in the questionnaire where 66% (n=58) of students indicated that they expected flying skills to come from the introduction of UAVs in fieldwork. Regulation is increasing in the UK, and as of November 2018, any operators of UAVs must pass a CAA approved competency exam. Therefore it is often impractical to ensure a cohort of students passes this online exam in order to fly a UAV on fieldwork. Therefore, any UAV flying by students is highly unlikely and impractical now in the UK for a lecturer to facilitate, and therefore students do miss out on the flying part of the UAV.

One interesting thing which emerged from the data was that while students encouraged the use of UAVs on fieldwork and believed them to be beneficial in their fieldwork studies, they were often very uncomfortable with having the UAV on their field course, Fig. 5.4. What this came down to were students concerns about a lack of flying skill and damaging the UAV.

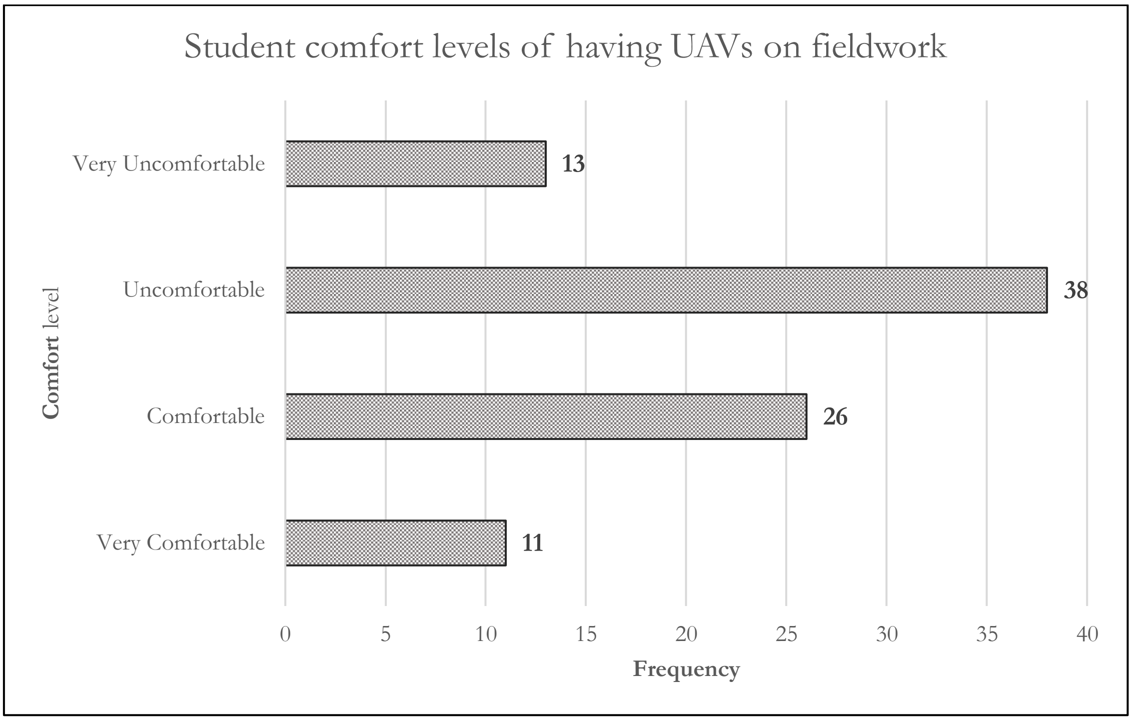


Fig. 5.4 - Student's comfort levels with UAVs on fieldwork

Fifteen students mentioned one of their concerns with UAV technology on fieldwork was simply their lack of experience with UAV technology. Typical responses included "*not knowing how to use them*" (Q-F-G), students being "*unsure of how it works or haven't used it before*" (Q-F-G) and some students being "*not really sure. However, I have never used one and may find using one worrying, making me feel unsure about using it*" (Q-F-OE).

5.6.6 Cost and Procurement

Cost is still an issue for the introduction of UAV technology both in terms of being expensive to acquire and operate but on the other hand also relatively inexpensive. For high-quality UAVs with sufficient battery life, camera, sensors, easy to control flying characteristics and built-in safety such as GPS recovery systems for sufficient research, can cost from around £1000 up to £25000 (Mailey, 2013). These UAVs represent a significant investment to be made by any person, or in the case of their potential use in education, the institution (Morris, 2015). Adequate public liability insurance and training are highly recommended and in the case of insurance, mandatory (ARPAS, 2016). The licencing requirement can cost up to £1500, and the submission of the PfCO is currently set at £175 per year, while spare parts such as batteries must be obtained, so there is a significant cost for a department to operate an aircraft each year.

5.7 CONCLUSION

There are many benefits and challenges to the introduction of UAVs in fieldwork as summarised in Table 5.3. UAVs can be beneficial in teaching through their ability to provide access to data in both high temporal and spatial resolutions, from inaccessible locations, and can provide students with different perspectives of landscapes for their learning. To date, however, their uptake in education is limited. While there are plans by some to implement UAVs and their outputs into the curriculum, currently this is a longer-term vision. For now, it seems that UAVs are used more for research purposes than for teaching. As regulation increases, those who wish to pursue UAV data collection may be put off from doing so.

Table 5.3: A summary of the pros and cons of using UAVs in geoscience fieldwork

The benefit of UAV in Geoscience fieldwork	Negative of using UAV in Geoscience fieldwork
Helps to enhance learning by gaining a bird's eye view perspective of a landscape	Extensive and often confusing Laws & Licencing requirements to operate
Accessing data from inaccessible or dangerous locations on fieldwork	Aircraft can be expensive
Data collected in High Spatial and Temporal resolutions	Limited by small weather operating windows in the UK
Ability to collect photographs, Videos, Digital Elevation models, Orthomosaics & 3D models	Student and Public perceptions of UAVs and licencing
Data allows students to plan research before fieldwork	Malpractice in using UAVs
Quick to collect data	Damage to the aircraft
Student believe they will be useful in their learning	The time investment required to maximise the use of UAVs
Increase student skills such as photogrammetry, data manipulation and data planning skills	Students unlikely to be able to fly the aircraft on fieldwork despite wanting to
	Disruption via noise, privacy and ethics
	Software issues and accessibility

There have been many potential challenges and barriers that have arisen in this research that could affect the uptake of UAVs in Higher Education. Laws and Licencing is the number one concern for lecturers; while UAV flights can be conducted, there is the challenge around staff qualifications, permissions, and perceptions of regulations that are not bespoke to UAV operations. Concerns also range into those that cannot be controlled such as limited flying weather in the UK or malpractice from other UAV users. Students and lecturers envisaged that they would have liked students to physically fly the aircraft, however, in most circumstances, this is not feasible in a UK context. Therefore, there may be some reluctance from departments or students to welcome UAVs into their learning if they are not directly involved.

Nevertheless, there are roles that students can play in UAV operations such as acting as observers and using the data collected by UAVs. As discussed so far, it is more the outputs generated by the UAV that is important for learning, rather than the act of flying the UAV itself. UAVs have been shown to offer students many benefits to their learning and if a lecturer has the time, the resources, and the persistence, then they can become a valuable asset in higher education, and possibly in schools, though the perceptions and attitudes of staff and pupils to using UAVs in schools is yet to be investigated.

UAVs do have the potential be used as useful educational tools for students, but the challenges continue to be a barrier to their mainstream introduction. For now, it has been shown that lecturers see the benefit of UAVs for research rather than teaching purposes. As the best teaching is often informed by research, it is hoped that in the future those who do use UAVs will use this output in their teaching. Perhaps as the cost of UAVs continue to decline and regulation in the United Kingdom becomes more stable, UAVs as an educational tool will become more attractive. UAVs in the future may become the norm in fieldwork teaching, rather than the exception. This chapter has completed the second aim of this research which was *to investigate and document the regulation, the benefits and the challenges of using Unmanned Aerial Vehicles in Geoscience Fieldwork*.

As per the aim, one potential way to increase the benefit of UAVs in geoscience fieldwork and to reduce some of the challenges is to consolidate the benefits of UAVs and the advancement of mobile technologies into one specific learning tool, the 3D virtual field guide. From this data and the challenges posed by regulations perhaps universities should work together to pool their resources of qualified pilots or outsource their data collection to a qualified UAV pilot as a consultant on their field courses. Such a qualified pilot could liaise with the lecturer to understand what data is to be collected and go ahead and collect such data for a fee. This could potentially alleviate some of the challenge of using UAVs on fieldwork by having the main issue of regulations and procurement, costs and training already taken care of.

The following chapter takes this idea further by exploring in-depth the development and evaluation of a specific 3D Enhanced Virtual Field Guide generated in conjunction with a lecturer to enhance students learning on a specific fieldwork location.

The next chapter, Chapter VI details in depth how this EVFG was created and Chapter VII, explores the impact of such an EVFG on a select cohort of Outdoor Education students.

CHAPTER VI: THE GENERATION OF THE VIRTUAL LANDSCAPE MODEL AND THE SUBSEQUENT ENHANCED VIRTUAL FIELD GUIDE

This chapter will explore an accumulation of the previous chapters' work that has led to the creation of an Enhanced Virtual Field Guide (EVFG) developed from data collected by a UAV. Before the model and subsequent EVFG can be presented and evaluated as per aim (3) *To explore and refine how Virtual Field Guides can support authentic learning* and (4) *To evaluate the use of an innovative Enhanced Virtual Field Guide model generated from Unmanned Aerial Vehicle Data*, this chapter outlines what a Virtual Field Guide is. After this brief review, the lessons that have been learnt have been taken into consideration for the development of this specific virtual field guide for students to access in this research. The chapter outlines the location of the field site and an in-depth methodology of the specific workflow and procedures that the researcher took in order to create the model. This chapter will then form an essential contextual understanding for the next chapter, chapter VII, which answers aim 3 and 4 of this study.

6.1 WHAT ARE VIRTUAL FIELD GUIDES

As discussed in the previous chapters, the introduction of technologies from smartphones to UAVs have changed the way fieldwork is conducted. One area in which technologies have enhanced education is through their ability for collaboration (Becker, Cummins, Davis, Freeman, Hall & Ananthanarayanan, 2017). Now more than ever there is an abundance of accessible, collaborative rich data sets created online in communities from amateurs to professionals, which both educators and students can access to enhance their learning environments (Litherland & Stott, 2012).

Virtual Field Guides, *Virtual Field Trips* or *Virtual Fieldwork* are terms used interchangeably throughout literature, yet they are contested concepts with varying definitions (Litherland & Stott, 2012). Virtual Field Trips, in essence, try to capture the real world environment of a specific location or region through a collection of data, photographs, cartography and other technologies such as GIS, without the cost of physically being there (Carmichael & Tscholl, 2011).

The aim of the virtual field trip at present has not been to replace the traditional field trip but to introduce students to the fundamental skills needed to understand their environment before going out on the 'real' field trip (Gilmour, 1997). Due to the lack of "virtual" such as being immersed in a 3D augmented reality, the term Virtual Field Guide (VGF) will be used from here on, instead of a virtual field trip. Throughout this chapter and the following chapter the term Virtual Landscape Model (VLM) is used in conjunction with the term VFG and EVFG. A VLM is the reconstruction of the physical environment virtually in 3D form (Adriaensen, Chardon, De Blust, Swinnen, Villalba, Gulinck et al., 2003). A VLM becomes a VFG when additional information is added to the VLM for learning purposes. For this research UAV data is used to create a new VFG which is referred to as an Enhanced Virtual Field Guide (EVFG).

VFGs are often a repository of various data, yet what makes them more than just this, is an element of educator-led discussion situated within a framework of tasks to be completed (Stott, Litherland, Carmichael & Nuttall, 2014). Some VFGs have tried to create an opportunity of travel for the students without ever leaving the confines of the classroom. For example, in the VFG created by Jacobson, Militello & Baveye (2009) the guide was broken down into days and stops with specific tasks to be completed at each one, much like a real field trip. Older VFGs are more simplistic by making data available such as photographs, maps or videos with tutor-led commentary for students about the specific location (Baggott la Velle, 2005).

Spatial scale is of vital importance for geoscience disciplines and must be taken into account when considering VFGs (Jones, McCaffrey, Clegg, Wilson, Holliman, Holdsworth et al., 2009). The scale of VFGs often differs depending on their purpose and their aims (Ramasundaram, Grunwald, Mangeot, Comerford, & Bliss, 2005). Spatial scale in VFGs can be small-scale providing broad overviews of topographical data such as mountain ranges (Stott, Nuttall & McCloskey, 2009; Eusden, Duvall & Bryant, 2012) and national parks (McMorrow, 2005). Small spatial scale VFGs can provide a student with a deeper understanding and situational awareness of the topic or location that they are studying (Jacobson et al., 2009). Often students do not maximise their time on fieldwork due to lacking the bigger conceptual picture (Falk, Martin & Balling, 1978). Providing an extensive overview of a field location helps a student to formulate ideas and apply knowledge to how that field site sits within the wider world. Small-scale VFGs, however, lack finer details, for example in the VFG designed by Arrowsmith, Counihan and

McGreevy (2005) students anecdotally mentioned that they misinterpreted the distances between sites and that steepness of gradients were vastly underestimated.

Larger spatial scale VFGs provide the opposite in the sense that they are highly detailed and can vary from meters of a walking path to a smaller section of a cliff face (Pringle, Westerman & Gardiner, 2004). Larger scale VFGs are more practical as they replicate what would be seen if a student were to visit in reality (Jones et al., 2009). Details are more visible at this scale, with individual rocks and trees shown in high detail that allow students to explore and research in depth. At this scale, it further facilitates students' skill development by practising skills here that they may use on real fieldwork that would be difficult with a smaller spatial scale VFG. However, larger scale VFGs are large regarding data size due to their high detail, and so when creating a VFG, there must be a trade-off of between scale and detail (Arrowsmith et al., 2005).

6.1.1 Standardisation

One issue with VFGs is their lack of standardisation. While there is no agreed spatial scale for VFGs due to their varying purpose and nature as commented on by Arrowsmith et al., (2005) multilayers of VFG scale that are all linked to each other provide the best learning experience for students. In their study, they had a three-scale approach that incorporated small to large spatial scales. The first VFG was a small-scale overview of an entire park; the second was a larger spatial scale of the area in which they would conduct most of their fieldwork and finally a large spatial scale that was a site-specific VFG was developed with a geospatial link between all three 'nested' models. A summary of the benefits and drawbacks of VFGs see Table 6.1.

Table 6.1: Benefits and Drawbacks to Virtual Field Guides

Benefits of Virtual Field Guides	Drawbacks of Virtual Field Guides
- Relatively cheap to create	- Can be challenging to create and requires a level of technological competence
- Easy to update, adapt and change	- Lacks virtual in the true sense of immersion in the digital environment
- No real limitations on size or scope	- Still hindered by lack of technology, i.e. computing power/ virtual reality
- Helps develop skills for students before going on real fieldwork	- Students can get lost and disorientated in the virtual world
- Provide inclusivity benefits to disabled and disadvantaged students	

- Can replicate seasonal change of a landscape
- Allows a student to revisit over and over again unlike a real field trip
- Allows students to develop skills in a controlled environment

6.2 Creation Of The Thurstaston Enhanced Virtual Field Guide

So far fieldwork, mobile technologies in fieldwork, and UAVs have been explored concerning students learning. One output that can combine all of these elements is the VFG. As alluded to in the previous chapters, new technological advancements can enable better and more sophisticated approaches to learning to occur. This technological advancement can also transcend into making more sophisticated VFGs, which was not possible a few years ago. In this research, taking lessons from the evaluations of fieldwork, mobile technologies, and UAV use in education, the researcher brings all of this together into the development of a dedicated enhanced VFG for a small cohort of Outdoor Education students. This EVFG was developed from literature, primary UAV data and feedback with staff and students through semi-structured interviews. This development is somewhat of a different approach to the development of educational technologies where they were developed and then evaluated afterwards. Instead, this EVFG was developed with the needs and wants of both staff and student to ensure the EVFG was a benefit rather than a hindrance to learning. This EVFG is a large-scale VLM of a field site that students visited as part of their final year module. This chapter outlines in detail how what is known so far was brought together and facilitated by the data collection techniques enabled by the UAV to create a dedicated VFG for learning.

6.2.1 Structure From Motion

In order to create a new and enhanced VFG of a field site, data had to be collected and processed under specific methodological procedures. The generation of 3D polygonal models of field sites has been a developing area for many years. However, such models are often created through expensive techniques such as airborne and terrestrial laser scanning e.g., (Lohani & Mason, 2001; Rosser, Petley, Lim, Dunning, & Allison, 2005; Heritage &

Hetherington, 2007; Jones, Brewer, Johnstone, & Macklin, 2007; Hodge et al., 2009; Notebaert, Verstraeten, Govers, & Poesen, 2009). Such systems are often costly and complex to operate to achieve their desired results. A relatively new technique for the generation of 3D models of the environment in geoscience is a technique called *Structure from Motion* (James & Robson, 2012; Westoby, Brasington, Glasser, Hambrey, & Reynolds, 2012; Micheletti, Chandler, & Lane, 2015; Smith, Carrivick, & Quincey, 2016).

Structure from Motion (SfM) is an area of photogrammetry that essentially creates a 3D structure from a series of overlapping offset images (Westoby et al., 2012). These images are often around a particular object in one plane of movement; however, more accurate results can be obtained through the collection of images at different angles and planes such as vertical top-down images, to side on horizontal images.

SfM was developed in the early 1990s (Spetsakis & Aloimonos, 1991) and incorporates and builds upon the development of automatic feature-matching algorithms in the previous decade (Forstner, 1986). How this differs to traditional methods is the camera positions, locations, and angles are not necessarily needed to be known in order for the model to be generated (Carrivick, Smith, & Quincey, 2016). Further to this, SfM does not require complex systems or data collection devices and instead can be achieved through smartphone cameras and digital DSLR cameras (James & Robson, 2012). The fundamental processing of the images is through a series of algorithms that align and create a localised space through the mapping of specific parts of the overlapping images. It is from this that the algorithms can orientate the model to create a 3D structure. This 3D structure is accurate relative to the images in a '*local space'*. Knowing the camera positions can increase the accuracy of the models and can then be transferred to a real-world physical space if need be (Smith et al., 2016).

SfM, therefore, opens up the 3D mapping of a landscape through the collection of still images from for example UAVs. UAVs have proved to be an effective tool in collecting images to reconstruct large areas of land from different angles c.f (Lucieer, et al., 2014; Ryan, Hubbard, Box, Todd, Christoffersen, Carr, et al., 2015; Woodget, Carbonneau, Visser, & Maddock, 2015; Clapuyt, Vanacker, & Van Oost, 2016; Tonkin & Midgley, 2016). This research, therefore, sought to create a Virtual Landscape Model from SfM via a UAV and develop such a model for educational purposes into a dedicated VFG.

SfM can have complex algorithms and procedures, and for this research, such algorithms are embedded within the software used, *Agisoft Photoscan*. However, in order to create the model from SfM, Agisoft outline a 'Work-Flow' that needs to be followed in order to create the model. This workflow was adapted by the researcher to incorporate the set procedures developed for the capture of data from the UAV.

6.2.2 UAV Used In This Research

In order to use a UAV for SfM of a field site and to evaluate its effectiveness as a tool for model generation, a UAV had to be procured for this purpose. Many UAVs could be used in this research, but the primary purpose of this research was to use tools that are available at a relatively low cost and that do not require any expert operations or the need for extra expensive equipment. Therefore, it was decided the *DJI Phantom 4 Pro* was to be used for this research, Fig. 6.1.

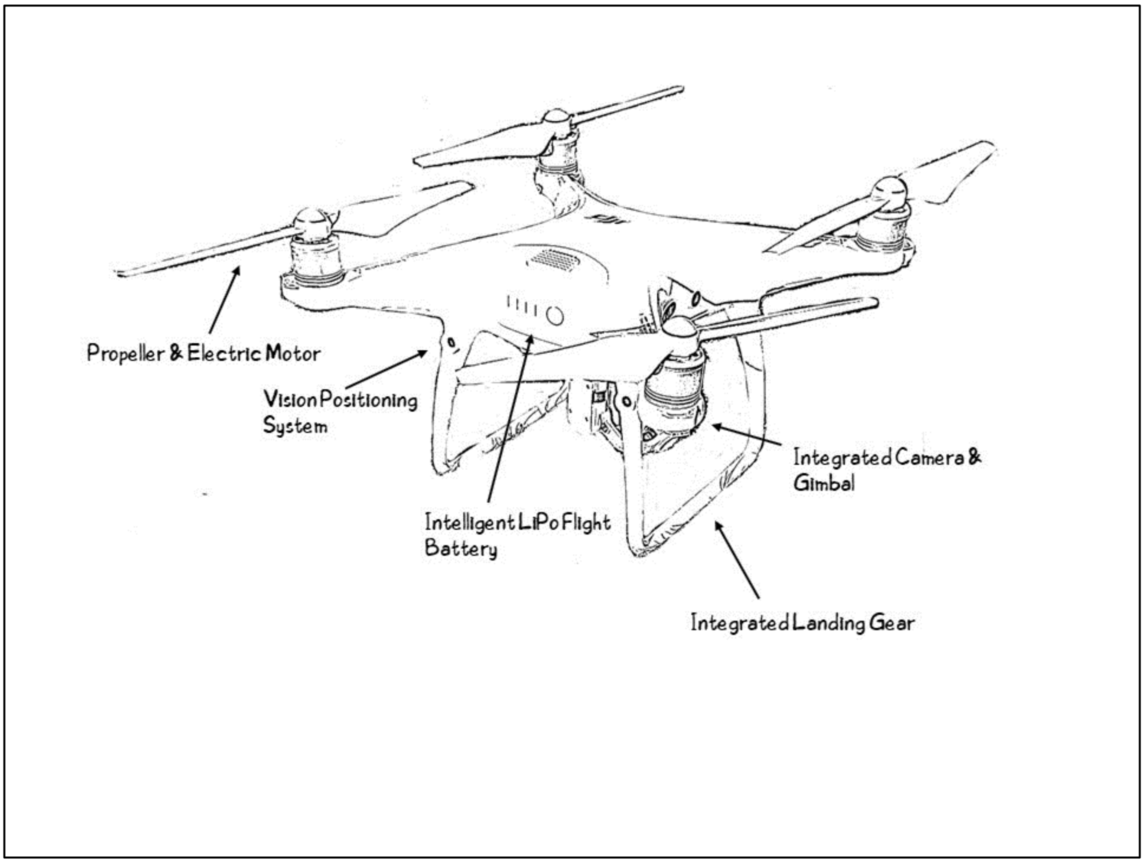


Fig. 6.1 - DJI P4P outline

The DJI Phantom 4 Pro was at the time (February 2017) the most advanced and most sold commercial UAV on the market with 70% market share in UAVs over £1000 (Valentak, 2017). The DJI Phantom 4 Pro is a Quadcopter that weighs 1388g. This UAV is equipped with a 15.2v Intelligent LiPo 45 flight battery with a capacity of 5870 mAh that equates to around 30 minutes of flight time. Importantly for this research, the aircraft is fitted as standard with a camera and gimbal as an integrated system. The camera, which is integrated into the gimbal assembly, is a small camera that can take 20-megapixel stills and video of up to 4096x2160p at 60fps. The gimbal operates on a 3-axis basis providing a stable platform for the attached integrated camera. The gimbal has a 120^0 tilt angle. $+30^0$ from the horizontal and -90^0 from the horizontal 0^0 degrees, which is useful for SfM photography.

Safety features of this aircraft include the use of both GPS and GLONASS satellite systems to ensure redundancies are in place for keeping the required satellite number at 6. This aircraft includes 360-degree vision system and infrared system that helps to avoid collisions with objects under certain conditions. The aircraft has three primary flight modes, Position, Sport and Attitude mode. It has further intelligent flight modes, and they are as follows; Course Lock, Home Lock, Point of Interest, Follow Me and Waypoints (more detail in appendix Q). The cost of the aircraft at the time was £1800 in February 2017.

This aircraft was chosen due to its proven safety record and high-quality optics for a relatively small cost. What UAV SfM often lacked was sufficient quality optics and stability of the platform while flying to produce effective images (Clapuyt, et al., 2016). This aircraft, however, had multiple systems to ensure stable flights in a hover, which is important for clear images. This aircraft combined GPS and its vision system for stability to high degrees of accuracy. In *Position* mode, providing the winds were within the manufacturers limit can hover stably over the ground with a movement over a single point in a hover of: Vertical with Vision Positioning +/-0.1m; GPS positioning only +/-0.5m. Horizontal with Vision Positioning = =+/- 0.3m; GPS positioning only =-1.5m.

Of most useful for SfM data collection was the aircrafts *intelligent flight modes* of which one, the *point of interest* mode was a novel and effective tool for SfM data collection. This mode enables the aircraft to circle around a designated point of interest selected by the pilot. To activate the mode, the pilot will fly over the designated point of interest with the camera orientated 90^o downwards. Once over the desired point of interest, the pilot selects "OK" and will then move away at least 5m from that point laterally. The pilot will yaw the aircraft so that the camera is now facing at the desired point of interest. Once at the desired distance away, selecting start and the aircraft will continue to circle the object. The pilot can control direction (clockwise/anticlockwise), height via the throttle control and speed using the speed indicators on the GO app. This setting means that a perfect 360^0 profile of an object can be achieved, making SfM more accurate and more manageable from a UAV in this mode.

The DJI Phantom 4 Pro was also chosen due to the manufacturer DJI being a commercial leader in commercial UAV products (Borak, 2018). In practice, what this equates to is accessibility and compatibility with a number of third-party software providers which is beneficial for the collection and post-processing of data. Such compatibility makes the replication of this model in this research by others easier, as all software and hardware used in this research can be accessed by non-specialists and operated on the notion of 'out of the box and play' which is an important mantra that runs through the creation of this model.

6.2.3 Enhanced Virtual Landscape Model Generation Workflow Part A

In order to create the VLM, the researcher had to follow a specific workflow. The workflow while somewhat long is a relatively straightforward process with the software taking the main workload. Those using this software only need some specific knowledge of systems and some computer code in order to recreate the digital environment from the images accurately. In Fig. 6.2, the adapted workflow to incorporate the UAV data collection is shown and will be outlined more in detail throughout this chapter.

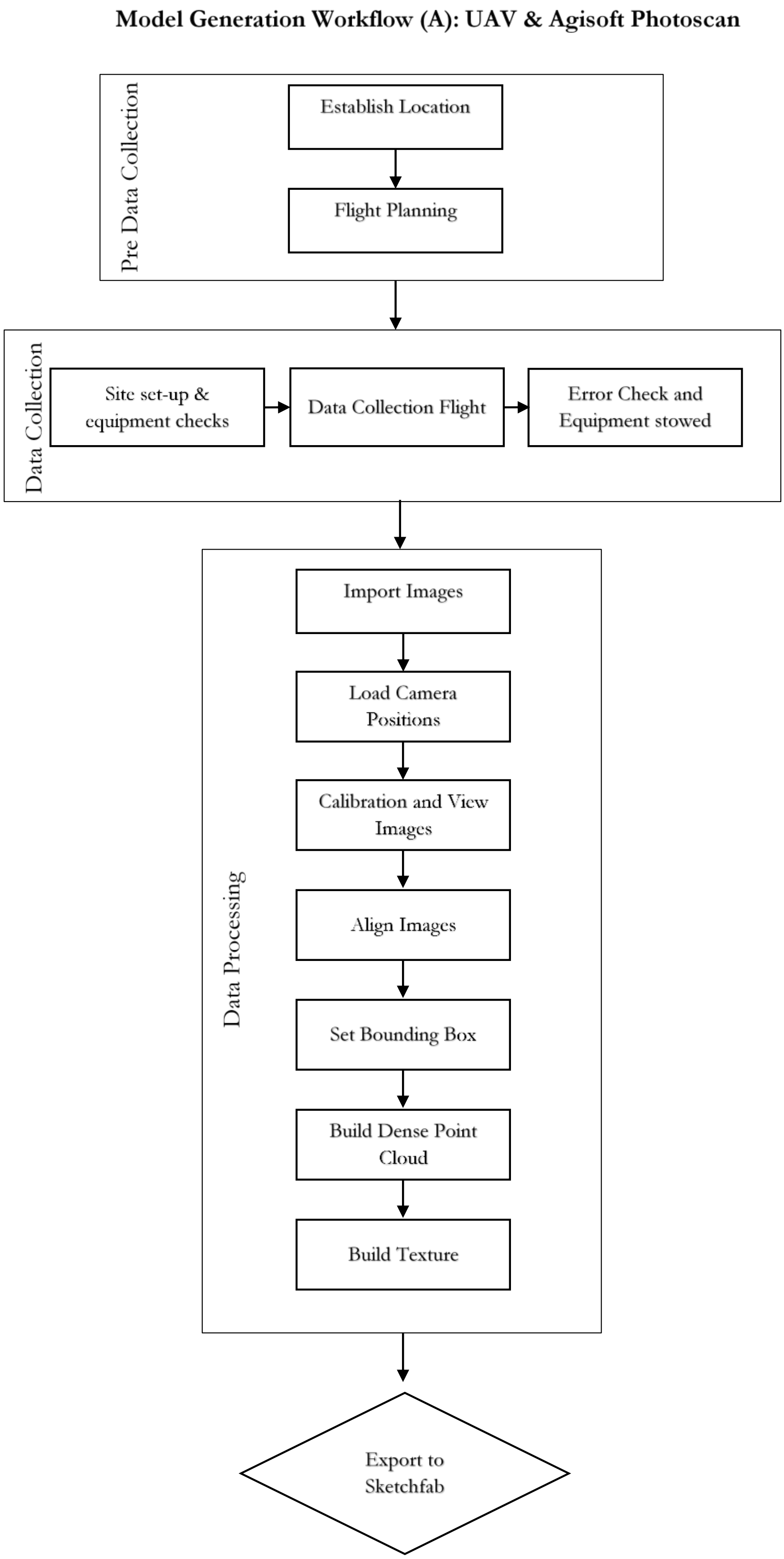


Fig. 6.2 – Enhanced Virtual Landscape Model Generation Workflow (A)

6.2.4 PRE-DATA COLLECTION

The location of the field site was determined by accessibility to students, and it was decided that in March 2018, a cohort of final year Outdoor Education students would be visiting Thurstaston Cliffs, as part of their 6035OUTDOR: Evolution of Glacial, Fluvial and Karst Landscapes module. This trip is run every year in the department and usually takes place early in the year. Once the location was established, the researcher set about planning the flight in accordance with the operations manual.

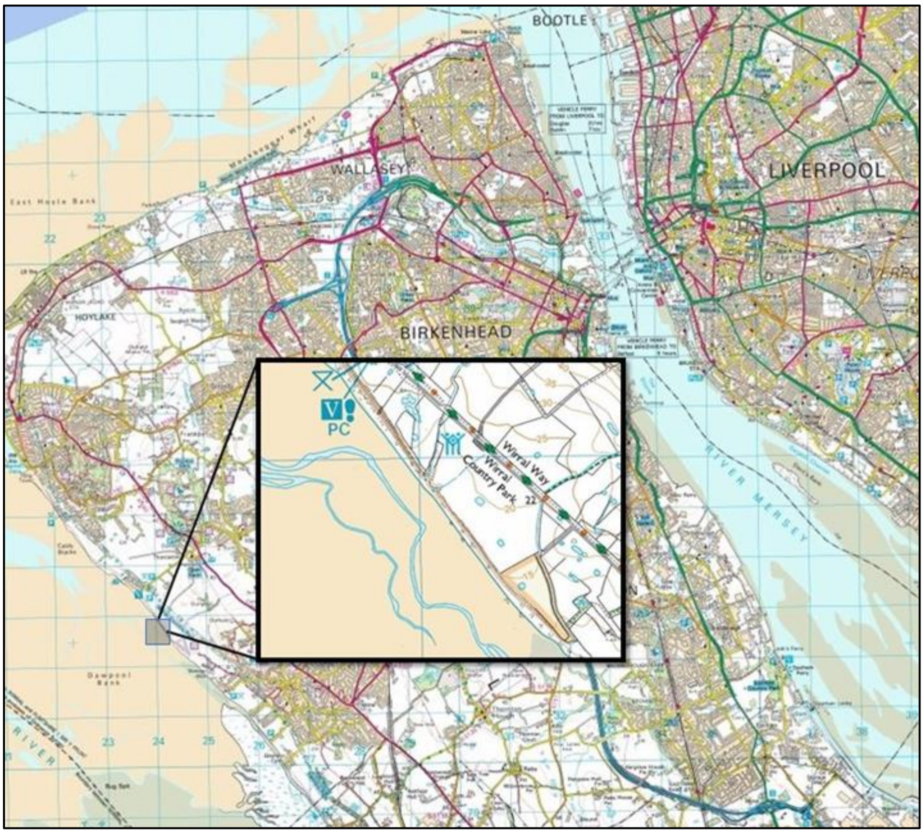


Fig. 6.3 - Location of the field site (Ordnance survey map 1:50 000, 2015)

6.2.4.1 Establishing a location

Thurstaston cliffs are a well-researched geographical site. The site is situated on the North East bank of the Dee Estuary on the Wirral Peninsular, Fig. 6.3. The Wirral Peninsular is located to the South West of the river Mersey and the Liverpool Bay area. Thurstaston has been a site that has been well researched due to the finding of glacial deposits (Glasser, Hambrey, Huddart, Gonzalez, Crawford & Maltman, 2001). Many Glacigenic sediments are persevered here and are easily accessible to investigate (Brenchley, 1968). The site and surrounding Irish bay area have been used by researches to understand the deglaciation process that occurred with the retreat of the Irish Sea Glacier. Many authors have investigated the site and the surrounding areas through varying lenses, such as glaciomarine conditions (Eyles & Eyles, 1984; Eyles & McCabe, 1989), Stratigraphic and Sedimentary (Thomas, Chester, & Crimes, 1998) and Paleontological (Austin & McCarroll, 1992).

Thurstaston has many cliffs that are made up of upper and lower boulder clay that are accessible at low tide. Part of the students course is to investigate the sedimentary composition of the clasts that are present. An assignment is set for which students must use data collected on the field course along with established research, to make an informed decision about how the glacier retreated. Current LJMU Outdoor Education students spend one day around the site collecting Clast orientation, size, shape and rock lithology. One of the issues that educators and students face is the inability to access the clasts that are present higher up in the cliffs due to safety reasons, Fig. 6.4.

Fig. 6.4 - The Field site and cliff

Currently, the students can only visually assess the clasts from the beach, and only measurements of clasts and rocks that are accessible from the beach can be investigated. The top of the cliff is inaccessible due to it being private farmland and potentially the cliff top is unstable and therefore dangerous. Consequently, the UAV was used to create a 3D model of the cliffs along with a detailed Orthomosaic 2D map which students and educators could use to look in detail at the clasts that are present in the inaccessible cliffs.

6.2.4.2 Flight Planning

In order to fly the aircraft safely for mapping purposes, the pilot must plan the data collection flight in detail covering the following as per Part B section 1 of the operations manual, which includes the following:

- Airspace
- Airports & Airfields
- Hazards (Airspace)
- Local Bylaws
- Hazards (Ground)
- Habitation and Recreational Activities
- Public Access
- Permissions
- Alternatives
- Weather
- Risk Assessment

The above will not go into detail in this thesis although such information can be found in appendix Q. What this shows, however, is how much detail goes into planning a flight with a UAV for data collection purposes. The most fundamental barriers to UAV flying are airspace and airspace hazards, public access, and weather. While the foremost two can be overcome to an extent, weather cannot. The wind speed must be 15 knots or less at the point of take-off and for best image quality for photogrammetry; the skies should be overcast but clear of precipitation. For mapping purposes, the ideal wind speed should be less than 10 knots, as an increase in wind speed can induce motion blur to the images and create issues with flight leg width and stability (DroneDeploy, 2018). Overcast skies reduce harsh shadows and colouring in the images which can affect the stitching process of the images. If the skies are clear, it is recommended that a mapping flight take place when the sun is at its highest to offset the length of the shadows (DroneDeploy, 2017).

For this research and this particular flight, the weather and the issue of negotiating tide times to comply with the weather and access to the site was a particular challenge. In order to collect sufficient data from the UAV from SfM two types of flying of the UAV were needed: oblique images and 360 images. To obtain these, the UAV was programmed using the DroneDeploy flight planning software to fly a set aerial survey flight to capture top-down oblique images. One benefit of having dedicated UAV Photogrammetry software is the ability to plan flights on a desktop PC and then store such information to use out in the field. Using the desktop application allows the pilot to plot a flight path for the aircraft to fly taking into account battery performance, height, speed and direction. By using these different parameters, the pilot can work with the educator to gain the best images of the site with high enough clarity and resolution. Prior flight planning on such software allows simulations to be run so that the pilot can ensure that the aircraft will cover the requested area, will clear all terrain and hazards, and can estimate the number of images that will be collected.

To collect the SfM data, the pilot was to fly the aircraft manually around the cliff in question to collect oblique photographs at varying heights and angles in order to create a 3D model. Such a flight must be planned for in advance but can only be put into action once at the field site, as it requires pilot inputs rather than autonomous flight and monitoring as above.

6.2.4.3 Placing the flight path

Using the DroneDeploy software that is connected to Google Maps satellite view, the location was searched for, and this transposes a small 1-Acre box over the area. This box was then manipulated into covering the area that was to be mapped. In Fig. 6.5, the final flight path was constructed covering an area of 9 acres.

Fig. 6.5 - Flight Path over research area for aerial survey

The flight path can be manipulated within the flight box by changing various aspects of the aircraft's flight profile. Altitude and flight direction can increase or decrease flight time depending on the option chosen. The higher the aircraft flies the quicker the data can be gathered, however, the quality, in this case, the pixels per inch, are reduced (DroneDeploy, 2018). There is a compromise to be made between speed and quality. Here is where the simulation aspect of the software can give the researcher an idea of flight time and expected quality. The flight direction is changed to ensure that the aircraft follows a traditional photogrammetry aerial survey pattern. It can also be used to make sure the aircraft has a head and tailwind across the planned legs. A crosswind can make inconsistent leg widths and introduce motion blur to the completed image and model.

Side Lap and Front Lap

Further adjustments can be made for the flight in question. Side lap is set to 60% as a default. Due to the nature of the research site having only small distinguishing features due to the vast majority of it being sand, side lap was increased to 75%. Side Lap is used to ensure that the software can match more features per picture, especially useful in areas such as tree canopies or sand. For environments like sand, it gives the software a greater chance of matching individual and unique points for stitching. An increase in side lap does nonetheless increase the time the aircraft is in the air, as the legs are closer together and therefore more legs are needed to cover the same area.

Increasing Front lap ensures that the camera will guarantee that the next image will incorporate 75% of the previous image. An increase in front lap provides the best chance for the software to ascertain patterns and unique structures to help with the stitching process. Increasing the front overlap does not increase flight time but does improve the quality of the final model or orthomosaic. An example of this in practice is demonstrated in Fig. 6.6.

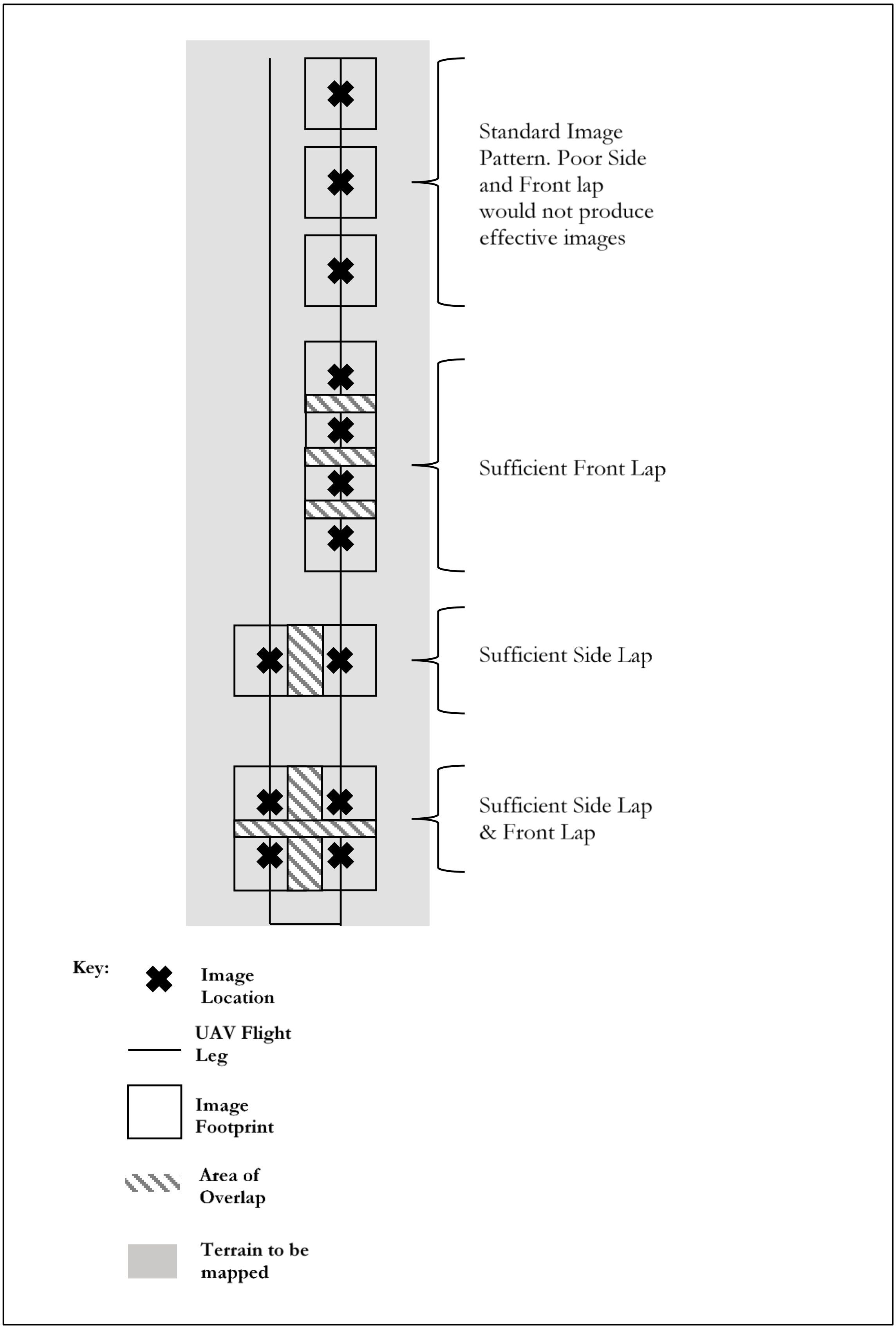


Fig. 6.6 – Demonstration of sufficient front and side lap during mapping

6.2.4.4 Aircraft Speed

The speed of the aircraft can also be altered. The quicker the aircraft is allowed to fly, the quicker the mission can be completed. Under the DroneDeploy software, the aircraft can fly at a minimum speed of 1mph and a maximum of 34mph. An increase in speed also reduces the quality of the final product due to the introduction of motion blur. It is recommended that flying speeds between 8 and 12mph are optimum for high-quality images vs flight time. Once the flight plan has been created, the flight is saved and sent to the DroneDeploy application on a mobile device with which the aircraft will communicate once on site via wifi. In the present example, a 10:56 minute flight time covering 9 acres generated a potential maximum resolution value of 0.7 inches per pixel.

6.2.5 PREDETERMINED POTENTIAL RESOLUTION & ERROR

As the data is captured from the air, two types of accuracy that have relevance to the maps and models are created from the UAV data. They are Relative (or Local) accuracy and Absolute (or Global) accuracy.

6.2.5.1 Relative (Local) Accuracy

Relative Accuracy (RA) is the accuracy between a point on the map or model relative to other points within that map or model. The maps that are created have a RA as all the images have been taken in the same area and processed in the same way. The RA of the maps and models created in the DroneDeploy software depends on the *Ground Sampling Distance* (GSD) of the map. GSD is the distance per pixel, usually given per cm or per inch. The smaller the distance between pixels then the more accurate and higher resolution the map is in relative terms (DroneDeploy, 2018). The DroneDeploy software expects the relative accuracy to be around 1 to 3 times the average GSD. For example, if the GSD of the map were 0.6 inches per Pixel, that would give an average relative error of 1 to 4 cm of error. DroneDeploy automatically calculates the GSD of the map. However, manual calculations of a GSD can be made before the flight to predict what expected GSD could be achieved.

The formula for GSD as outlined by Goncalves & Henriques (2015):

$$GSD = \frac{H}{f} \cdot \frac{\alpha}{\beta}$$

Where H is the height of the aircraft, *f* the focal length of the camera, α is the height dimension of the sensor and β the pixel height.

For an example from the Thurstaston virtual landscape model,

$$GSD = \frac{50m}{8.8mm} \cdot \frac{13.2}{4096} = 1.83\ cm$$

In principle, this means that any measurements made within the model generated in this research would have an RA of +/- 1.83 cm to 7.32 cm.

6.2.5.2 Absolute Accuracy

Absolute Accuracy (AA) is the degree to which the calculated position of a point on a map corresponds to the actual point on the Earth's surface. Many things can degrade the absolute accuracy of the map, such as camera model, lens distortion, altitude and GPS errors (DroneDeploy, 2018). If data were not captured with Ground Control Points (GCP), then it would have been impossible for the software to determine the exact AA of the map. If GCPs are included, then the AA of the map can be known to within 2-5cm horizontally and 4-8cm vertically. Without such GCPs the software uses an algorithm based on the aircraft model flown, the known height from which an image was taken and the GPS co-ordinates attributed to each image allowing the software to make an expectation of accuracy of the data. GCPs were not available to the researcher during data collection, and therefore the AA is automatically calculated by the DroneDeploy software.

6.2.5.3 RMSE – Root Mean Squared Error

The *Root Mean Squared Error* (RMSE) is measured across three dimensions *X Horizontal, Y Vertical, Z Depth*. The DroneDeploy software calculates a RMSE for the model, which is the root, squared mean error across all three dimensions. This error is the average error of where the GPS believed the camera to be at the time the photograph was taken and where the software calculated the camera needed to be, in order to make the overlapping images stitch. As an example, the images taken in this data collection had an RMSE of 3.4 feet, this means that the VLM created, and subsequent outputs such as Orthomosiacs and Digital Surface Models are +/- 3.4 feet in all dimensions compared to the actual real-world site. While this is not suitable for detailed scientific analysis, such accuracy from the UAV alone is surprisingly accurate and was deemed more than sufficient for undergraduate teachings. As outlined, if GCPs are used then this RMSE can be reduced to a few centimetres.

6.2.6 Data Collection Flight

Once the flight was planned, and the first autonomous flightpath was uploaded to the aircraft, the researcher along with an observer made their way to the Thurstaston site. Before any flying could take place, the remote pilot (the researcher) had to ensure that the site was suitably set up for flying of the UAV. This set up consisted of a detailed pre-flight walk around which provides the pilot with a visual refresh of the area and allows the pilot to place everything in the flight planning report into context. This walk around helps to increase the pilot's situational awareness. Now on site, the remote pilot completed a detailed *Site Assessment* form, parts of this are completed as part of the flight planning form, but it must be finished off on site, typically, this includes any local hazards that can only be viewed in person.

Once the remote pilot was satisfied that the site was safe to conduct the flight, a final check of the weather was made. The weather on the day was measured by a handheld anemometer to be on average 9 knots but gusting up to 14 knots, which is 1 knot below maximum. The pilot handed the anemometer to a member of the research team who was the designated *Ground Crew Observer (GCO)* for the day’s mission. The GCO monitored the wind over a period of five minutes, while the remote pilot followed the assembly checklist for the aircraft. At no point did the wind reach 15 knots, so the remote pilot elected to carry out the mission on the proviso that the GCO continuously monitored the wind. A GCO is any member of the flight team who is chosen by the remote pilot to help conduct the flight as safely as possible as outlined in Part A: Section 8.1 of the operations manual which includes *spotting, incursions, emergency procedures* and *site set up*.

The remote pilot then assembled the aircraft and tested the flight systems before giving the GCO a pre-flight briefing as per the procedure in the operations manual Part B: Section 2.4 that states:

Crew briefing must be given before the start of flight by the Remote Pilot and involves all members of the flight operations. The briefing consists of the following:

The nature of the flight: What the planned mission goal is, expected flight time and manoeuvres to be conducted.
The take-off, landing & alternate areas: Clearly identified by the Remote Pilot verbally and visually by the ground crew observers.
Responsibilities: Their respective responsibilities as per Part A – Section 8
Weather: Any potential weather issues that may affect the flight.
Emergency briefing: Outline any hazards that may affect the flight and detail the emergency procedures should a ground/airspace incursion occur or if an in-flight emergency occurs.
Questions: The briefing will conclude with an opportunity to ask questions to ensure all members of the operation understand the task and their roles and responsibilities.

Once this was completed, the pilot activated the autonomous survey flight that was pre-planned into the aircraft. This flight mode only requires constant supervision of the aircraft systems by the remote pilot. A live feed is available to the pilot to monitor data collection of images as they are received by the aircraft during this phase of flight. This flight had a total flight time of 12 minutes. Following a successful autonomous landing, the remote pilot changed batteries and took manual control of the aircraft to perform SfM data collection of the cliff. This flight required performing a series of 360° passes of the cliff with the camera orientated at different angles on each pass, Fig. 6.7. As this is a manual flying process, this is a very intensive time for the pilot as not only are they flying the aircraft at all times but must count 2 seconds between each picture capture. To help with the pilot workload, the Point of Interest intelligent flight mode was activated. Here, the pilot has full control of what images to take by pressing the shutter button on the controls, much like a standard camera, while the aircraft yawed around a fixed point. Again, the pilot has a live feed view of what the camera is seeing in order to compose the pictures.

Fig. 6.7 - Flight map of 360 profile

Due to the nature of the cliff face, only a number of 360^0 images could be taken due to the terrain. Therefore, in order to gain detailed images of the cliff, the pilot exited the Point of Interest mode and flew the aircraft in a series of Zig-Zag patterns taking oblique images of the cliff face as shown in Fig. 6.8 & Fig. 6.9. Once the data was collected, the remote pilot landed and stored the aircraft. The SD Class 10 64 GB card was removed from the aircraft to transfer the pictures onto a portable hard drive for the next stage, which was post data collection processing.

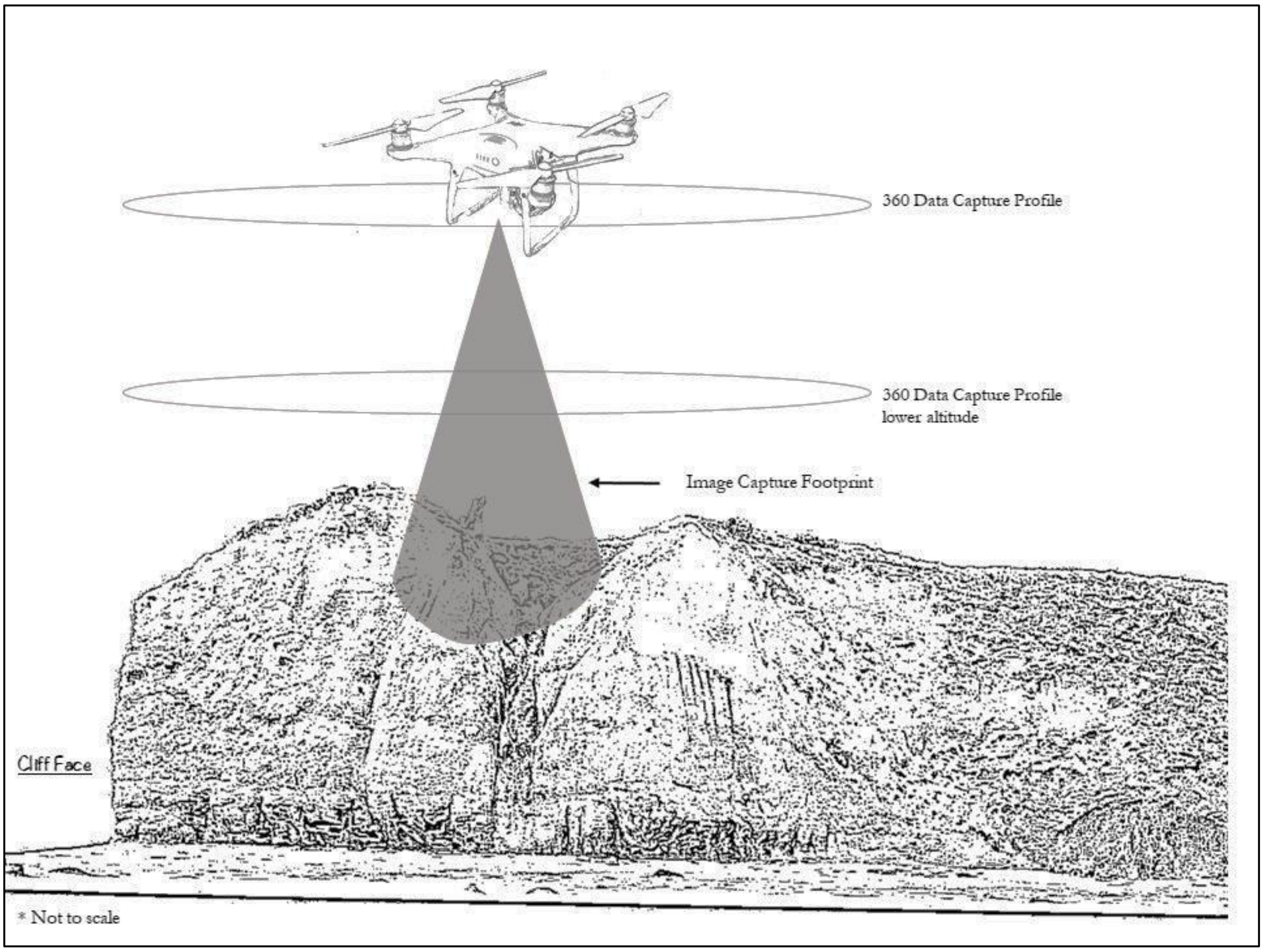


Fig. 6.8 - Demonstration of the UAV and the images taken during the 360^0 profile

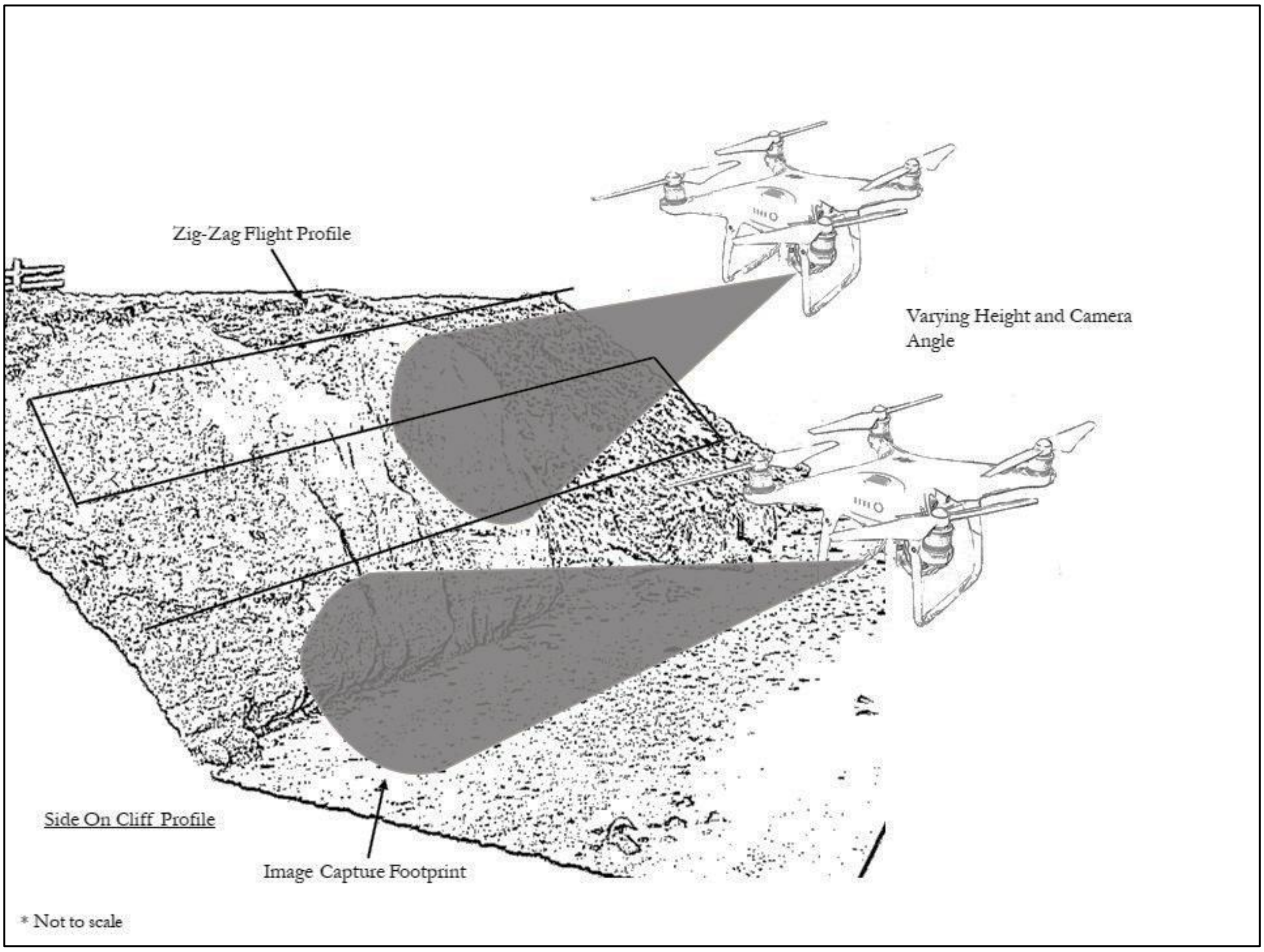


Fig. 6.9 - Demonstration of the UAV and the images taken during the zig-zag profile

6.2.7 POST DATA COLLECTION

After the flight was conducted, the researcher arrived back from the field, and the images were uploaded to two separate software systems. The first software was the DroneDeploy software (DroneDeploy, 2017). This software is an external software system which processes the images 'in the cloud' with no input or control from the researcher. While this method does produce 3D models, they often lack sufficient detail and usability. Instead, this software produced accurate and detailed Orthomosiacs (2D aerial images/maps) along with a selection of Digital Surface Models. This system is an 'upload and forget' system that makes it less time intensive for the researcher and little to no technical knowledge needed. In order to create accurate 3D models requires a more intensive time and knowledge-based process. To achieve this, the model was made in a dedicated photogrammetric software called, *Agisoft Photoscan* (Agisoft, 2018). This software requires a step-by-step workflow in order to create a detailed model, and it required a specific high-powered computer (specifications in Table 6.2) and some specific knowledge in order to create the model.

This method is time-consuming (based on the computing power available) and requires a far more hands-on approach than the DroneDeploy software. For an in-depth workflow can be found on the tutorial section of the Agisoft website. The rest of this section will outline in less detail the main points of the workflow, as per section 6.2.3.

Table 6.2: Minimum computer hardware requirements for Agisoft Photoscan (Agisoft, 2018)

Minimum Requirement	
CPU	Quad-core Intel Core i7 CPU, Socket LGA 1150 or 1155 (Kaby Lake, Skylake, Broadwell, Haswell, Ivy Bridge or Sandy Bridge)
Motherboard	Any LGA 1150 or 1155 model with 4 DDR3 slots and at least 1 PCI Express x16 slot
RAM	DDR3-1600, 4 x 4 GB (16 GB total) or 4 x 8 GB (32 GB total)
GPU	Nvidia GeForce GTX 980 or GeForce GTX 1080 (optional)

6.2.7.1 Import Images and Check for Errors

Importing the images into Agisoft Photoscan is a straightforward process of importing a folder into the system. What this allows is for each picture to be viewed before any processing takes place. An error check is performed whereby any overly blurred, overexposed or badly composed pictures (too much sky) are removed for the dataset. This procedure is done as such images can distort the final VLM as the software struggles to match points through the SfM method (Agisoft, 2018).

6.2.7.2 Loading Camera Positions, Calibration and Alignment

In order to help the software match the points, it can help speed up the process if the software knows the position of the camera and the angle of the camera at the point an image was taken. To do this, the researcher must upload a CSV File into the system with the coordinates and yaw and angle of the images. Unfortunately, this is not a straightforward process as this information is embedded within the EXIF file of each image taken from the DJI Phantom 4 Pro and is not readily accessible. There are only two ways to gather such information. The first is an incredibly long process of opening up each image taken and then right clicking > properties > EXIF and then manually typing the coordinates and angles into an Excel file. The other method that was employed in this research was the use of EXIF reader software and some basic computer code. An EXIF reader was installed, and then the command prompt of the PC was opened to where the following code was inputted. The EXIF reader was the *EXIFTool* a free and open software tool developed by Harvey (2018) and accessed here https://www.sno.phy.queensu.ca/~phil/exiftool/. This code pulls EXIF data from a set folder (in this case the folder containing all the images for the VLM) and depending on the code used, will pull data such as filename, altitude, roll, yaw, and GPS coordinates. The software uses specific command prompts for different UAV data, and these commands were found on the software developer's website and are shown in Fig. 6.10 (part a.). For the latter, it is essential to tell the system to convert the coordinates from the UAV which is in Degrees, Minutes, Seconds (DMS) (e.g. 53^0N 33'68.92 -3^0W 14'16.1) to Decimal Degree (DD) (e.g. 53.3368920, 3.141616) format so that the software can read it. A further step is in this format the software does not automatically convert negative longitude, so it has to be told to incorporate the minus. In bold are names of what should be inserted, Fig. 6.10 (part b.).

Once a CSV file has been inputted into Agisoft, it helped the system to align the photographs and aided the system to align the VLM to a real-world location through the WSG 84 (EPSG:4326) coordinate system. Once this is achieved, the system was further helped in aligning the images through the *Camera Calibration* procedure such as telling the software the type of shutter used, image size and focal length.

Once this has been completed, the first significant workflow step was commenced, the *Alignment* of the images. For this, the accuracy level was set to *High* and the software was told to use the *Generic* and the *Referenced* function (i.e. the coordinates, yaw, and altitude data as per the previous step). The software then aligned the photographs through its own SfM algorithms specifically developed by Agisoft Photoscan. This alignment can take anywhere between 20 minutes to a number of hours depending on how many images are being aligned. For this VLM, it took just under six hours for this process to be completed. Once the alignment had taken place, a sparse point cloud was generated, and the locations and orientation of the pictures could be observed in the software, Fig. 6.11. The blue squares represent the area and the orientation covered by the camera for that particular picture.

(a.) Command Prompts for DJI UAV data

Tag Name	Data from UAV
GimbalPitchDegree	Pitch angle of Camera
GimbalRollDegree	Roll angle of Camera
GimbalYawDegree	Yaw angle of Camera
RelativeAltitude	Altitude between the takeoff point of the aircraft and the image taken
AbsoluteAltitude	Is the altitude given by the GPS sensor above the reference ellipsoid of the GPS constellation (WGS84)

(b.) Code for extracting EXIF data

EXIF Code:

C:\Users**nameofuser**>exiftool -csv -filename -imagesize -GimbalPitchDegree -GimbalRollDegree -GimbalYawDegree -RelativeAltitude -gps:GPSAltitude -gps:GPSLatitude –n/> **nameoftheintendedoutputfile.csv** /User/**username/location of input folder/ input folder name [press enter]**

(c.) Example of the code in practice in this research

Command Prompt

```
Microsoft Windows [Version 10.0.16299.431]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\Anthony>exiftool -csv -filename -imagesize -0x0009 -0x000a -0x000b -gps
:GPSAltitude -gps:GPSLatitude -n -gps:GPSLongitude -n/> modelwithyaw.csv /Users/
Anthony/Desktop/Thurstaston
Invalid TAG name: n/
    1 directories scanned
  375 image files read

C:\Users\Anthony>exiftool -csv -filename -imagesize -GimbalPitchDegree -GimbalRo
llDegree -GimbalYawDegree -RelativeAltitude -gps:GPSAltitude -gps:GPSLatitude -n
 -gps:GPSLongitude -n/> modelwithyaww.csv /Users/Anthony/Desktop/Thurstaston
Invalid TAG name: n/
    1 directories scanned
  375 image files read
```

(d.) Example of data retrieved in a .csv file from the code

File Name	Image Size	Gimbal Pitch °	Gimbal Roll Degree°	Gimbal Yaw Degree°	Relative Altitude (m)	GPS Altitude (m)	GPS Latitude	GPS Longitude
DJI_0001.JPG	5472x3078	-45.8	0	54.7	32.4	6.801	53.33689208	3.141616139

Fig. 6.10 – Exif code and outputs

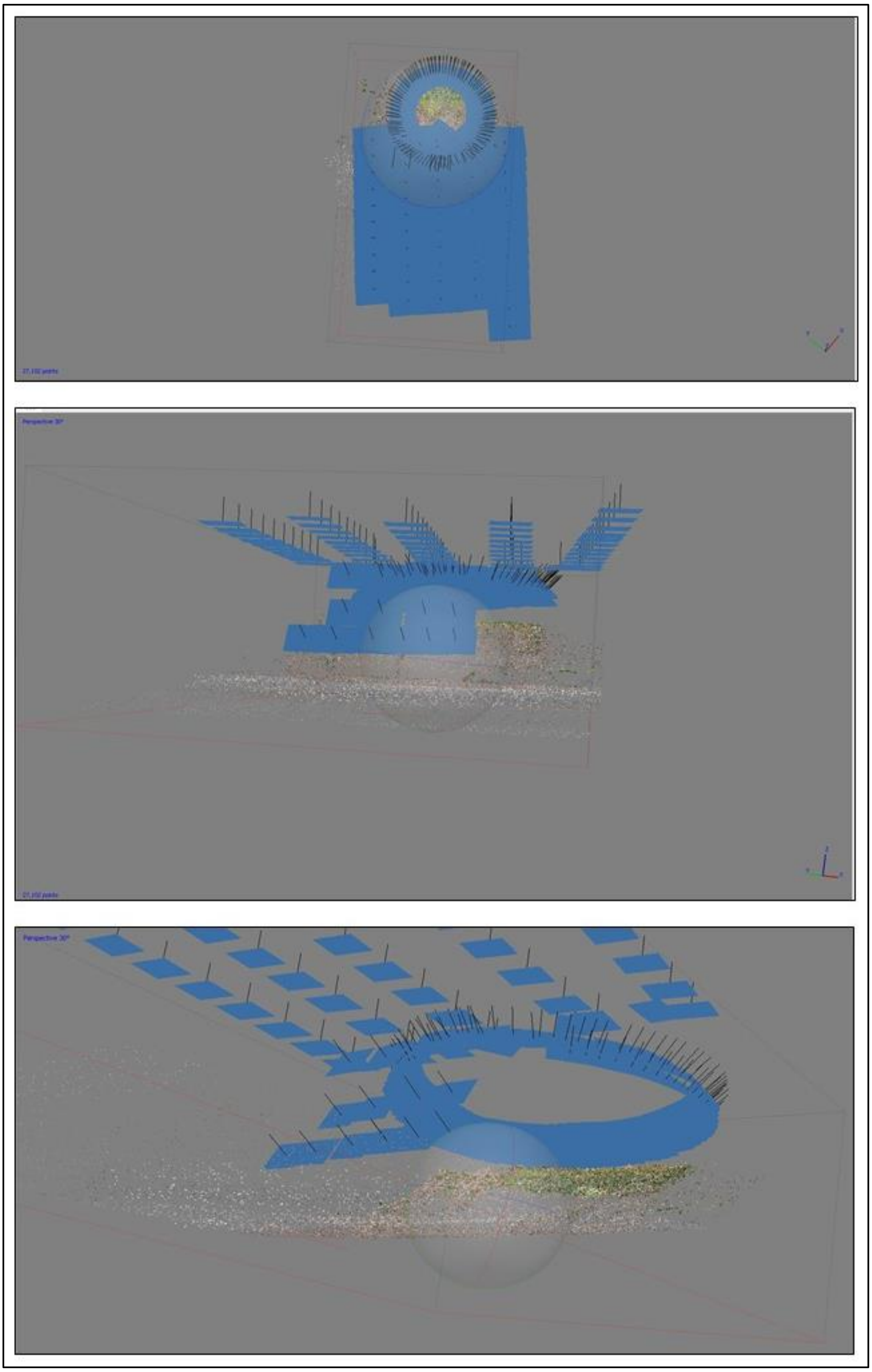


Fig. 6.11 - Camera Alignment and Sparse Point cloud

6.2.7.3 Building a Dense Point Cloud

Following on from the alignment of the images and the creation of a sparse points cloud, a bounding box was transposed onto the model. This bounding box ensured what the software included in the rendering of the model and where the floor and orientation of the final VLM would be. This bounding box was easily manipulated through the inbuilt controls in Agisoft. At this stage, anything outside of the bounding box was deleted to save processing time. To build the dense point cloud is a simple process of following the Agisoft workflow and selecting the Build Dense Point cloud option. Here were two options to choose from, Quality: *Low, Medium, High* and Depth Filtering: *Aggressive, Mild.*

Quality dramatically affects the final output but also the time to render with *Low* being the lowest quality but the quickest rendering time. *High* is intensive and can take up to many days depending on how many images are processed but offers the highest level of detail. For the Depth Filtering option, the *Mild* mode is needed when a scene has complex small details and untextured areas. The mild mode was chosen for this research due to the location of the site having many fine details and relatively untextured landscapes such as the beach. As seen in Fig. 6.12, a dense point clouds can offer a high level of detail. Overall, this step took 26 hours to be completed for this VLM.

Fig. 6.12 - Detail of the dense point cloud

6.2.7.4 Build Mesh

After the dense point cloud had been generated this could then be exported to various other software platforms for other purposes but for this model, a mesh was needed to produce a final polygonal model. The surface type was set to *Height Field*, the source 'Data' was set to the *Dense Point Cloud,* and the 'Face Count' was set to *High*. After the time had passed (approximately 1-hour) and the mesh had been generated, the virtual scene now resembled a more accurate lifelike reconstruction of the cliff. Using the *geometry* function, any holes in the model were identified and closed. Holes appear when the pictures have not had sufficient overlap, or the software has struggled to match sufficient common points. This procedure made the final version more accurate and lifelike.

6.2.7.5 Building Texture

Finally, the model can have texture built, and it is at this stage that the model changes from numerous points to a highly accurate polygonal model of the landscape. The texture building takes the textures and colours from the images and transposes them onto the created mesh to give an authentic and lifelike look. It is up to the researcher how many textures they would like on the model, for this model after a series of tests, five where chosen in order to accurately represent the sand, the rocks, the clasts, the cliff face, and the grass. The software rendered this over a short period, and the initial polygonal model of the landscape was created. The virtual landscape model could now be exported to Sketchfab for further work as detailed in section 6.2.8 or could be used to create orthomoasics and digital surface models.

6.2.7.6 Digital Surface Models and Orthomosaics

While Digital Surface Models and Orthomosaics were not to be the final output for this research or their inclusion in this research, they are important to acknowledge, especially as a by-product of UAVs in teaching. Orthomosaics are raster images that are a combination of Orthophotographs. An Othophoto is an aerial image that has been geometrically corrected into a uniformed scale. When combined, this can create a large highly detailed photograph of an area which has the perspective of being taken top down at an infinite distance (ASPRS, 1994). However, such Orthomoasics often offer a good base for the creation of maps in other software applications such as ArcGIS or QGIS.

Digital Surface Models (DSM)/Digital Terrain Models (DTM) and Digital Elevation Models (DEM) are often used to mean the same thing but are actually two different models. This is a common misrepresentation of the data where DSMs are labelled as DEMs, an example of this is that the software used in this research claims to generate a DEM from the UAV data when in fact, it should be labelled a DSM or DTM. They are defined as "A digital elevation model, or DEM is a representation of the terrain (bare-earth) with elevations at regularly spaced intervals. A digital surface model (DSM) also contains elevations at regularly spaced intervals; however, the elevations represent the first reflected surface detected by the sensor. These first returns may be reflected by bare ground or by surface features such as trees and structures" (United States Geological Survey, N.D). Like Orthomosaic's, DSMs can be exported and further manipulated in other GIS software and can form the basis of many models of a land site. As such they can provide a valuable teaching aid (Al-Tahir, 2015). Examples of the two being generated by DroneDeploy and Agisoft can be seen in Fig. 6.13.

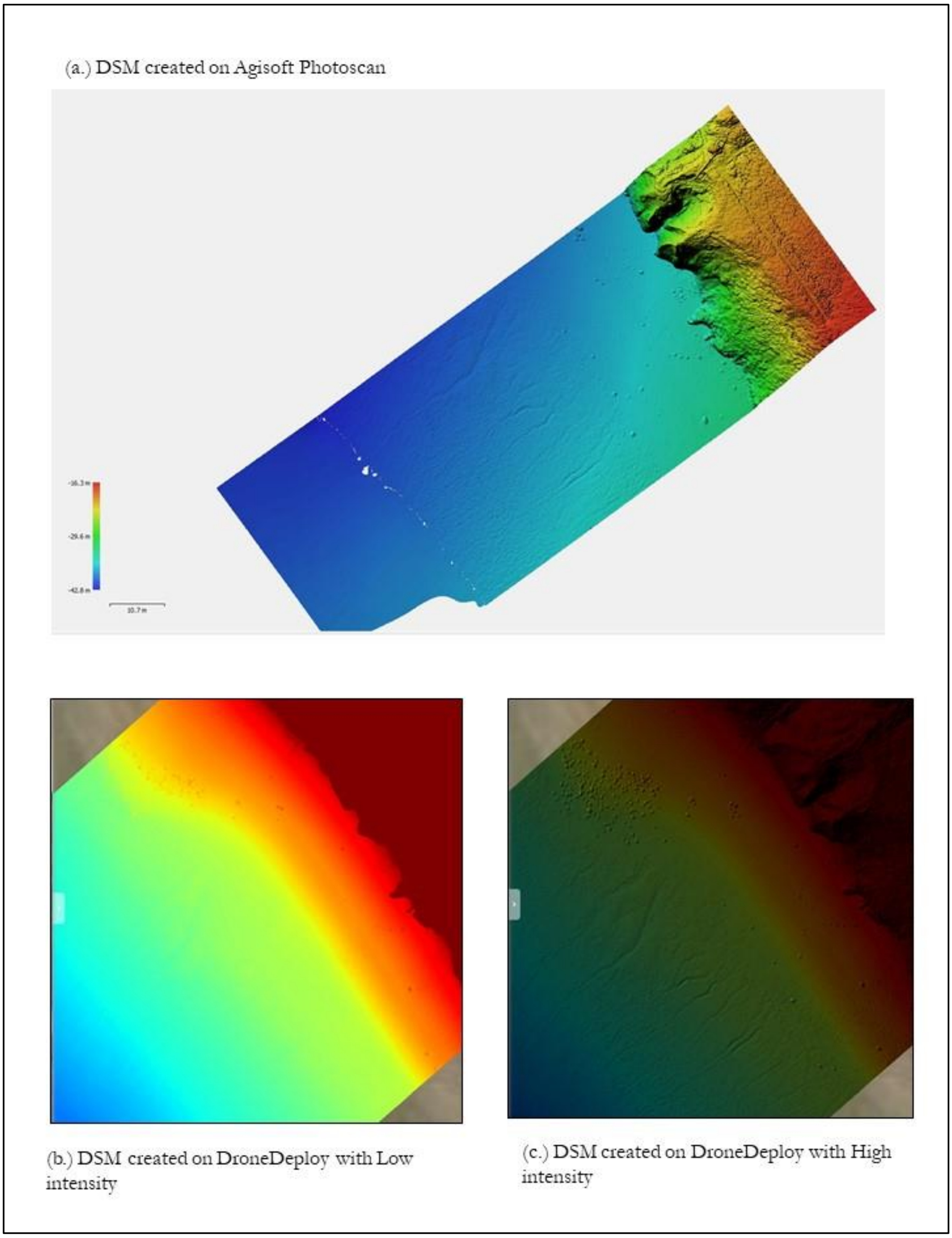


Fig. 6.13 - DSM Generation

One further note, not explored in this research due to administration rights, the DroneDeploy software allows a user to measure distance, land relief, crop health and area of a DSM or Orthomosaic. As shown in Fig. 6.14, the measuring tool is an effective way to show the beach profile from the cliff to the water. Such a tool may well be useful in teaching or as discussed in the previous chapters, a way of increasing efficiencies and time on fieldwork for students. Beach profiles are often completed by students on fieldwork using the 'Emery method' which uses two graduated rods to read off their alignment with the horizon to determine the slope profile (Emery, 1961.) While this is a simple method, it can take a long time to be completed (Andrade & Ferreira, 2006). Using a UAV and such software has the potential to dramatically reduce this, not only for students but for industry applications also.

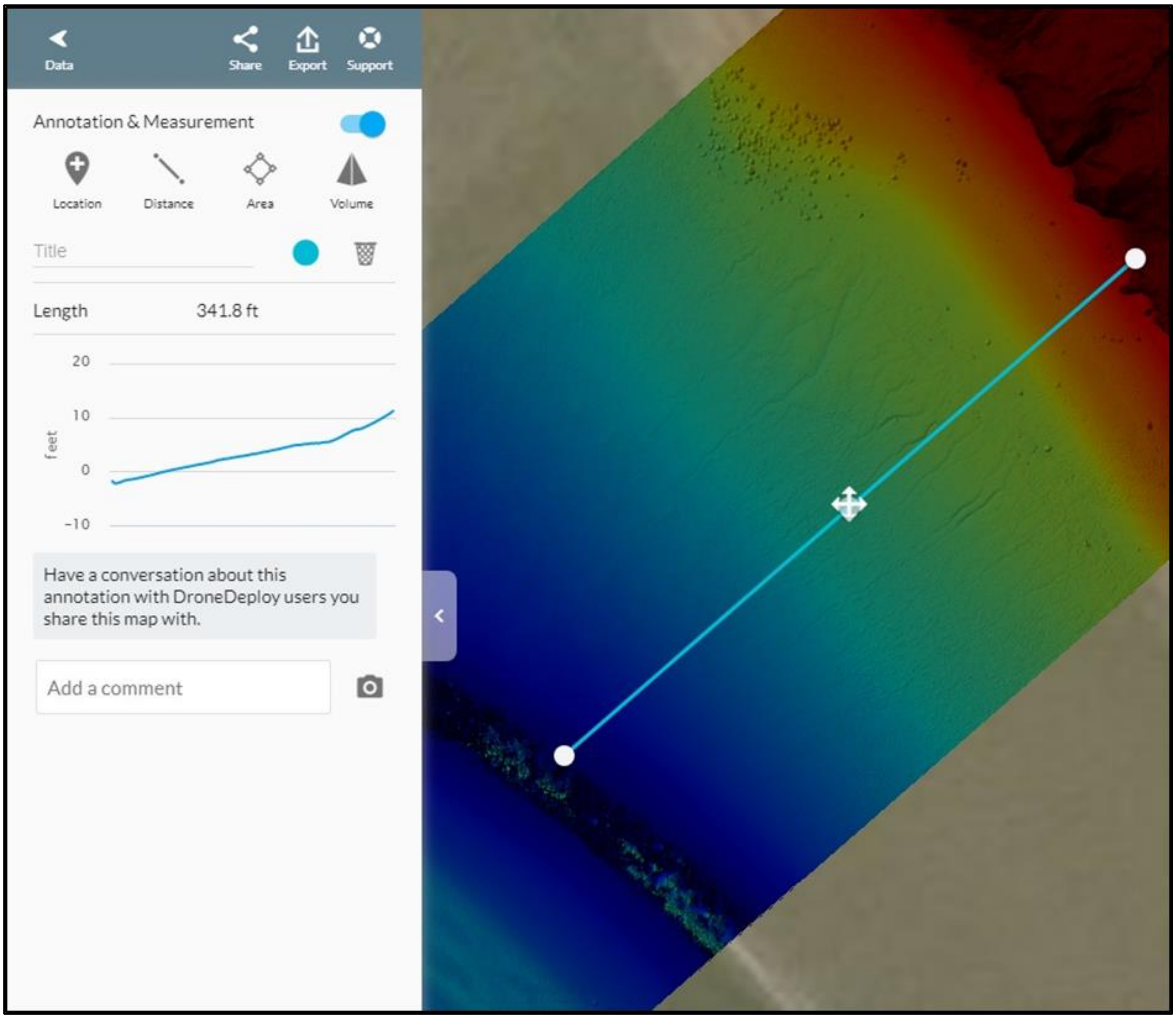


Fig. 6.14 - Measuring tool in DroneDeploy for DSM

6.2.8 Developing the Virtual Landscape model into an Enhanced Virtual Field Guide

Once the model was developed in Agisoft Photoscan, it became apparent that while effective visually, as a learning tool it was not much use to lecturers or students. SfM and Polygonal Models created in Agisoft often stop at this point and are used as visual aids or may be used in other software such as GIS systems for further analysis. For this research, however, the idea was to enhance this effective replication of the environment by using annotations and contextual information to transform it into a new VFG. In order to complete this task, a suitable platform was needed that allowed the researcher to add such extra detail to the VLM. It was decided that on an online platform called *Sketchfab* would facilitate this.

Sketchfab is an online free and paid subscription hosting website which allows developers to share their 3D animations and artworks along with the ability to add annotations and Virtual Reality integration (Sketchfab, 2018). This platform was chosen to be an effective place to host the model as not only did it allow the ability to customise the model but it was a relatively low-cost subscription (£10 per month with the ability to unsubscribe at any time). Models created under the subscription stay available. The subscription service gives the user access to support larger input files and the ability to add up to 25 annotations (compared to the 5 for free users) and eliminated the issues of models hosted on Agisoft. Such issues included the lack of annotations but also a more systematic issue of students being unable to gain access to Agisoft software and not having sufficiently powered computers to operate them. Using Sketchfab, anyone with access to the link can access the model from any device with internet access. In order to create the final virtual fieldguide, the researcher created a workflow as shown in Fig. 6.15.

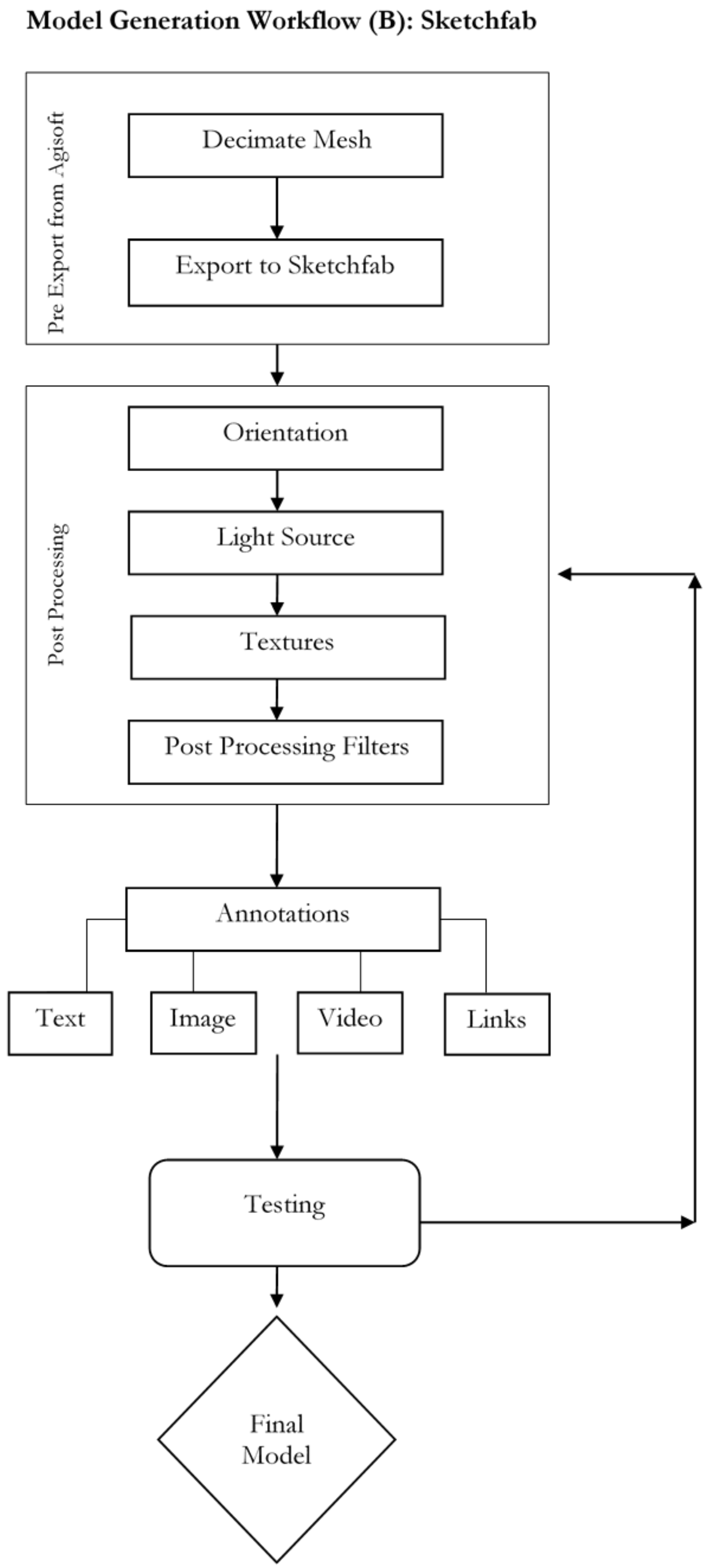


Fig. 6.15 – Creating an Enhanced Virtual Field Guide from a Virtual Landscape Model Generation Workflow (B)

6.2.8.1 Preparing for export

The VLM in its current form in Agisoft was not suitable for export to the Sketchfab platform. Sketchfab recommends that polygonal models have around 400,000 points or faces in order to operate smoothly on most PCs. The model had over 1.5 million points in Agisoft and was therefore too large to export to Sketchfab. The resizing of the model in Agisoft was relatively straightforward by *Decimating the Mesh*. This process allowed the researcher to select the desired number of points in the model and the software reduced the model points down to this number. The model could then be downloaded as an Object File along with the associated textures and uploaded manually into Sketchfab. However, Agisoft has a dedicated plug-in to its software that allowed models to be uploaded directly into a Sketchfab holder's account through their unique code and password. This process took no more than half an hour to complete.

6.2.8.2 Orientation and Rendering

The model from Agisoft is not level with the plane of view in the Sketchfab viewing platform and therefore needed to be aligned to the 'Floor'. This was a simple process of using the orientation tool within Sketchfab to align the model using sliders in the X, Y & Z dimensions, Fig. 6.16.

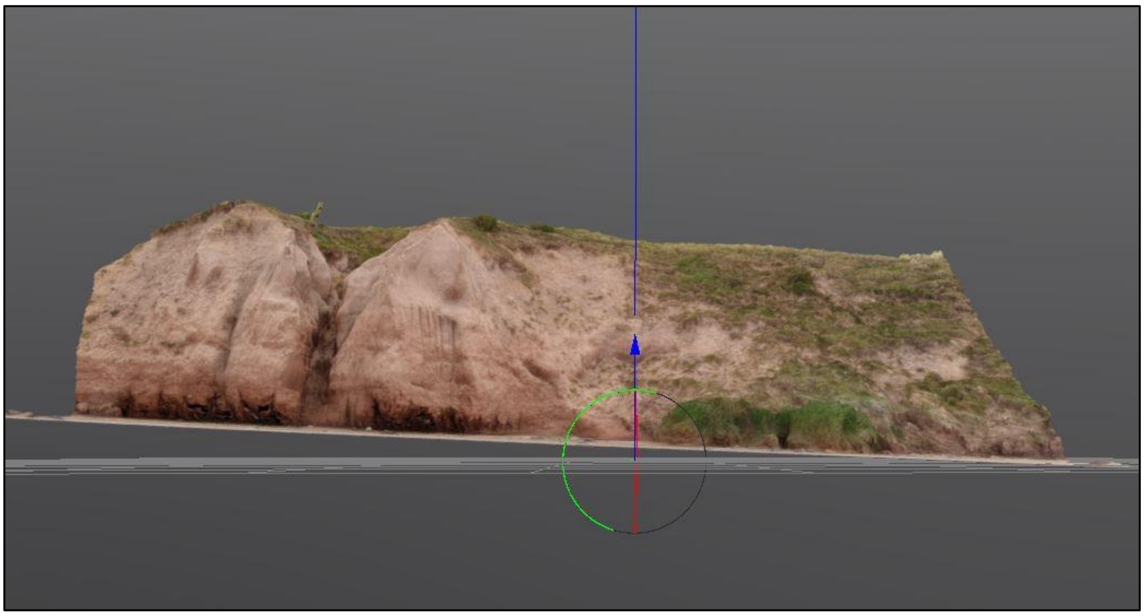


Fig. 6.16 – Orienteering the model onto the floor of Sketchfab, using the X,Y,& Z axis tool

At this stage, various options of rendering could be used and a choice between *shadeless* or *lit* rendering. The difference between these two is that the first uses the textures of the images to give a lifelike look, whereas the lit rendering looks more computer generated, however, shadows from a light source can be incorporated into the model. The shadows can be used to good effect to simulate shaded areas of a model at sunrise, mid-day and sunset. For this model, however, this was not relevant, and so the shadeless option was utilised.

When the model was exported from Agisoft, it still had, in the opinion of the researcher, a virtual and computer rendered appearance. This computer-generated appearance is one issue that virtual replications of the environment have had. The lack of real-world appearance has often meant that students never felt fully immersed in the environment and lecturers struggled to use it to great effect as a teaching tool for this reason (Spicer & Stratford, 2001). As shown in Fig. 6.17, while it is an accurate representation of the field site, the look is not authentic.

Fig. 6.17 – Virtual Landscape Model before post processing

To combat this, Sketchfab allows a user to manipulate a number of various post-processing filters such as depth of field, shadow, tone mapping and sharpness. There are 27 options and sub-options within them to customise the model. This process of adjustment was a continual process throughout the development of the model until both students and lecturers were happy with how the model looked. As seen in Fig. 6.18, it is now a far more accurate representation of the real world location and this helps the model to be an effective immersive environment.

Fig. 6.18 – Virtual Landscape Model view post processing

6.2.8.3 Transforming from Virtual Landscape Model to an Enhanced Virtual Field Guide through the addition of annotation

The specifics of the annotations used and why they are included will be discussed further in chapter VII. For now, however, this section will outline how those annotations were created and embedded into the VLE to create a VFG. As will be discussed in chapter VII the annotations that were requested and implemented in this EVFG were the following; (a) *Text*, (b) *Image*, (c) *Video*, (d) *Context Maps* & (e) *External Resources*. Sketchfab can add annotations to the model but does require some use of *Markdown*, which is a text-to-HTML conversion tool for web writers. All annotations require a title, but descriptions are optional. A useful tool in Sketchfab is the ability to place a viewing angle for each annotation that is implemented. With careful planning this will pull the viewer around the model to view specific areas of the model to enhance student learning.

6.2.8.4 Text Annotations

Adding text to the model was the first and basic requirement which lecturers requested. This was a straightforward process using the annotation function in Sketchfab with little use of the Markdown. Specific Markdown Syntax can be used to emphasise various elements of the text such as headers or bold font. If this is not required, then merely inputting the text into the annotations box is all that is needed as shown in Fig. 6.19.

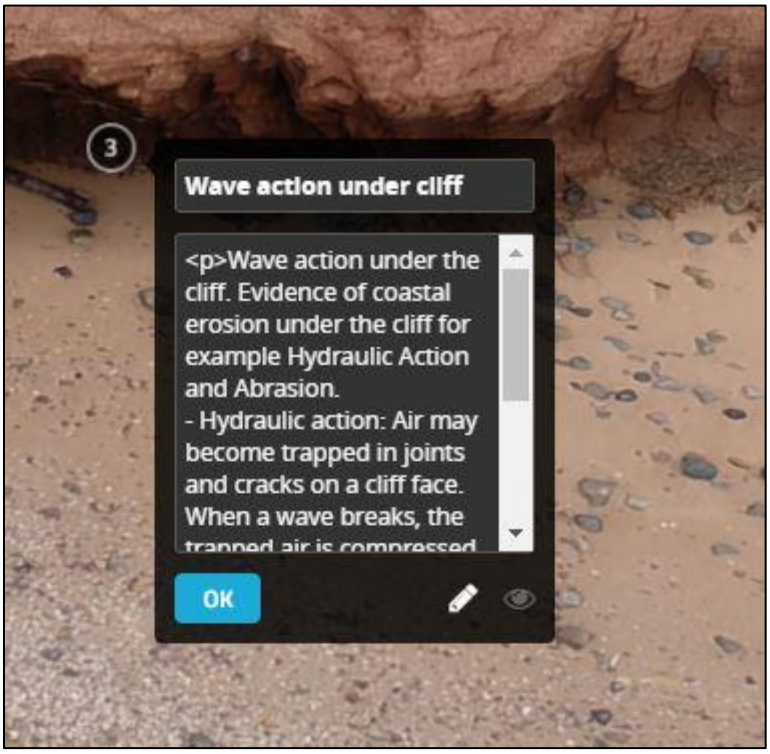


Fig. 6.19 - Text annotation

6.2.8.5 Image Annotations

The incorporation of images requires more in-depth Markdown language to be inputted into the system. It became apparent through trial and error that images had to be hosted on a website to be accessible in the EVFG (such as on a Google Image search). However, for educational purposes and specific site locations; this was not a viable solution, especially when considering copyright issues. To combat this issue, the researcher set up a discrete open access blog on blogspot.com to store images that the EVFG could then access. This creation of a blog satisfied the requirements for the images to be open access on the internet. While there may well be more efficient ways to do this, currently this is the researcher's best attempt at incorporating such images. Once the images are uploaded to the blog site, the link to the image is copied from the address bar and incorporated into the Image Markdown, which is as follows.

Markdown for Image

```
![Alt text](https://website.com/path/to/img.jpg "Title")
```

For this research an example of this in practice was as follows.

```
![Alttext](https://3.bp.blogspot.com/-LNJK6NZ0dRo/WrIhPVF-VbI/AAAAAAAABpY/iM4eMpMDZ9Axw804wh1F77IjlXKGzkx0ACLcBGAs/s1600/20180316_134421.jpg "Title")
```

Not only could images be embedded into the EVFG but links to larger images for students to access or adding descriptions to the EVFG can also be utilised. This involves the process above and then following the text Markdown. An example of a link to a larger image with a description as seen in Fig. 6.20. One issue that was discovered during the testing phase was that only portrait orientated images would be embedded full-size into the EVFG. Landscape orientated images would be compressed, and therefore a link to a larger image was needed as seen in Fig. 6.20, part c.

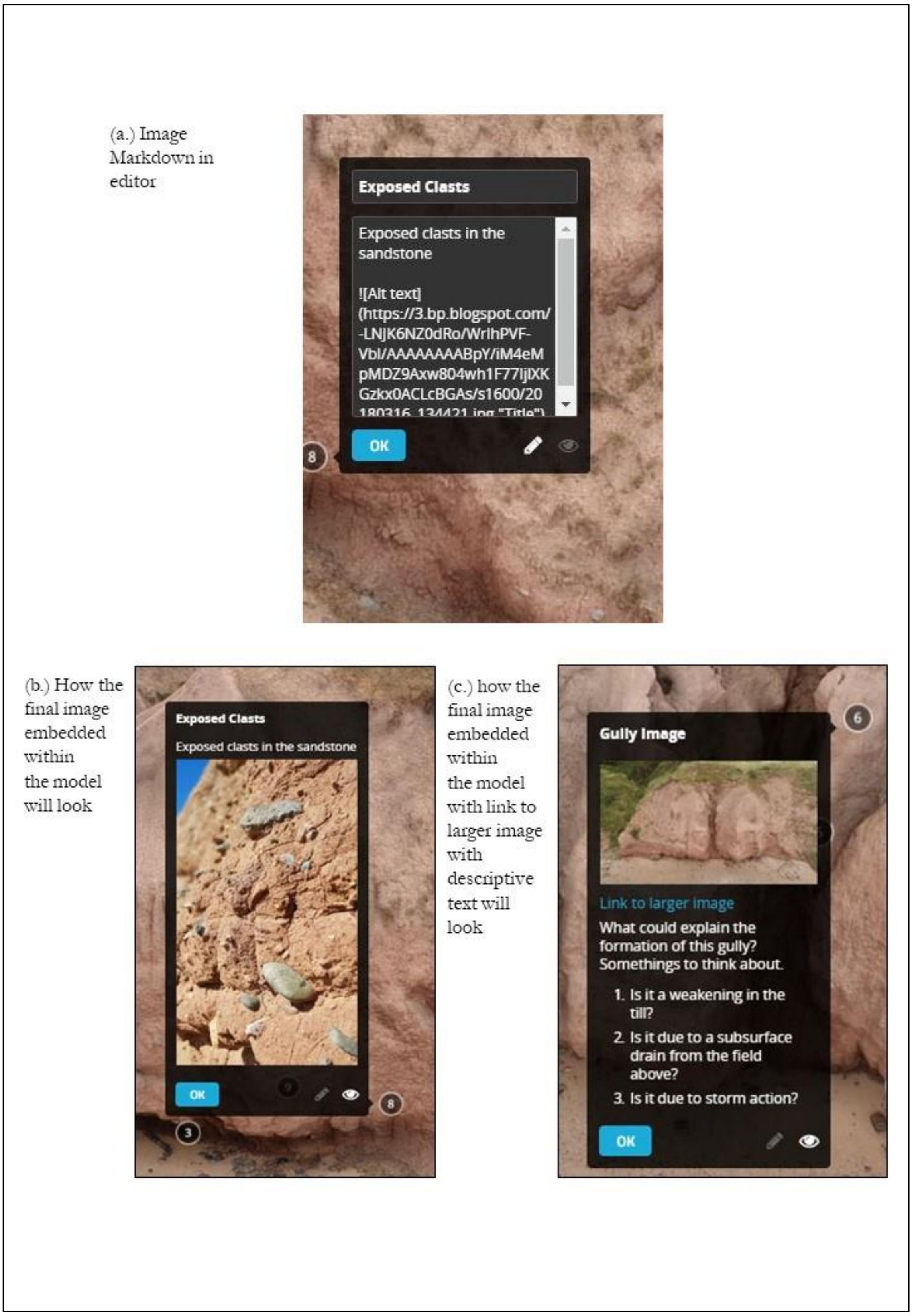
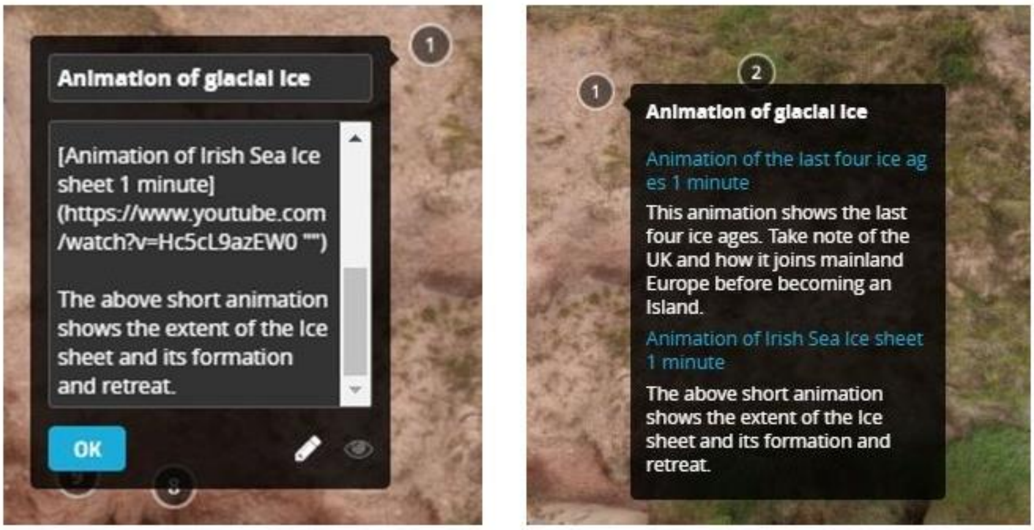


Fig. 6.20 - Picture annotations

6.2.8.6 Video and Linked Annotations

Like images, specific markdown is used to access videos within the EVFG. Unfortunately, at present, there is no specific way to embed videos directly into the EVFG. Instead, a link is used to access a specific video such as a YouTube clip, Fig. 6.21. Such embedded links can link to any open access video site, but in this research, YouTube was used as it is the most accessible database of open access videos (YouTube, 2018). This ability to link to video sharing websites provides the lecturer with the opportunity to create his or her own videos to be embedded within the EVFG or can use already well-established videos to help their students. Links to the videos can also contain a description and using the sharing link of YouTube, even allows for the video to play at specific parts to help keep students engaged and focused. Through this process, not only can videos be accessed but also any link can be accessed, be that websites or journal articles.

Such links provide the lecturer and the student with numerous possible avenues for learning and teaching by using a range of information and data. All the student has to do is click on the hyperlink, and they will be taken directly to whatever the link contains. One example of this in practice in this EVFG was the creation of a Google Drive file where hundreds of pictures of the cliff and the embedded clasts were stored for students to access for their assignments. What this has created thus far, was a portal of information within the EVFG which is unlike traditional field guides where a virtual landscape model is often a branch off. Instead, here the model acts as the anchor and further information is linked to it.



(a.) Video link Markdown in editor with a text description

(b.) In the model students can access the video or link via the hyperlink

Fig. 6.21 - Video annotation markup

6.2.8.7 Map Creation for Context

In order to satisfy the requirements of contexts in the EVFG, a map was created within Google Maps of the proposed field site along with annotations embedded within the map. To create this, the researcher needed a Gmail account to access this feature within Google Maps. To create the map using the tab on the left-hand side of Google Maps was used, then > Maps > Create Map. Here the researcher positioned the centre of the map over the field site location using establish co-ordinates (although specific towns and postcodes can be searched in the search function). Once here the map is set in place. Using basic GIS skills the researcher used the inbuilt layer and overlay tools to place markers of interest for students or items that the course tutor had asked to be included. Descriptions, pictures and locations could also be included in the map to help students with their context of the site. For instance, established research was embedded geographically into the map so that students could gain an understanding of where that established research was conducted in relation to their chosen site. This contextualization was achieved through the creation of an Excel file that was then imported into Google Maps which recognises this as a Data Table and overlays the information into the map as shown in Fig. 6.22.

Glasser et al. research locations a...

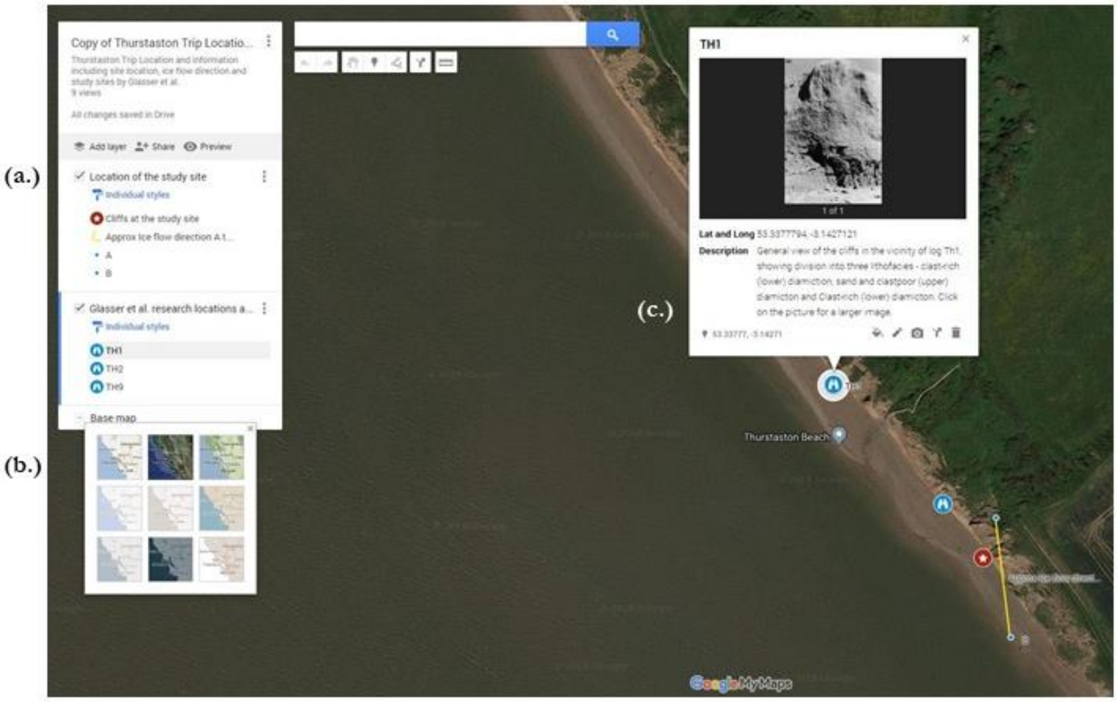
Find in table

1–3 of 3

	Lat and Long	name	Description
1	53.3377794, -3.1427121	TH1	General view of the cliffs in the vicinity of log Th1, showing division into three lithofacies - clast-rich (lower) diamiction, sand and clastpoor (upper) diamicton and Clast-rich (lower) diamicton. Click on the picture for a larger image.
2	53.3380741, -3.1430662	TH2	Some regular pebble-sized clast concentrations occur in discontinious layers near the base of TH2. Click on the picture for a larger image.
3	53.3372541, -3.1419075	TH9	Eroded level (by the trowel) represents a near-horizontal de ´collement surface and preserves slickensides. Click on the picture for a larger image.

Fig. 6.22 - Data Table for contextual map

Further to this, the file can be downloaded as a KML file that opens up into Google Earth Pro for students to access. Google Earth is more interactive than Google Maps and often more familiar to students. Interestingly, the creation of the map and its overlays and use in Google Earth is what the original and most common forms of Virtual Field Guides looked like in appearance and style. The students can view the online map Fig. 6.23 or via Google Earth Fig. 6.24.



(a.) Layers including location of the field site and numerous other information

(b.) Choice of base map between satellite view and numerous topographies

(c.) Information pop up in the map of pictures, locations and descriptions of established research of the site

Fig. 6.23 - Contexual Map

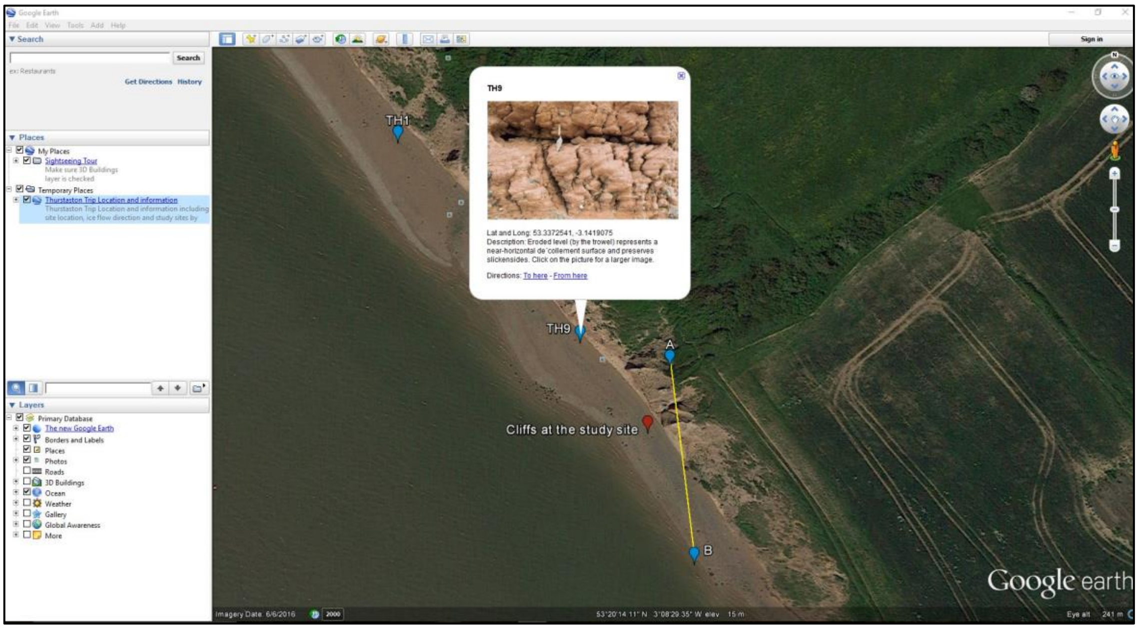


Fig. 6.24 - Map and pop up annotations in Google Earth

6.2.9 Testing, Refining and Limitations of the Enhanced Virtual Field Guide

The process of refining textures and adding annotations was a gradual process with feedback from staff and students as the virtual landscape model developed into a virtual field guide. There have been four different versions of the model from the first model, which had stitching errors and was visually not representative of the site to the final model today that can also be improved further. The continuation of the development of the model was facilitated by staff desires of what they would like to see in the final EVFG, and the researcher then had to find ways to make that happen. Not everything that was desired was practically possible to include in the EVFG due to system and software restrictions or due to lack of knowledge of how to do so by the researcher. The lack of prior knowledge is one of the limitations of the EVFG that while no in-depth specialist knowledge is needed, specialist software and some detailed knowledge and understanding is needed to create the virtual landscape model and subsequent virtual field guide.

The researcher had no prior knowledge of computer code, the Markdown Syntax language, and only limited GIS experience and no experience of 3D model generation. It was, therefore, a challenge to learn an entirely new software system for generation of the virtual landscape models from scratch, especially as this was a new product, there was no direct go to help guides or persons to seek advice from. Nevertheless, it has been completed to a standard acceptable to lecturers. The researcher is aware that the model can be improved and some of the workflows presented in this chapter may not be the most efficient ways to produce the desired outcome. Regarding the 4th research aim, to evaluate the use of an Enhanced Virtual Field Guide generated from Unmanned Aerial Vehicle data, such challenges and the documentation of the learning process of the guides creation was to be expected.

A period of testing was completed on the model, which was a series of tests between standard and high definition settings on a number of computers and devices. This testing occurred on University-owned computers, a standard desktop computer, and numerous mobile devices. The researcher tested various platforms but also gave the link to the model to various associates, friends and family to Beta test the model on their own devices. Any issues were recorded and can be seen in appendix R. The main issues were the EVFG regardless of the operating system, or device, was slow or would crash if it was not accessed via the Chrome Browser. This issue was particular to the crashing of Internet Explorer and Edge browsers. Currently, it is not known why such browsers have such an issue, and therefore all staff and students were directed to use Google Chrome when viewing the EVFG. It also became apparent that the model was easier to navigate using a click wheel and mouse than a laptop trackpad.

Despite these issues, what has been demonstrated here is that even with limited knowledge and experience, the data collected from the UAV can be made into a highly detailed, accurate and interactive EVFG.

6.3 Conclusion

The creation of the EVFG has not been easy and has been limited at times by limited knowledge and access to suitable equipment. Nevertheless, this chapter has provided an understanding of the accumulation of all the chapters so far being brought together into one model for students to use on fieldwork. The researcher has tried to take the lessons learnt from established VFGs and embed them into this virtual landscape model, which has been possible due to the opportunities and data that mobile technologies and specialist software can now provide. Throughout this chapter, detailed workflows and procedures have been outlined in order for replication to be possible. It was important that the models were accessible and created on accessible platforms. While DroneDeploy and Agisoft Photoscan are specialist software to which a cost is applied, they are user-friendly, and both Universities and Schools alike should have access to them. The development of the VLM into a VFG through basic Markup on Sketchfab is another easily accessible hosting and user-friendly site. Sketchfab is relatively user-friendly and can be completed with sufficient patience and reading of the provided help guides and manuals.

Overall, this chapter has demonstrated that through some knowledge and the use of such software and equipment and as UAV data, VFGs can be transformed and updated. VFGs often struggled to replicate the environment in sufficient detail and realism, and this model has proven that with modern technologies and techniques highly customisable and accurate EVFGs can be created. In literature, it seems that VFGs have somewhat been left behind in education due to potentially appearing on the scene too early. VFGs promised in literature an immersive environment that by some had the vision to replace fieldwork altogether (Dede, 1995). VFGs, however, were ahead of technology, and this lack of immersion and realism hindered their true potential (Fletcher, France, Moore & Robinson, 2002). Therefore, perhaps VFGs may well become more effective now that technology has caught up with the idea of Virtual Replications of the environment and as shown in this chapter, is very much a possible reality in 2018.

The next chapter, Chapter VII investigates this EVFG with staff and students in relation to aims (3) To explore and refine how Virtual Field Guides can support authentic learning and, (4) To evaluate the use of an innovative Enhanced Virtual Field Guide generated from Unmanned Aerial Vehicle Data.

CHAPTER VII: EVALUATION OF THE ENHANCED VIRTUAL FIELD GUIDE

This chapter is the final major chapter of this thesis as it explores an evaluation of the Virtual Landscape Model that was generated into an Enhanced Virtual Field Guide in the previous chapter, in relation to its effectiveness as a learning and teaching tool. This evaluation comes in the form of established literature on Virtual Field Guides and primary data from this research from staff and student interviews and extracts from student assignments. This chapter continues the exploration of aim (3) *To explore and refine how Virtual Field Guides can support authentic learning* as per the last chapter but also aim (4) *To evaluate the use of an innovative Enhanced Virtual Field Guide generated from Unmanned Aerial Vehicle data.*

The EVFG presented in this chapter is the product of all of the work of the previous chapters thus far laying the foundations to answer the research question that is *How can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Fieldwork Guide for Geoscience fieldwork?*

The data produced from the UAV was used to develop a virtual landscape model that was generated in chapter VI, to create the EVFG. This EVFG was used by a small cohort (n=8) of Outdoor Education students for their final year field trip to Thurstaston and used in their subsequent assignment. While the EVFG was only tested on a small number of students, it is important to note that as shown in chapter IV, Outdoor Education students in this study were significantly more likely to prefer traditional methods and less likely to use mobile technologies. Therefore, if the outcomes of the EVFG are positive with such students, then there is potential for this to be received even more positively by geography students in this study. Outdoor education students were also selected due to ease of access by the researcher.

7.1 METHOD

As the previous chapter has outlined how the EVFG was created, in order to evaluate its effectiveness two methods were used. Staff (n=5) and one student were interviewed through a semi-structured interview about the EVFG in their teaching or learning; this lasted on average 58 minutes. Following on from this, student assignments (n=8) were subjected to a form of thematic analysis to evaluate the EVFG's advantages and disadvantages to the students in their learning. As the overarching evaluation is thematic analysis, the results and discussion are broken down into themes with the two methods merged. Quotes from the interviews are labelled, and screenshots of the student assignments are used as separate figures.

Students had access to this EVFG two weeks prior to the field trip taking place and had continuous access to the EVFG up until the point of their submission for the assignment. Students were given a small tutorial on how to use the EVFG via a bespoke YouTube tutorial: https://youtu.be/6AmJMavAewg and in written form as shown in the field guide handbook; an extract of such is shown below in Fig. 7.1.

A Virtual Model of the Thurstaston field site developed using a UAV and Google Earth

Tony Cliffe, PhD student, has developed this model to help with your understanding and interpretation of the past and present geomorphic processes at this location

Link: https://sketchfab.com/models/542c6e51b05a4df19476da4d936e1fd9

You are advised to visit this link (which includes using Google Earth and 9 annotations/external links to articles and short videos/ animations. You can spend as long as you wish using the model, before and after your fieldwork, but we recommend that to just get a feel for the resource you should spend at least 20 mins on first visit. It works best when opened in the Google Chrome browser.

Clast Shape.

6

Created: Feb 2018

Fig. 7.1 - Instructions for the EVFG on the field guide handbook

The researcher also observed and talked to students on the field trip to Thurstaston to understand the student's interactions with the EVFG in action on the field trip and to assess any potential learning advantages or barriers that the students faced. There was no record of the time spent within the EVFG by students as there was no way for this to be recorded accurately within the software. It was also not possible to record how students engaged with the EVFG and at what point of the fieldwork did they access it, i.e. pre, during, post-fieldwork or a combination of all three. The view count did increase however by 30 during the time the EVFG was live to the students. In this research, it is known that at least one student did not access it before fieldwork (as indicated in an extract from their assignment) but all eight accessed it at least once post-fieldwork as evidenced in their assignment. Therefore, it is not possible to tell whether the viewings were multiple viewings from one student or many students.

This chapter explores the advantages and disadvantages that this specificE VFG had for these students on this fieldwork, as well as evaluating the views of lecturers about the EVFG in general for their own teachings and any improvements they would require for this to be used full scale in their teaching.

7.2 THE ADVANTAGES OF VIRTUAL FIELD GUIDES

Stainfield, Fisher, Ford & Solem (2000) stated that VFGs for actual field trips have many benefits over traditional handbooks such as;

- Much easier to update VFGs year on year and with last minute changes
- Active links to different sources of all kinds of information from websites to videos
- No real size or capacity limits
- Cannot be physically lost on the field trip
- Portable, especially on today's mobile technologies

Lecturers in this study were keen to point out the many learning benefits that the EVFG could offer them and their students. These benefits included the ability to revisit aspects of the field site virtually before entering the field, using the EVFG as a discussion tool in their teaching to help explain a theory, to the EVFG helping to engage students on fieldwork and make it more efficient. Students in their assignments noted a number of positive attitudes towards the EVFG in being beneficial to their learning and in helping them to complete their assignment. Students cited the high level of detail in the EVFG, the use of the embedded external resources and the ability of the EVFG to help explain the context of the site as a valuable learning tool.

7.2.1 First Impressions Of The Enhanced VFG

First impressions of the EVFG were essential to gauge how interviewees saw the VFG and what aspects they picked out of the EVFG before the researcher highlighted certain aspects to them during the interview process. All interviewees, both lecturers and students, had a positive first impression of the EVFG.

One of the first significant points that were discussed positively about the EVFG was the level of detail that the EVFG provided over traditional methods to which they currently had access. All lecturers immediately began linking the EVFG and its high resolution to their field of teaching and explained how the high level of detail would benefit their students, as outlined by a typical first response by lecturers below:

> I think general impressions is it's really good. The level of detail that you can get out from it and the sort of features you can pick out of it is really good. As a coastal person, there are all sorts of things you can pull out of it. So my eye gets drawn down to the beach because that's my area of study, so the fact that you can pick out the different sediment sizes, you know you can see the bands of fine sediment distribution, pebbles and cobbles and shingle in different areas, all those sorts of features which is really useful in a kind of potential teaching aid to highlight those sorts of things to students.
>
> (Lecturer [A], Geography)

As shown in the account above the EVFG offers high levels of detail, particularly for small and fine landforms such as pebbles. It is encouraging also that immediately such high resolution of the EVFG is "really useful in a kind of potential teaching aid". Not only lecturers but students with four of the eight assignments also commented on the high-quality resolution and detail of the EVFG. Students noted that the '*quality of the software has been impeccable with high-quality images to reference*' and that such images had aided their field trip assignment as seen in Fig. 7.2.

Evaluation of 3-D model and virtual field guide

The 3-D model and virtual field guide has been very useful and beneficial as the author didn't take a great deal of photos on the day so opening up the model and taking screenshots to use proved helpful. On top of using it for long distance photos, it was extremely useful for zooming in, even on the SD setting it was possible to get close enough to make out whether clasts were present in the sediment or not which was a major aid for the field trip assignment. Another positive point would definitely be the field guide, the author found the links to relevant articles and videos that were available to be more than useful enough so that they got used in this assignment.

Fig. 7.2 - Student Assignment Extract [i]

One student showed considerable surprise of the benefits of using the EVFG in her learning with comments such as "*this is cool! I didn't know you could do all of this*!" and "*I think it's very useful; actually, I'm surprised at how useful I think it is*" (Female, L5, Outdoor Education Student).

7.2.2 RESOLUTION AND REPRESENTATION

Lecturers stated that two of the main positive points around the physical attributes of the EVFG were its resolution and its representation of a real-world environment. Having a high resolution and replication of the field site in the EVFG allowed lecturers to point out certain features and allowed a solid base for further learning. Without such resolution, this may not have been possible. Some of the lecturers had either conducted fieldwork at this site or currently conduct research in this geographical area. While this was unknown to the interviewer prior to the interviews, it further cemented the EVFG's ability to replicate the environment to a high standard with lecturers mentioning that it '*looked familiar*' and therefore could offer a degree of qualification of the EVFG's ability to replicate the environment. Having a EVFG in high detail that replicates an area allows smaller details to be picked out that are useful for lecturers in their teaching:

> You can distinguish everything from fairly smaller shingle down to sand, and you know you can pick up a lot of detail within the cliff, you know erosion patterns, drainage wearing away eroding small areas in the cliff, vegetation you can see in the cliff right down to fine detail, you know you may even be able to identify species from that. So yeah I don't think there is any need for any higher resolution, everything I'd want to talk about I can pick out.
>
> (Lecturer [B], Geography)

While the resolution was high enough to work for one lecturer, there were some parts of the EVFG at very zoomed in levels where the resolution decreased, although this is common even with standard photographs at such zoomed in levels unless a GigaPan is used. Yet, even at this zoomed in level when resolution decreased is was still sufficient for the lecturer to pick out different elements of the landscape.

One lecturer stated that this is "*really what is lacking from aerial photographs, you know that's great having aerial photographs you can zoom in but if they haven't got the detail there…*" (Lecturer [E], Geography). Therefore, this supports the notion that this EVFG provides the large-scale, in-depth resolution that is clearly unavailable or currently lacking for educators on fieldwork of specific fieldwork locations in this study. While this is, on the whole, a positive attribute to the EVFG, it raised one concern from a student who believed that due to its high resolution and quality of appearance that it may, in fact, replace fieldwork as they explain in Fig. 7.3.

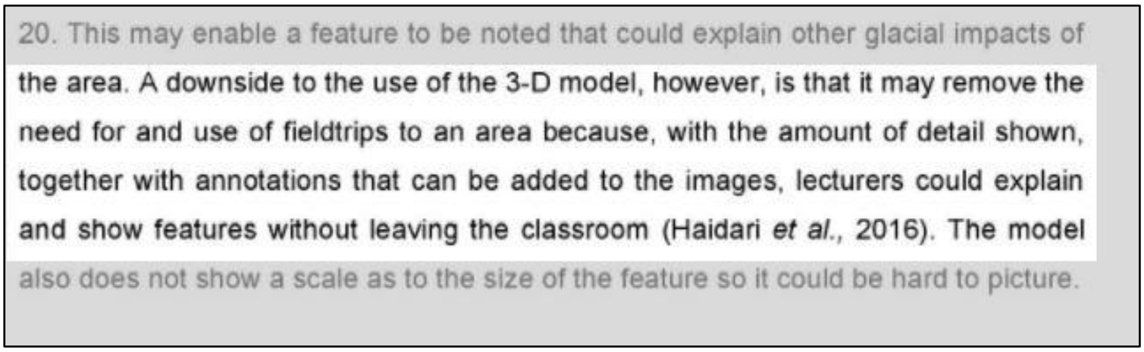

20. This may enable a feature to be noted that could explain other glacial impacts of the area. A downside to the use of the 3-D model, however, is that it may remove the need for and use of fieldtrips to an area because, with the amount of detail shown, together with annotations that can be added to the images, lecturers could explain and show features without leaving the classroom (Haidari *et al.*, 2016). The model also does not show a scale as to the size of the feature so it could be hard to picture.

Fig. 7.3 - Student Assignment Extract [iii]

While this student saw this as a negative aspect of the EVFG, it underlines the aspect of this EVFG in this research of the quality of the resolution and appearance that the EVFG offers both staff and students. VFGs have often struggled at times to recreate the world virtually in such high resolution and detail, but due to the high-quality optics of the UAV used in this research, it has opened up new opportunities for VFGs at large-scales to be highly detailed and accurate representations of field sites for staff and students.

7.2.3 Engagement Of Students For Learning

While the resolution was deemed to be high in quality of appearance, if students were not engaged by the VFG then potential to increase learning from it is limited. Lecturers referred to the EVFG as being another tool that they could use to enhance and improve their students' engagement with their own teaching which in turn as explained by

Scheyvens, Griffin, Jocoy, Liu, & Bradford (2008) may increase their learning uptake.

In the departments to which lecturers in this study belonged, often before a fieldwork task supporting material is hosted on an online-dedicated space on University servers where students can access such materials. This is common practice in Geoscience in Higher Education (Porter, Graham, Spring, & Welch, 2014). Through the interviews, it became clear that not every student engages with these materials, and as one lecturer remarked, students who do not turn up to lectures rarely engage with the online materials either. So one way the EVFG could help such students is through the collation and consolidation of such materials needed for the field trip but in a more engaging way, as highlighted by Lecturer A in his discussion around engagement of students.

> I think it's [the 3D model] something that is interesting and different and the use of 3D models isn't something that is done in teaching and I think we can add additional information on PowerPoint slides or Moodle pages [university online learning space] and that kind of thing but maybe they're more likely to engage with something which is more interactive and more exciting to look at than if they would if it was just stuck under a heading on a Moodle page.
>
> (Lecturer [A], Geography)

Having the 3D VLM of a field site within the EVFG allows a student to have an extra layer of interaction with the materials as a student "*can look at pictures of course before [they] go but it's not the same as being able to interact with a model like that*" (Lecturer [E], Geography). That interaction is enabled since students can zoom into areas in high detail while lecturers can actively point to specific areas of the VLM. While this is usually done with aerial photographs, lecturers were keen to stress that having such a VLM and the ability to explore and look at different angles makes it far more engaging than a passive paper or even a 2D digital photograph. This view was supported by one student who echoed this sentiment in their evaluation of the EVFG, Fig. 7.4.

be the field guide, the author found the links to relevant articles and videos that were available to be more than useful enough so that they got used in this assignment.

The good thing about the virtual field guide is that you can really give students a insight to how different glacial/ fluvial processes affect the earth and get learners involved by allowing them to explore the site for themselves rather than merely looking at a 2-D image on a screen.

The only negatives that spring to mind are if it were to be used instead of a field trip

Fig. 7.4 - Student Assignment Extract [iiiv]

What this EVFG provided is a new tool for both lecturers and students to potentially engage more with the materials than the current methods used.

7.2.4 Inclusivity and Disabilities

As discussed in Chapter III, disability in fieldwork is a significant and ever-increasing challenge for departments to facilitate. As noted in that chapter, lecturers offer different types of alternative field trips for those who cannot or do not want to go on the original field course. What this creates is a disparity in learning for students as they are not with their fellow classmates or in the area of study. As much as the lecturers have tried to recreate the same environment on the alternative field trip, it cannot replicate the landscape accurately.

VFGs are incredibly accessible for students of all types and all abilities (Klemm & Tuthill, 2003). With the introduction of modern techniques and the introduction of UAV technology and modelling from structure-from-motion, landscapes can be replicated to high accuracy and detail, as demonstrated so far with this EVFG. Such digital recreations of landscapes can be taken even further with the incorporation of Virtual Reality headsets that enable the student to be immersed into the environment digitally and while not perfect, is as close as the student can get to being included in the original field course (Ott & Freina, 2015). VFGs, therefore, eliminate the need for this inadvertent discrimination by reducing the need for physical travel and this is possible as outlined by the student in Fig. 7.3.

None of the students in this study identified themselves as disabled and therefore no direct conclusions can be drawn about the effectiveness of such a EVFG in helping a disabled student feel more included or increasing their learning through a virtual visit, rather than the standard practice of alternative field trips (Fuller, Bradley, & Healey, 2004). Nonetheless, in principle, some lecturers linked the challenges of inclusivity and how EVFGs such as the one presented here "*in terms of students disability in fieldwork…something like this has the potential*" (Lecturer [C]) to be a solution to the ever-present challenge of disabilities on fieldwork as one lecturer describes:

> I think one of the other things is we're always trying to think of is equality for students and accessibility. If we had any students who couldn't access the field site and beaches if someone was in a wheelchair, it's not ideal there is no solid path to go on so if we went out to this environment, if someone had access difficulties [they] wouldn't be

> able to come down. So this kind of model gives them as close as you can get to being there you know? (Lecturer [A], Geography)

Hence, while it cannot be tested in this research if such a EVFG would enhancing learning for disabled students, it does demonstrate the potential to do so. Through the use of external links and the high resolution of the VLM, disabled students now at least, have some means of visiting the site in a more engaging way than what is currently on offer to such students. Without the development of the EVFG from UAV data, such students would not have the option of such a tool and instead would rely on the current method of alternative field trips. Also not tested in this research due to lacking specific equipment, the EVFG is set up for the use with a virtual reality headset. For future research, this EVFG can be tested in VR to aid further its case of being able to help disabled students access the site virtually.

7.2.5 Reduced Impact on the Environment

Traditional field trips and principally those of an international nature have some disadvantages. The cost often means that not every student can afford to attend; there may be gendered issues, cultural and language barriers, logistical issues, security issues and problems in creating accurate risk assessments without prior visits by staff (Ternan, Charlkley & Elmes, 1999). Travel to and from the site can create excessive carbon emissions, along with increased footpath erosion for example on some fieldwork locations. Such issues are common issues on fieldwork in the UK as outlined through literature and echoed by lecturers in this study.

Such issues can be alleviated by visiting locations virtually meaning that no emissions or environmental damage to the site occur. One student observed that the utilisation of the EVFG could be advantageous for the environment through reducing environmental impacts as she clarifies:

> Again it's quite interesting...I want to be there, and I want to see it [the landscape] because that helps me learn and understand because you know you're touching and you're feeling etc. etc. but potentially it would stop 20 people descending every day and looking at that particular landscape, so actually you could be preserving quite a lot of landscape by taking the fieldwork a bit more virtually…you could be protecting the landscape.
>
> (Female, L5, Outdoor Education Student)

The EVFG therefore, can provide both staff and students with many positive aspects for the incorporation of fieldwork. The EVFG has been shown to have the potential to increase engagement and inclusivity and the potential to protect the environment. However, the EVFG provides many more in-depth advantages to both staff and students depending on when the EVFG was utilised by staff and students as explained in the following sections.

7.2.6 Using the bespoke EVFG Pre Fieldwork

Lecturers and students indicated that they would like the EVFG to be used both before and after fieldwork but for various reasons. Their use of the EVFG and their perceived advantages that the EVFG facilitated, shifted depending on if the EVFG was used before, during, or after fieldwork. The following section outlines how lecturers and students would use and have used the VFG before, during and after fieldwork. Firstly, the EVFG is examined for its advantages before fieldwork.

7.2.6.1 Preparing students

Due to limited resources and time when on ‘real’ fieldwork, academic staff want to spend as much time as possible getting the most out of their environment for their students (Stoddard, 2009). VFGs therefore, permit introductory information about the field site to be learnt by the students before going to visit it for real (Spicer & Stratford, 2001; Kingston, Eastwood, Jones, Johnson, Marshall & Hannah, 2012; Litherland & Stott, 2012). This information was incorporated into the EVFG made in this research through the creation of the context map and additional links to videos and resources. As identified by Tuthill & Klemm (2002) combining VFGs with ‘real' fieldwork provides the students with prior knowledge of the site, what data they are tasked to collect, how to analyse the data, and gives them the opportunity to design and develop their own projects before visiting the field site for real.

One of the benefits of the EVFG that was highlighted through the interviews was this ability of the EVFG to prepare students for their fieldwork trip through planning and familiarisation. The 3D VLM embedded in the EVFG allowed lecturers to “*take the students to the field before you take the students to the field*” (Lecturer [E], Geography). In practice, one student explained how using the EVFG before fieldwork helped her to explore the landscape and helped to alleviate the concerns of being placed in an unfamiliar environment on fieldwork. This not only helped the student to be more efficient but as demonstrated in Chapter III, student health and wellbeing and the student experience is an increasing part of geoscience in higher education. The EVFG, therefore, can go some way towards enhancing this as she explains below:

> It's really useful just before you go because it's a good sort of intermediately. You've got that classroom learning, and you've got a book, and you're learning from it whereas this is somewhere between the physical and the sort of a little bit more tangible. You can kind of go around; you can explore it whereas if I'm there, I'm not going to feel as like, oh here I am, I'm dumped in the middle of a landscape.
>
> (Female, L5 Student, Outdoor Education)

This ability for the EVFG to prepare students is a new and engaging way for students to become prepared with a field site. Current practice for the lecturers in this study was to give a PDF or printed handout version of the field trip handbook which often included the location, the aims and objectives and some further readings (an example can be found in appendix S). Often this can be unengaging to students as previously discussed and often fails to prepare students sufficiently for their time out in the field. Using such a new EVFG can alleviate such issues by making the information more interactive and immersive.

VFGs 'supportive simulacra' allow an environment, to in essence, scaffold students in building their own understanding of the tasks set both pre and post real field visit by incorporating their own and secondary data. This scaffold learning is arguably the key area in which VFGs can be used as online learning tools in geosciences education (Litherland & Stott, 2012). In this EVFG tutor led annotations, data and question prompts are used to help the student learn in this environment. Not only this, but a large selection of secondary data (in the form of pictures of the clasts) were embedded as a google drive file for students to access for their assignment. This allows the student to mix their primary data with the secondary data on offer within the EVFG. Dykes (2000) evidenced a greater understanding and depth of knowledge in students via this dual approach.

Hence, when the students arrive at the field site, they can get down to developing those skills in the field straight away, maximising their time in the field. Kent et al., (1997), stated that the completion of real fieldwork is what helps to make successful graduates. VFGs allow students to develop their skills and enhance their confidence in implementing such skills, in a real-world environment. Such confidence that can be developed before a real field trip means a better quality learning and data collection process for the student, which further enhances the benefits of real fieldwork (Killerman, 1996; Warburton & Higgitt, 1997; Bellan & Scheurman, 1998; Rozell & Garner, 2000).

Lecturers also believed that the EVFG helped to prepare students by being able to help them explain complex processes or locations in the field that were difficult to get across through pictures and other materials. This valuable tool helped students to understand the processes better through interaction and allowed the student to look at the landscape and visualise aspects through the 3D nature of the EVFG as lecturer C outlined:

> Yeah, I think before you go out into the field trying to explain to students that's a gully, that's a vail, that's an undercutting, and you see imagery and allowing them to almost touch it I think that makes a difference. So yes, pre-fieldwork I think it's an invaluable tool.
>
> (Lecturer [C], Hazards)

7.2.6.2 Increase efficiency

Having students who better understand the landscape that they are going to visit and the purpose of the field trip could potentially make students more efficient in the field. Preparation and planning can aim to make fieldwork more efficient (Warburton & Higgitt, 1997). While mobile technologies have been shown to increase efficiencies while in the field through data collection (Welsh & France, 2012; Martin & Ertzberger, 2013; France, et al., 2016) the EVFG developed could potentially increase efficiencies further by preparing the students in their planning of such data collection in the field.

Spicer & Stratford (2001) investigated how biology students felt about the use of a virtual field guide concerning tide pools. Of their study, 80% of students showed a highly positive attitude towards the educational value of this VFG. Many students stated that the benefits of exploring an area before actually visiting increased their confidence by being able to explore, make mistakes, and allows them to use the materials and prior knowledge gained for their own virtual field notebooks to compare when in the field. What this in turn facilitates is less time spent in the field discussing what to do and what data to collect and instead that is now done virtually before the field trip meaning students can get straight into data collection, maximising their time in the field.

The EVFG in the eyes of one lecturer believes that it enabled students to be more efficient in the field by getting straight down to the task through this prior learning and exploration:

> In a prior lecture when we teach students about you know cliff erosion or glacial landform you could use that [bespoke EVFG] really nicely as a resource and then take them out to see stuff or do stuff in the field so that they're familiar with what they're going to get when they get there which they can [then] get straight into the job at hand [in the field].
>
> (Lecturer [B], Geography)

This efficiency is something that one student highlighted, showing the potentially important role the EVFG can play in preparing students for fieldwork.

> Student: … quite often you waste so much time when you're there assessing something whereas if you had access to this, to begin with, you'd already know certain angles to be looking for.
> Interviewer: So you think it will be more efficient?
> Student: Yeah and your equipment can be set up in areas of focus, all those sorts of things will be really interesting.
>
> (Female, L5 student, Outdoor Education)

Another student mentions how in hindsight using the EVFG before their fieldwork may have aided their time in the field and subsequent assignment. Thus, provided further evidence that students value the EVFG for its ability to prepare them for fieldwork as one student enlightened below.

> One limitation of the study was a lack of preparation which the researcher took before the field trip. The Thurstaston Virtual Field Guide produced by Tony Cliffe could have been used as a preparation tool before the field trip, and the tutorial to its use would have perhaps been better explored earlier.
>
> (Student Assignment Extract)

This potential increase in efficiency on fieldwork is an important aspect to focus on due to the pressures already placed on fieldwork such as time and staff resources as discussed in chapter III. If a student can be more efficient on fieldwork, then it makes the limited time in the field more productive. One lecturer alluded to this pressure and the EVFG as the EVFG can make fieldwork "*more efficient, save more time in the field as that time costs more money and is valuable*" (Lecturer [D], Outdoor Education). One lecturer commented on how the VFG is important to have because "*you're only going to get one shot at the fieldwork*" (Lecturer [E], Geography). The VFG, therefore, allowed the maximum to be extracted from a relatively short time in the field.

In this section, the EVFG has been shown to be effective before fieldwork in making students feel more at ease in the real world location, their ability to plan and facilitate data collection strategies and all of this saves time on fieldwork. This frees up more time for students to be doing rather than listening or setting up for their time in the field. The EVFG links well with established mobile technologies and the notion of M-learning as discussed in chapter IV, have been shown to be excellent tools in developing efficiencies once on fieldwork and post-fieldwork regarding data collection and analysis. In conjunction with the EVFG, this increase in efficiency can now be extended to before the field trip, something that mobile technologies had often struggled to do. Therefore, utilising the EVFG before fieldwork and then mobile technologies during and after can have the potential to increase learning and make fieldwork more efficient. A summary of the advantages that the EVFG offers both students and educators can be found in Fig. 7.5.

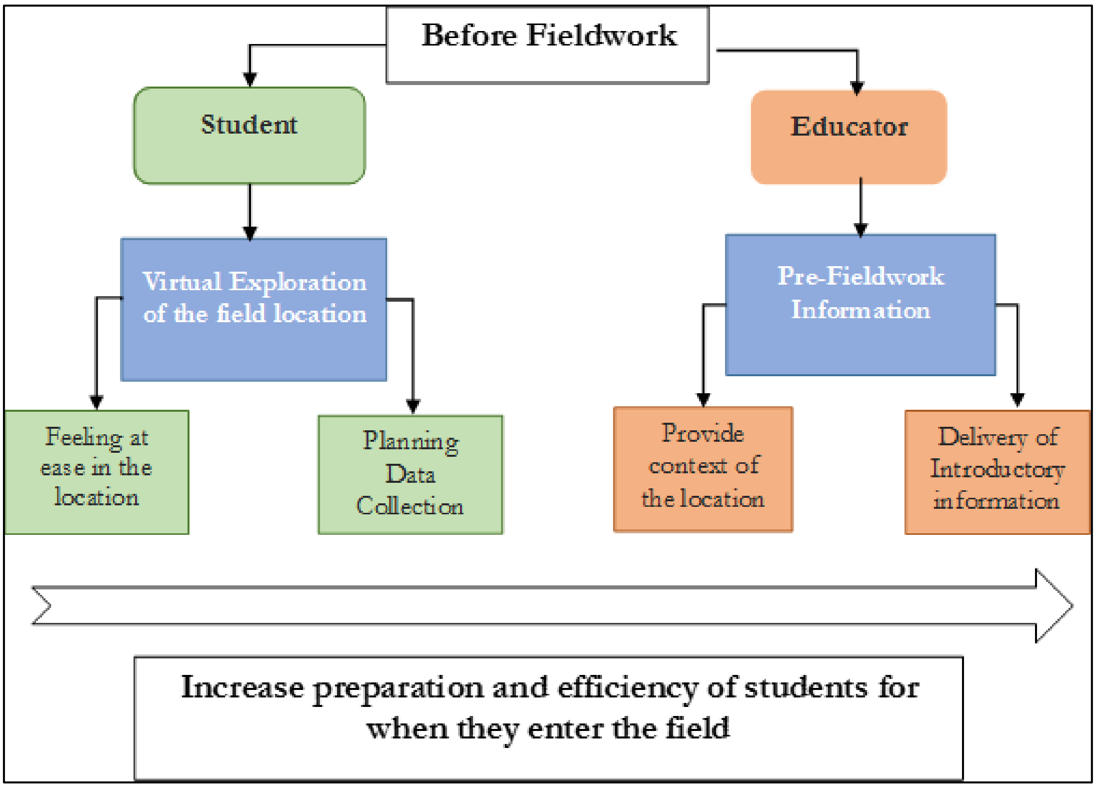


Fig. 7.5 – Model showing the effectiveness of the EVFG pre fieldwork

7.2.7 Using the Bespoke EVFG During Fieldwork

The researcher observed the use of the EVFG during the fieldwork activity on the day of the field course to Thurstaston. Multiple students accessed the EVFG from their mobile devices during the time spent at the cliff. Most surprising to the researcher was the ability of the EVFG to promote unaided or unprompted discussion between students as shown below from an extract of the researcher's field observation.

> By now we had arrived at the field site, and while [name] was showing the students some coastal landforms I made a quick dash up to the location the students would be working on. I knew the cliff fairly well after all the revisions of the model, but to my surprise, the big gully had partially collapsed near the bottom, clearly evident from the spilling out of the material. It looks fairly recent too!
> By now the students were very quick to notice the collapse, and this was confirmed by one female student looking at the model on her mobile device and showing her peers where exactly it had collapsed. What I witnessed next was quite possibly the best moment I've had seeing the model in action. Unprompted by myself or [name] the students started to discuss what might have caused it. Was it coastal erosion, perhaps some storm action as half of them thought or as the other half argued it was rainwater from the top of the farmer's field that caused it, they used the map from the model to help explain their point. While this was not the main purpose of the field trip to discuss erosion, I think such debate and tangents are necessary and most importantly for me, I don't think such an in-depth conversation would have occurred had the students not known the cliff was different from the time the model was captured to what they saw today. I personally feel the model alone has demonstrated today to be an effective learning tool to promote discussion. I can't remember which lecturer mentioned this, but I know he alluded to the model having the potential to promote such discussion in the field. I think today has proven that.

While the researcher observed this peer learning and discussion on fieldwork, this continued across into the student assignments with some students using screenshots of the EVFG to highlight the collapse of the cliff. One student (Fig. 7.6) used the EVFG and their own observations to explain the context of the field site, while another used the partial collapse of the cliff to potentially explain the nature of their results (Fig. 7.7).

It is believed by the researcher that the gully in the cliffs was formed by several processes acting upon the cliff. At the top of the cliff, there is a farm field boundary, as is shown by the virtual field guide with a fence. Farmers tend to put drainage ditches or underground drains at the edge of their fields. It is likely that running water from the drainage system caused erosion on the rock, especially with the rock predominantly being composed of sandstone sediment. It may be the case that there was a weaker vein of rock, although this is unlikely, as sandstone is already a friable rock, registering less than 3 on Moh's Scale. However, the porosity of sandstone lends credence to the theory of fluvial, that is running water, erosion, which is probably accelerated by storm erosion from the sea and from weather.

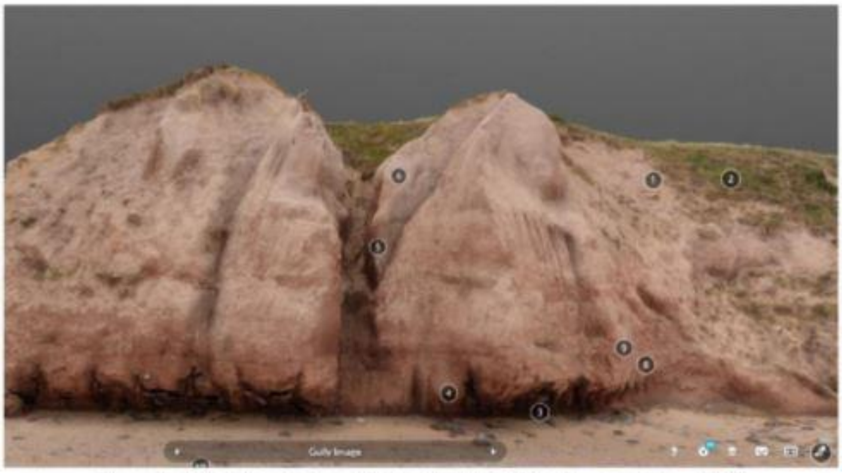


Figure 5: The Thurstaston Virtual Field Guide. Source: Tony Cliffe

Fig. 7.6 – Student Assignment Extract [v]

The area that was investigated is constantly changing. By comparing the 3-D model, Figure 18 and Figure 19, it can be seen that a substantial amount of material has collapsed from the centre gully. This could therefore be another reason as to why the direction of the material is inconsistent, due to coastal erosion effects from the sea and the amount of precipitation the area receives, weakening the rock and the embedded material (Bernatchez and Dubois, 2008).

Figure 18: Thurstaston Cliffs 2018

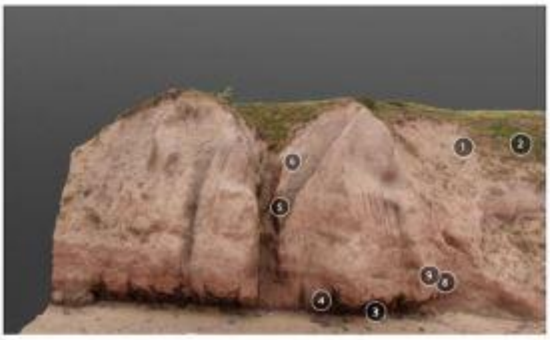


Figure 19: Thurstaston Model Test Photoscan from 2017 (Cliffe, 2018)

Fig. 7.7 – Student Assignment Extract [vi]

While the EVFG's benefits are more pronounced during and after fieldwork it has been shown through the short extract of observations that it can be a tool to promote discussions and peer learning in the field. The EVFG in action with the students and the discussions that took place had elements of student reflections and showed some evidence of a community of practice existing. The students used the EVFG as a tool to select and deselect ideas for the erosion between them. This peer learning was encouraging to see and goes some way to agreeing that some level of communities of practice does exist amongst students on fieldwork as discussed and evidenced in the data in chapter III. In Fig. 7.8, is a model of the effectiveness of the EVFG during fieldwork.

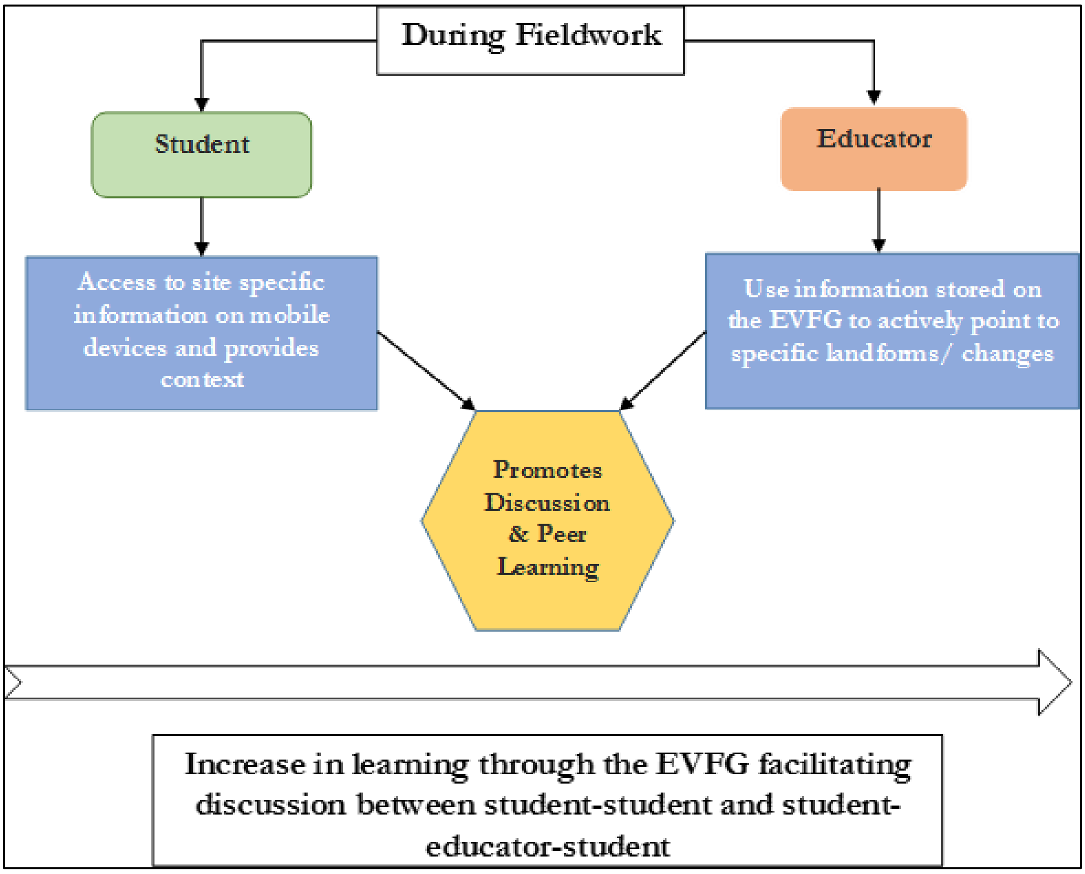


Fig. 7.8 – Model of the effectiveness of the EVFG during fieldwork

7.2.8 Using The Bespoke EVFG Post-Fieldwork

The EVFG being used before fieldwork offered lecturers and students some benefits in terms of their learning and their efficiency on fieldwork. All participants mentioned using the EVFG post-fieldwork in some form of capacity, and this ranged from the ability of it to facilitate discussion to the EVFG being used extensively in the assignment.

7.2.8.1 Discussion tool post-fieldwork

While the EVFG had been shown to be effective in encouraging discussion in the field, using the EVFG post-fieldwork as a tool for discussion was a common theme arising from the interviews. A basis for this discussion was often situated around the students now being familiar with the landscape in question. As the students are now familiar with a location having visited it, the EVFG can be used to further enhance their learning through tutor-led discussion. This point was emphasised by one lecturer who discussed the potential benefit of using such a EVFG in his coastal modules:

> …[use the EVFG] as a discussion tool afterwards so it's got a lot of power to say okay we saw all of those things and we talked about them in the field now let's relate that back to the theory now that we're back and they'll have the context because they've seen it.
>
> (Lecturer [B], Geography)

This view was also indicated from a student perspective that they find using the EVFG post-fieldwork beneficial as a discussion tool as the EVFG "*you sort of know what you're looking for and compare like, oh yeah I remember that happening, or I didn't expect that to be there would be quite good!*" (Female, L5 Student, Outdoor Education).

7.2.8.2 Ability to revisit the site virtually

As fieldwork is often time-limited as it is often a "one-shot" experience sometimes due to weather or external pressures such as equipment failure, some tasks or measurements may not be completed. On the other hand, perhaps the limited time in the field can hinder some students and lecturers in their ability to utilise the landscape fully for their learning and teaching. The EVFG, therefore, provides the ability for lecturers and students to spend as much time in that location as they want virtually, without any time pressure. This ability to revisit a location can potentially enhance student learning by continuing to access the field location whenever they want.

> If you've forgot something or didn't take the notes. If something happens and you didn't have enough time. So being able to go back in that way kinda' virtually almost isn't it? You know just having that sort of resource available to us is just fantastic!
>
> (Lecturer [E], Geography)

The EVFG proved beneficial to one student who did not take notes on the day and therefore relied on the EVFG in order to gain access to images to use in their assignment as they show in Fig. 7.9, supporting the idea from the lecturer above that having such a EVFG can offer a safety net on fieldwork to capture data.

> The 3-D model and virtual field guide has been very useful and beneficial as the author didn't take a great deal of photos on the day so opening up the model and taking screenshots to use proved helpful. On top of using it for long distance photos, it was extremely useful for zooming in, even on the SD setting it was possible to get

Fig. 7.9 - Student Assignment Extract [vii]

Students in their evaluation of the EVFG mentioned that they appreciated that they could revisit the EVFG in a virtual space with no time pressures to jog their memories or to do further work, Fig. 7.10. This further supports the benefits of the EVFG being able to be accessed continuously and at any time, taking away the one-shot experience of fieldwork and the pressures that come with that. By allowing the student to spend as much time as they require in the field site, along with the ability to offer a safety net of missed data, has the potential to further aid student learning, especially as shown in Fig. 7.10 the ability to jog a student's memory for their assignments.

> The model created of Thurstaston has been of great help, it has allowed for a continued virtual presence at the site upon which we were studying. The model allowed me to go back and view sections of the cliff that I had forgotten about, such as the stream that is located on the site, and see how this has caused the cliff to change since the field visit as the model was made before the field trip.

Fig. 7.10 - Student Assignment Extract [viii]

7.2.8.3 In the Assignment

Direct evidence of the EVFG being beneficial to learning was in how students utilised the EVFG and its various resources in their assignment. One student commented that the EVFG was "*certainly a powerful tool for learning and has proved valuable in the writing of this report*". Students used the EVFG in their assignment in a variety of ways. Every student used a screenshot image of the VFG at least once in their assignment, with others using multiple screenshots and annotations support their assignment.

The first use of the EVFG and its external resources were evident in students using the tool to help explain the context of the site. As shown in Fig. 7.11, both students used the context map that was created within the EVFG to help explain the location and the direction of the ice movement to support their argument in their assignments. Other students used the EVFG to help explain their results. One student used the EVFG effectively through annotating the EVFG and using the various picture resources in the EVFG to help qualify and explain their results through such images and linking them to established research, Fig. 7.12.

Fig1. An aerial view of the location of Thurstaston (google earth, 2018).

Fig3. An Aerial shot showing where the samples were collected from along Thurstaston beach. The yellow line depicts the rough direction of glacial movement from point A to point B.

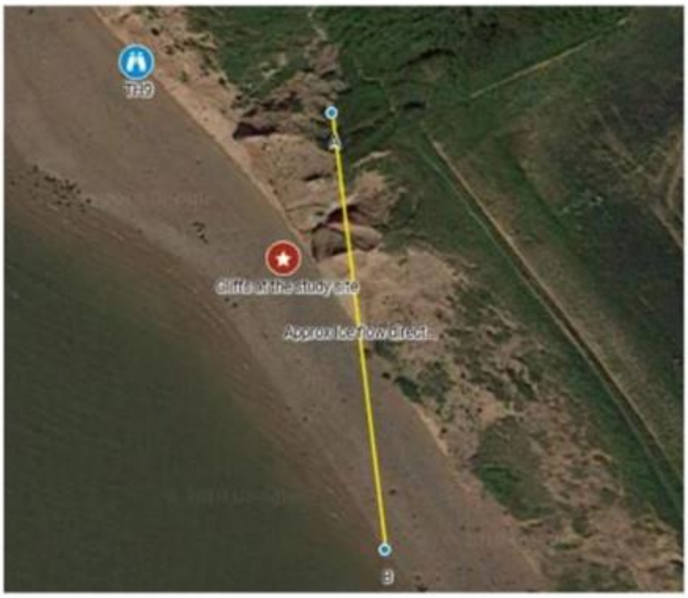


Fig. 7.11 – Student Assignment Extracts [ix]

Land formations

Fig5. (A, B,C,D), A: A cliff profile looking south; B. Rocks found at the bottom of the cliff face; C. exposed clasts in situ; D. the cliff face showing the cliff lithogy (Cliffe, 2018). Good

Good illustration

A. *Good annotation* **B.**

C. **D.**

Figure 5 gives a few examples of land formations and glacial sediments found at the sampling area at Thurstaston. Image A, shows the whole cliff edge looking from the south and shows many different landforms caused by glacial, solutional and wave erosion. It is possible to make out three separate lithogies in this area which can be identified as clast rich diamicton, sand and clast poor diamicton. These features are typical for the cliff faces at Thurstaston., these have been marked on the image to help identify these separate boundaries. This feature reflects what Glasser, *et.al.(*2001) stated in their paper and back up the idea that . Erosion caused by wave action can be identified at the bottom of the cliff where the process of undercutting is taking place, this will cause glacial till deposits from the cliff face to drop out onto the beach. Deposits found on the beach at the base of the cliff are generally sub-rounded to well-rounded in nature, evidencing that the deposited these at some point through the means of transportation (Fig5b.). Figure c. is a very good example of the glacial till in situ of the cliff face. The till is generally moderately-well sorted in accordance to Hubbard and Glasser's (2005) clast sorting diagram. The grey tones of the clasts are striking against the reddish brown backdrop of the parent material identifying these clasts as not local to the area. These characteristics are typical of glacial till showing that during the Devensian glaciation, these samples would have been transported along in the ice until deposition occurred. Photo D is a strong example of folded deformation till which can be found all along the cliffs. V.good

Fig. 7.12 – Student Assignment Extract [x]

Post-fieldwork, the EVFG was used extensively for the assignment and provided a useful tool in enabling students to use the EVFG to either support their arguments, develop new knowledge, revisit the location to jog memories, or to view the location from a different angle. What this provides is a tool which is beneficial to learning as discussed in the section below. A summary of the key effective attributes of the EVFG post fieldwork can be found in Fig. 7.13.

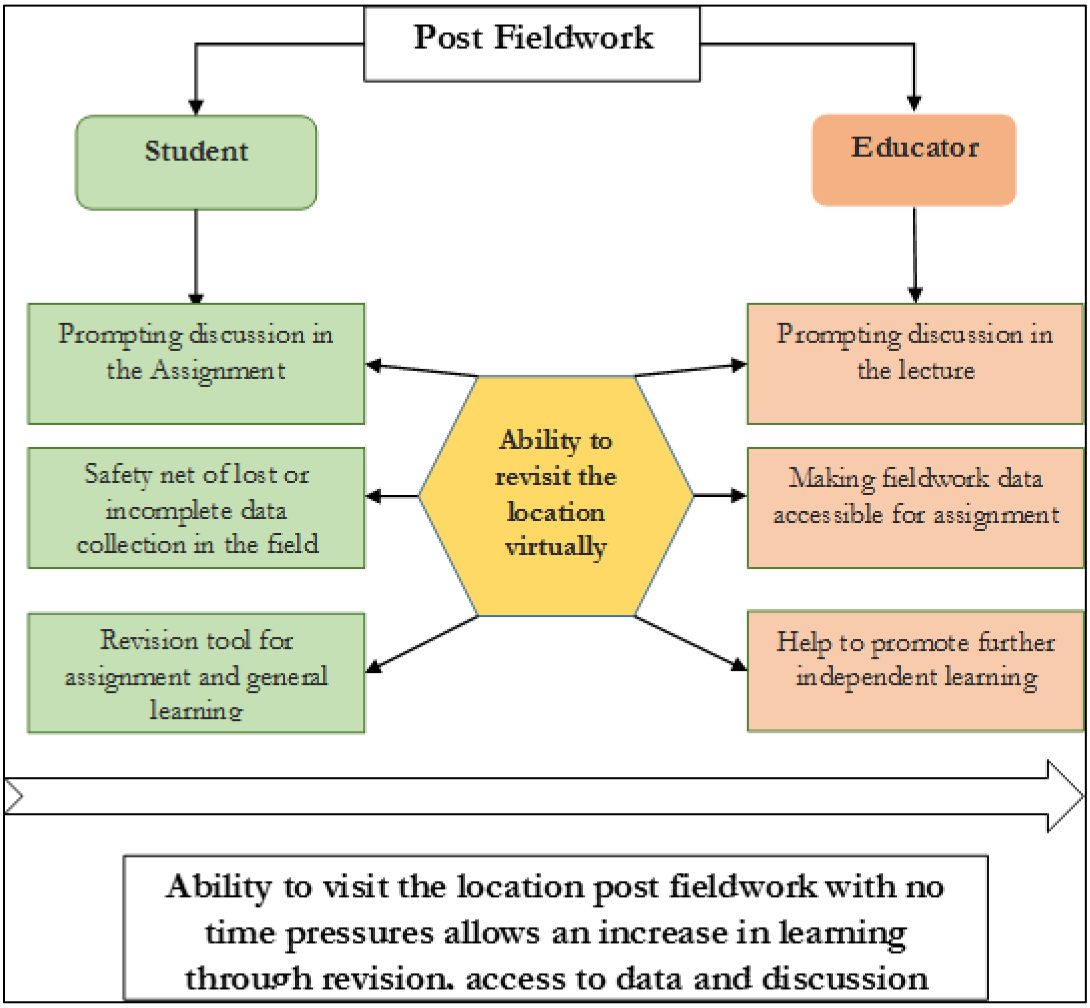


Fig. 7.13 – Model of the effectiveness of the EVFG post fieldwork

7.2.9 The EVFG as a Beneficial Learning Tool

While lecturers and students before using the EVFG surmised that it would be an effective learning tool, this was evidenced in the students' evaluations of the EVFG in their assignment. Some of the evaluations of the EVFG from students are given in Fig. 7.14. It is encouraging to note that students saw a great positive from the EVFG in their learning for a variety of reasons (a.) the software and its detail allowed students to gain a deeper understanding of the land formations, (b.) The EVFG helped to promote independent study for the students, (c.) The EVFG helped to confirm and support student theories and hypotheses in relation to their assignment, and (d.) it helped students to collect background knowledge and context before and after the field trip.

(a.) The Thurstaston 3D virtual field guide, created by Tony Cliffe is a fantastic piece of software to have when undergoing research and writing reports about the interpretation of what happened during the Devensian glacial period at Thurstaston, Wirral. The quality of the software has been impeccable with high quality images to reference and handle little links to external reference points. It has helped with the understanding of the land formations and allowed for up to date access to what stage the formations are currently at. The ability to apply different affects to the guide such as wire frames and UV points has been beneficial to gain a better insight into the depth of the formations.

(b.) The Thurstaston virtual field guide provided links to Youtube videos and photographs which together informed and eduated the researcher. Other parts of the field guide inspired the researcher to conduct independent study. One such example of this is link number six (see figure 5), which asks how the gully may have been formed.

(c.) The 3D model made by Cliffe (2017) was useful to me in looking back at the investigation site in order to look at the gully carved into the till from a better angle. It also enabled me to see that the gully lined up with the field boundary leading me to my conclusion on the gully being carved out by drainage water.

(d.) Thurstaston Virtual Field Guide

The Thurstaston Virtual Field Guide produced by Tony Cliffe is certainly a powerful tool for learning, and has proved valuable in the writing of this report particularly after the field trip. Not only has it been useful in providing information on the terrain beforehand, but the links on the guide have aided the collecting of background knowledge and asked some thought-provoking questions.

Fig. 7.14 - Collection of student assignments

It became clear through the first edition of the EVFG that lecturers would have liked some annotations to be included in the EVFG. Subsequent revisions were made and the annotations informed by lecturers were added. Using the Sketchfab software annotations were strategically placed around the EVFG to navigate the student and to highlight specific areas of interest that the lecturer had identified. This ability to highlight areas of the EVFG was a valuable tool for when students access the EVFG in their own time without a lecturer present.

A number of different types of annotations were used in this EVFG. For example in Fig. 7.15 annotations were used to (i.) link to videos for a context of the site and processes, (ii.) Embedded images with lecturer questions to promote critical thinking, (iii.) Embedded images for understanding, (iiiv.) Map created for contextualisation, (v.) Links to established research and (vi.) link to external data such as a database of images. All of these annotations were requested by the lecturer, and this allowed the EVFG to be flexible in its design and approach depending on what the lecturer wanted their students to gain from such a location.

What this enabled is the ability to look beyond the field site and place it more into a broader context that is more beneficial to their learning. One lecturer summarised that using the EVFG post-fieldwork could enable critical thinking in his students by making it '*easier for students to visualise that big picture*' (Lecturer [A], Geography). Allowing students to visualise this big picture is an extension to the perceived benefit of UAVs in education that can potentially provide students with this bird's eye view and wider view of the field site as discussed in chapter V. Students in their assignments referred to and showed examples that '*the links to relevant articles and videos that were available to be more than useful*'. In one student extract, they explained in detail how the various annotations helped them in their learning.

> The numbered annotations on the model were also really useful. For example, the evidence of coastal erosion seen by numbers 3 and 4 could be clicked on, and the annotation would explain the processes of coastal erosion as well as take you to a YouTube video showing and explaining the coastal erosion processes in more detail. The virtual guide is also useful more specifically to do with glaciation because annotation 1 takes you to a video showing the advance and retreat of the Irish Sea Basin ice sheet with the time frame alongside which helps improve an understanding of the lack of British Ice sheet advance and deglaciation. Annotation 7 and 8 are also very useful for this research because they define what a glacial clast is as well as provide a link to another YouTube video extremely helpful for developing an understanding of glacial deposits.
>
> (Student Assignment Extract)

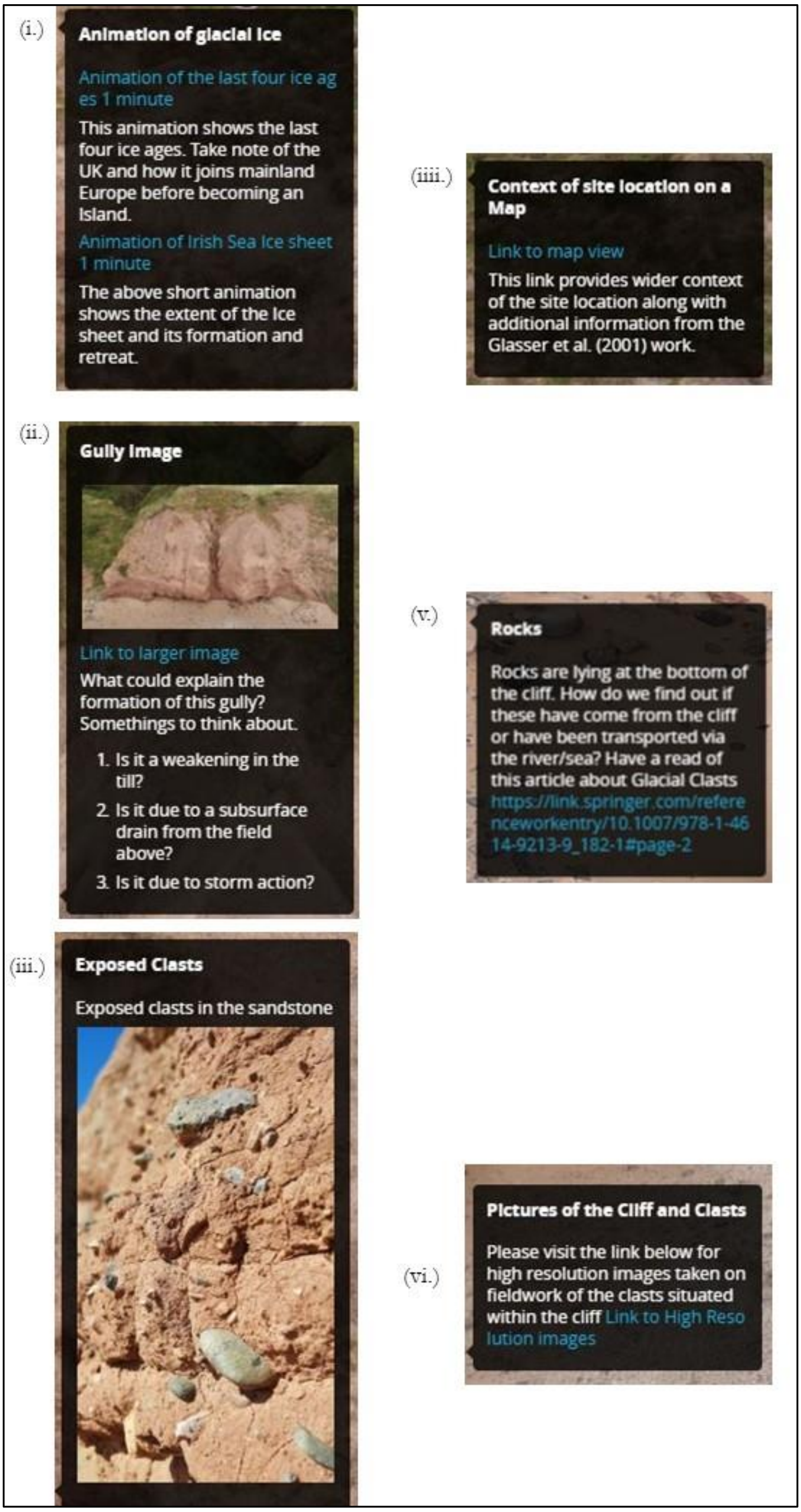


Fig. 7.15 - Variety of annotations in the EVFG

Providing students with extra information and the context of a field site is a development that lecturers in Chapter V stated that UAVs could bring to their students. Here, this is evidenced in effect for students who have shown a high level of engagement with the annotations and the external resources. This engagement with the material has been seen extensively in the student assignments and therefore has influenced their learning in a way that the traditional field guide may not have facilitated. Students overall have shown not only a positive engagement with the EVFG and its resources but have found it to be easy to use, to be an effective learning tool and has helped them to gain a deeper understanding of the landscape in question. In terms of fieldwork, it has been shown to increase efficiencies on fieldwork through students being familiar with the site, and it facilitated more in-depth learning through the comparisons made with the EVFG to the site in question on the day of the field trip. This EVFG has demonstrated that it can be an effective learning tool for students and a useful tool for lecturers to utilise in their teachings.

7.3 Limitations of the bespoke EVFG

While the model was well received by all those interviewed, there were a few issues that were raised about the bespoke EVFG. These limitations were mostly around the practical elements of navigation and the generation of the model such as stitching errors in the software.

7.3.1 Navigation Issues

The first issue of the EVFG was the difficulty of navigation within it. Difficulties in the navigation of VFGs is often an issue as found in many field guides (c.f. Stainfield, et al., 2000; Spicer & Stratford, 2001; Baggott la Velle, 2005; Garner & Gallo, 2005). This EVFG suffered a similar problem with the issues of navigation but for a different reason. Many VFGs have navigation issues in the form of students getting lost or disorientated in the VFG. The navigation issues present in this EVFG often centred on the EVFG tending to occasionally turn upside down if the mouse was dragged too far or too quickly. Such an issue was evidenced in the beta testing phase but was also highlighted by one student in their assignment who commented that '*when I first opened it, [it] spun around very quickly, often ending up not where you intended. Sometimes the model would spin round to the back of the cliff*' (Student assignment extract). If annotations are included in the EVFG, then it is not possible under the current software to place any restrictions on the movement of the EVFG to alleviate this occurrence.

However, if no annotations are included, then a floor and a restriction on the degree of movement can be built into the EVFG. Therefore, lecturers must decide if having this potential flipping of the EVFG with annotations is an inconvenience or if it is vitally important to be addressed. The other issue of navigation in the EVFG from the researchers testing phase is that the EVFG was far easier to navigate with a mouse and click wheel than through a standard trackpad on a laptop. While this is not a concern for students accessing the EVFG on university PCs which are connected with a mouse, those accessing the EVFG remotely through laptops may find this to be an issue. Further issues centred around the sensitivity of the EVFG. One student believed the EVFG to be too responsive, yet another student had the opposite problem with the EVFG being too slow as they enlightened below.

> Even when opening it in a chrome browser on [University] computers, a lot of lag is still experienced. It also slows the computer as a whole making it very hard to have the software open at the same time as any other browser tabs of software such as Microsoft Word. This slow process also makes it difficult to scroll around as it is not very responsive which causes issues when trying to navigate around the field.
>
> (Student Assignment Extract)

The above issues are the primary cause of concern for the EVFG, and particularly the issue of the EVFG being slow is a trait of large-scale VFGs which are often very memory intensive due to their size. Due to this, the issue of scale vs detail is one that the creator must finely balance with regards to the objectives of the EVFG and computing power that is available. More testing is needed on this EVFG on various platforms, and one potential solution is to reduce the number of faces in the EVFG further as discussed in chapter VI to ensure it runs smoothly on all operating systems and devices. Nevertheless, this may reduce one of the main positives of this EVFG, which is a high level of detail.

7.3.2 Rouge Artefacts and EVFG generation stitching

One lecturer when looking at the EVFG noticed some rouge artefacts that could potentially be confused as a geographical landform as they elaborated that '*I think these are possible some artefact of the VFG generation instead which could confuse students with a bedform in a coastal environment, but that is easily pointed out to students*' (Lecturer [A], Geography). While this can be alleviated through signposting to students, it is envisaged that more images taken in better conditions may be able to eliminate such artefacts. The artefacts in question can be seen in Fig. 7.16. As discussed in chapter VI the conditions for the data collection flight were on the upper limit regarding wind speed. As mentioned, higher wind speeds tend to introduce motion blur to data captured images. As such it can be concluded that as the winds on the data collection flight were gusty, this can potentially explain such artefacts.

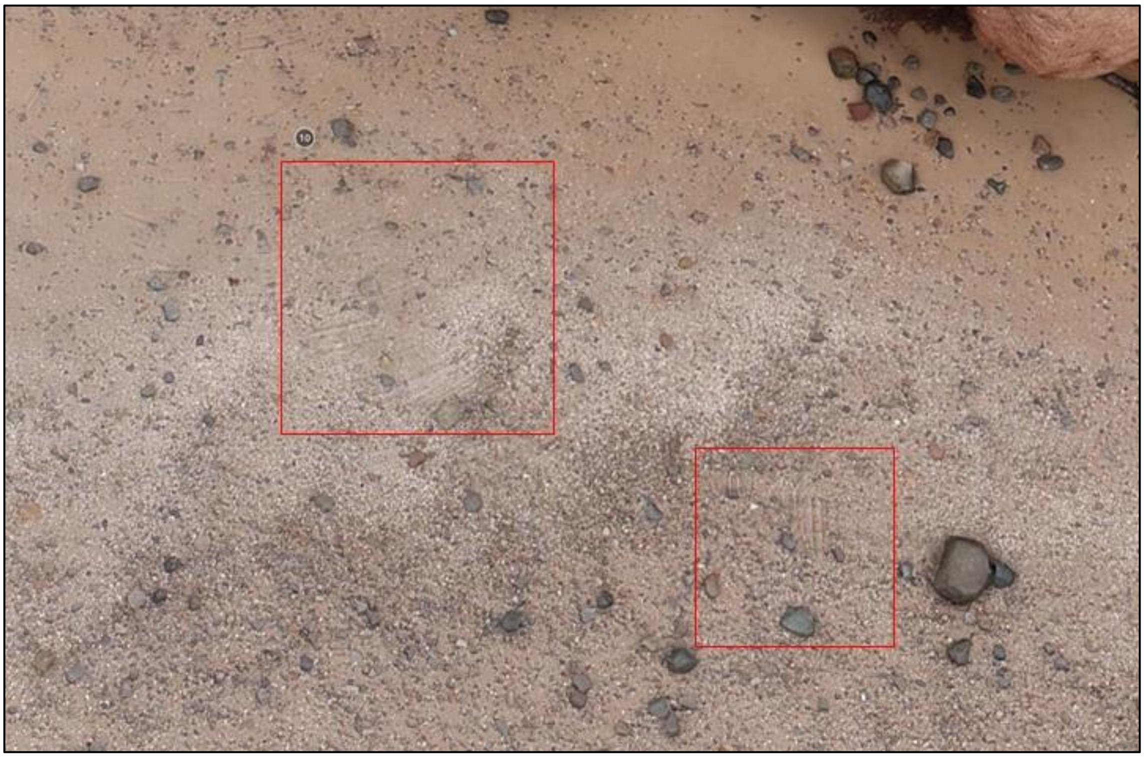


Fig. 7.16 - Stitching Errors [A]

While rouge artefacts appear in the EVFG, due to the nature of the cutting of the lower surface of the cliff the software struggled to correctly match or represent such a feature accurately. The issue of the stitching errors with the black spaces on the EVFG in Fig. 7.17. It has been identified that further pictures at ground level using a smartphone camera with GPS tagged should alleviate such an issue in a future edition of the EVFG.

Fig. 7.17 - Stitching Errors [B]

7.3.3 Replacement of fieldwork

An issue that was raised by one lecturer was a concern that the EVFG could potentially replace a field trip or make students question the use of physical field trips if it can be done online. His concerns were echoed by one student who stated a downside to the use of the EVFG is that it may remove the need for field trips to an area due to '*the amount of detail shown, together with annotations that can be added to the images, lecturers could explain and show features without leaving the classroom*'. While this is a concern for one student, another believes that the '*virtual field guides would not be able to successfully take the place of a field trip and certainly not without development*'. Another student in their evaluation of the EVFG believed that despite the EVFG being a useful tool it '*doesn't offer the benefits and connections that students make when recording data first hand on a field day*'. This comment can be explained by the students in this study as discussed in chapter III preferring to be out in the environment and exploring the landscape for themselves.

This was further supported in the literature by Arrowsmith et al., (2005) who argued that VFGs could not, and will not, replace the tried and tested method of real fieldwork. Spicer & Stratford (2001) in their Biology VFG when students were asked if they learnt more from a VFG and if a VFG should replace the traditional field trip, they showed a significant disagreement to those statements. They stated that although the VFG was useful, it did not compare to the actual experience of a field trip, a similar notion showed by the students in this research. Arrowsmith et al., (2005) student's remarked that VFGs do not provide the same experience or chance for students to develop the skills most developed on real-world field trips such as teamwork and communication.

As discussed in chapter III, 'real' fieldwork exposes students to different environments by taking them out of their comfort zone, giving a hands-on practical experience which despite increasing technology such as virtual reality, as of yet, cannot replace these experiences virtually (Stainfield et al., 2000). Students on fieldwork as discovered in chapter III often take away the experience of teamwork, bonding with fellow classmates and tutors as one of the most successful parts of a field trip (Dunphy & Spellman, 2009). The difficulty that VFGs have in replacing traditional fieldwork is the intrinsic nature of fieldwork that is to get out and explore the world around them (Bellan & Scheurman, 1998). While VFGs do allow for the exploration of sites, through data, maps and digital technologies, they are not the same as visiting first hand (Hurst, 1998).

VFGs have often struggled to become virtual in the sense that the technology for immersion was lacking and often required cumbersome body suits to place the user in the computer-generated field (Jacobson et al., 2009). Currently, it is impractical and costly to suit students up in motion capture technology to physically walk in the virtual environment, and there is yet to be a completely affordable technology that allows a student to be fully immersed in this virtual world. Therefore, while VFGs are very interactive and can be highly detailed as shown in this chapter, the student still sees that environment via a computer screen, and that limits its virtual aspect and thus its comparison to a real field trip.

Despite this, there is an acknowledgement by one lecturer who suggested that should the need arise for a field trip to be cut due to external funding pressures then this would be a viable alternative to consider.

> Yeah I don't think you can ever fully replace being there and seeing it and in the real world its constantly changing and the waves are hitting the beach but on the other hand yeah, if the pressures meant like I said you have to cut down to two out of three trips, maybe you know, you can use something like this to replace the third trip that you can't run and at least cover the same material in as close an approximation as possible.
>
> (Lecturer [A], Geography)

7.3.4 Scale and Historical Data

Lecturers enquired about scale in the EVFG and if this was possible to be implemented. Students wanted the addition of scale as for them using the EVFG '*before the trip it was difficult to judge the size of the cliffs, and also the extent of the erosion for example in the gully*'. This issue of scale and the misjudgement of the size of the landforms was also evident in the VFG of Arrowsmith et al., (2005) who's students anecdotally mentioned that they misinterpreted the distances between sites and that steepness of gradients were vastly underestimated. A scale is a vital missing part of this EVFG, however, currently there is no way in this software to include scale postproduction. Potentially the only way to alleviate this is to include some sort of physical scale in the EVFG during the data collection process such as numerous meter rulers or a 5-meter survey staff, although this is yet to be tested.

Both lecturers and students wanted a layering of historical data over the EVFG or future EVFGs to be included. Students wanted this to form a '*virtual 3D time-lapse of how the* *cliff has changed*'. This inclusion of a time-lapse is a reasonable request as UAVs have the ability to '*give us that high spatial resolution and fairly high temporal resolution over reasonable large extent that nothing else can easily do at the moment*' (Lecturer [A], Geography). As the EVFG is created from a UAV, it could potentially create EVFGs of high temporal and spatial resolutions. As of yet, there is no way to include such information on a sliding scale at present within the one EVFG in this software. There are ways to do this with still images or to link numerous EVFGs through the annotations; however, the lecturers and students indicated a want for an 'all in one' EVFG that could show change over time. Unfortunately, while this is an aspiration that would undoubtedly be a useful addition to this EVFG, it is limited by the current software and therefore cannot be added to a EVFG at present.

7.3.5 Developing the Annotations

While the annotations were well received, one student suggested having audio annotations in the EVFG. This was also something one lecturer would like with the annotations as he expressed the following:

> What would be fantastic would be if you could hover over parts of the image or the model and a pop up says this rock is 350 million years old its origin is in Borrowdale in the Lake District. Maybe those sort of things you could learn from in an active way or you click on something and it speaks to you and says that sort of thing.
>
> (Lecturer [D], Outdoor Education)

At present, this is not possible; however, development of links to external downloadable audio content is. One potential with audio annotations is to take it one step further to include video annotations instead. Currently, these videos must be hosted on YouTube, there is the option for a lecturer to be filmed in the field talking about a specific landform on the EVFG, and this video can be linked to in the annotations. Therefore, there is a possibility for students who could not visit the field location for various reasons to still understand what occurred, and this could then become a major learning enhancement for students in their work and for inclusivity of students.

7.3.6 Lack Of Student Involvement

One of the issues present in the EVFG is the lack of ability for students to create their own VFG (as discussed in chapter V due to UAV regulations this was not possible), but more importantly, a lack of adding their own annotations to the EVFG is a significant limitation to their learning. As shown in this chapter, students relied on screenshots of the EVFG to incorporate into their assignments. While this is sufficient in some aspects, if the software allowed for students to create their own annotations, it could have given students more ownership of the data and provided lecturers with useful information about how students would use the EVFG in their assignments. Not only this, but it potentially may have been a useful employability tool to show future employers a EVFG that they had made and annotated which is now one of the benefits of creating content through new systems such as story maps (Egiebor & Foster, 2018).

7.3.7 Challenge of Creation

Although VFGs are relatively cheap compared to actual field trips, it is not a simple task to create them (Bertol & Foell, 1997). VFGs require technical expertise to create and make engaging in a way that is beneficial to students (Ramasundaram et al., 2005). As outlined by Stott et al., (2009), the creation of VFGs can be challenging for tutors due to time pressures. Although an academic can retain complete control over the creation and updating of a VFG, limitations include time pressures from teaching and research. An academic is often unfamiliar with the software and requires extensive training, which further increases the time spent on development. The creation of a VFG is stated to take approximately 50 hours (Stott, Nuttall, Eden, Smith & Maxwell, 2009), which is similar to the completion time of an academic paper (Stott et al., 2008). Even when a dedicated technician is employed to look after the development of a VFG, Stott et al., (2009) voiced the frustration of having to wait for sites to be updated and issues arise when such technicians leave their post.

As discussed in chapter VI, there were some significant challenges in the creation of the EVFG. Lack of prior knowledge of VLM and VFG making, equipment procurement, access to field sites for data collection, UAV regulations, and access to software we're all issues encountered in the development of this EVFG. VFGs are not easy or straightforward to create and are very time intensive. While Stott et al., (2009) cite VFGs to take around 50 hours to be created, new EVFGs developed by UAV data as shown in this research took well in excess of 50 hours to complete. When factoring in the training of the UAV, the data collection process, the EVFG making process and then learning new code and systems, the researcher estimates that it has taken anywhere between 500 and 1000 hours of dedicated model making time, not including the many revisions which have taken additional time. While they envisage that any new VLMs would take less time now that the researcher is familiar with the systems and procedures, they still estimate in excess of 50 hours as depending on the size of the dataset; it can take up to 48 hours alone to render the 3D polygonal model in Agisoft. Therefore, if other departments, practitioners, or other educators are considering using such technology to create such a VFG from UAVs, they must be aware of the extensive regulations first and foremost but also the significant learning curve and time it takes to develop their first VLM and subsequent EVFG.

7.4 FUTURE DEVELOPMENTS

This EVFG is now on its fourth version, but subsequent revisions can be made to address the issues and concerns as outlined in this chapter. Nevertheless, such revisions are constrained by the software capabilities, researcher time, and access to equipment and the field site. Future versions of the EVFG should explore what face count would be suitable for high resolution but also to work effectively on a number of devices and systems. If a sweet spot can be found, then this may well become the new recommended number than the current blanket of 400,000 faces as recommended by the software. However, this would require extensive testing on numerous devices and operating systems that cannot be completed in this research due to time constraints.

Scale and historical data continue to be one of the major issues with this EVFG, and while the developers of the software Sketchfab have indicated that the addition of scale is something they are considering, no timescale for its introduction has been given. Historical data within the EVFG is something the researcher would like to see, as they believe it would be a powerful visual aid for students, but currently, this is not possible with the current technology. While Virtual Reality (VR) was not tested due to a lack of equipment in this study, the EVFG is VR ready as this has been built into the VFG by the researcher to future proof the EVFG. Therefore, more research and testing using VR could open up further exploration of the benefits of the EVFG for student learning and certainly can open up avenues of research for disabled students.

It is noted that this EVFG has been tested with only one cohort of students and at one particular site. Future research would be to understand if different cohorts of students have the same advantages and disadvantages that are present for this sample in this study or whether they have different ones. While it can be hypothesised that other cohorts of students would find this EVFG as beneficial if not more than the students sampled here (due to such outdoor education students showing a significant preference for traditional fieldwork techniques but showing a high level of engagement and praise for this EVFG) this needs to be tested. Further to this, the use of the UAV works well in producing SfM images to create a EVFG of a location, which is suitable for such a system, i.e. a cliff. If time allowed it would have been beneficial for the creation of EVFGs of other fieldwork locations that are most often visited on fieldwork such as rivers or mountainous areas. Any conclusions drawn about the effectiveness of this EVFG is only in relation to this particular site and with these particular students.

7.5 CONCLUSION

To conclude, the EVFG created thus far has shown the potential to be beneficial to student learning in this research on fieldwork in a number of ways. The EVFG has shown potential to help lecturers to familiarise students with concepts and locations and to provide further resources to enhance their learning and increase their engagement with the subject. For students, it has demonstrated the ability to make them more efficient in the field, to be less time-pressured on fieldwork and provided them with a tool to discuss complex processes on fieldwork. The EVFG has also shown the potential to benefit some disabled students on fieldwork. Students have also demonstrated the EVFG to be an effective learning tool and have utilised it in a variety of ways in their assignments.

VFGs and this EVFG have shown numerous advantages to students learning and in relation to the research question. Such a question asked '*How can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Fieldwork Guide for Geoscience fieldwork?*

This research has shown that not only is the development of a virtual field guide from a UAV possible; it is also a viable and effective learning tool. Through this research, it has become clear that VFGs can be a useful additional learning tool and they do not have to be overly complex to generate and share with students. Both students and lecturers are very positive about the use of this new EVFG created by UAV data for their fieldwork. It is important to note that while more testing of the EVFG with various cohorts of students and potential locations need to be conducted, it has shown at least for this location and cohort of students to be an effective and innovative tool.

In conclusion to the positives of the EVFG, the cohort used in this evaluation as indicated at the start of this chapter are students who showed considerable preference to traditional methods on fieldwork and were significantly more likely to prefer this over the use of mobile technologies. If such students as shown in this chapter are so complimentary of the EVFG and believe it is worth having it in their studies, then one can assume that cohorts of students who are more inclined to use technology and be more open to newer methods in fieldwork should see the same benefits if not amplified.

The EVFG is currently at a suitable standard, however; some more revisions are required and in some cases requested in order to enhance this EVFG further. This beta EVFG is not perfect, and issues of VFG generation, rouge artefacts, navigation, and the lack of the ability to make direct measurements or layer historical data is an issue with the EVFG and could be a potential barrier to their inclusion in higher education teaching. Further beta testing and research are needed to develop a field guide of this nature fully. While this field guide is enhanced by new technologies such as UAVs allowing the EVFG to be created in such high detail and to be specific to smaller locations, it is ultimately limited by the capacity of current technologies. Litherland and Stott (2012) stated that the term virtual field guide instead of virtual field trip should be used as there was a lack of being immersed in a virtual environment. While this is still true, this EVFG is much closer to the original intention of a virtual field trip. Despite the compatibility of this EVFG to be used with Virtual Reality headsets, we are still a few years away from a fully immersive interactive virtual environment that EVFGs have always strived for. Nevertheless, this EVFG is a step forward towards that ultimate inclusive virtual learning tool, and it is hoped with more revisions and the advancement of technology in the future that EVFGs such as this continue to enhance the learning of students and alleviate some of the pressures of Geoscience fieldwork delivery.

CHAPTER VIII: CONCLUSION

This chapter is the final chapter of the thesis and will first provide a summary of what has taken place in this study. Following this, conclusions are drawn in relation to the research aims and question posed at the start of this research journey. Finally, limitations and recommendations from the research are explored before offering potential avenues for further research.

8.1 SUMMARY

This research has been formed through five distinct interlinking parts that have come together for the development of a new learning tool for students on fieldwork. This mixed methods research has explored educator and student views on a number of issues from fieldwork, mobile technologies, UAVs, to the generation and evaluation of the Enhanced Virtual Field Guide. This research started by investigating the well-established practice of fieldwork in Geoscience. In literature, fieldwork is often portrayed as an 'educational utopia' for students and educators, but this research investigated whether this was indeed the case. Studies to date on the negative aspects of fieldwork are far fewer in number than the positive literature on fieldwork. This research has highlighted and supported the claims in the literature that fieldwork does indeed have many advantages to students. Nevertheless, this research has outlined some of the distinct challenges that are less well researched in fieldwork literature such as disabilities, time, student mental health and well being and the cost pressures of fieldwork in today's higher education system.

Following on from the discussion of fieldwork, the research then focused on how fieldwork has changed and has been influenced by the uptake of mobile technologies in the field. Mobile technologies in the history of fieldwork are a relatively new phenomenon, yet in recent times they have started to become embedded into fieldwork practices. Nonetheless, there are still some significant challenges that are yet to be addressed with such technology on fieldwork. One issue with established research around the use of mobile technologies on fieldwork is due to the rapid development of such technologies that often the conclusions and limitations drawn from such papers can potentially be addressed through newer technologies. Not only this, but early research around the use of mobile technologies was when such devices were new. Today, mobile technologies are embedded in our everyday lives, and therefore this research sought to capture what students and educators today thought about mobile technologies, how they utilised them on fieldwork and to assess their general attitude towards such technologies.

This research has discovered that while mobile technology uptake has increased over time and attitudes towards their use in education has softened (with more students less concerned with their personal space being infringed for educational purposes than they once were) the same challenges posed in the literature such as damage, cost and usability in inclement weather still remain.

One mobile technology that is not new but is new to the commercial sector and for research and educational use is the Unmanned Aerial Vehicle. The uptake of UAVs in the commercial sector and in research has exponentially increased in the past number of years. UAVs have been shown to be used in a variety of sectors from agriculture to emergency services. In geoscience research, there is an increasing number of papers and special editions in Journals that investigate the UAV as a tool for data collection. Despite such abundance of platforms and uses, very little research has been done on the educational potential of UAVs and their data and even less so on their effective use on fieldwork. This research, therefore, attempted to address this distinct gap in literature to investigate educator and student attitudes to UAV technologies in their fieldwork and education. Not only this but UAVs, like mobile technologies, are rapidly increasing in technological capabilities but also unlike mobile technologies they are subject to distinct and often complex regulations. This research outlined and signposted some of the complex challenges such as the regulation and processes an educator must go through if they are to use such a device in their teaching and fieldwork activities.

Lastly, bringing all of this together formed the creation of the bespoke learning tool for students on fieldwork. The Enhanced Virtual Field Guide was developed by the researcher from data collected from the UAV of a specific field site. This EVFG was developed and refined by educators and was utilised with a cohort of Outdoor Education students on their final year module field trip. Students were given access to this EVFG pre, during and post-fieldwork and through interviews with educators and analysis of the student assignments, and evaluations. Conclusions were drawn about the effectiveness but also the limitations that such a UAV generated EVFG can have for geoscience students on fieldwork.

8.2 Discussion In Relation To The Research Aim And Question

This research had a number of aims it wished to complete in order to answer the research question which is '*How can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Fieldwork Guide for Geoscience fieldwork?'* This section will now take each aim and conclude the findings.

8.2.1 To Enhance The Understanding Of The Role Fieldwork And Mobile Technologies Play In Learning About Geoscience In Higher Education

Fieldwork has changed considerably since the 1960s through changes in teaching practices, to the inclusion of technologies, to the new increasing pressures of higher education. Fieldwork is very different from the days of the 'Cook's Tour' method of fieldwork that took students to a location to listen passively to the educator explaining the location (Clark, 1996). Such a method of fieldwork was often deemed to be uninspiring, boring and unengaging (Brown, 1969). Despite such concerns, the Cook's Tour method existed for a number of years until the slow introduction and uptake of participatory fieldwork occurred. This shift moved away from passive learning to more active learning in the field with the introduction of critical thinking, skill development, group and independent study (Gold et al., 1991; Bradbeer, 1996; Kent et al., 1997; Pawson & Teather, 2002; Bracken & Mawdsley, 2004; Boyle et al., 2007; Drummer et al., 2008).

Fieldwork is often proved to be effective due to the numerous learning theories that are in play, most notably Kolb's Experiential learning model (1984) and Lave and Wenger's (1991) situated learning. Today there is a distinct move away from the Cook's tour to smaller groups of students being active in the field, and this has been aided through the use of technologies.

Literature often suggests that fieldwork is inherently enjoyable (Gold et al., 2003 & Boyle et al., 2007) as argued by Blunsdon et al., (2003), gives students a more in-depth learning experience because of this. This thesis supports the findings that students, on the whole, find fieldwork enjoyable with 86% of students in this study agreeing or strongly agreeing that fieldwork was enjoyable for them. Fieldwork in this study was often deemed enjoyable because it allowed students to experience a landscape for themselves and *"transforms textbook knowledge into practical knowledge*" as often supported in the literature.

However, this study discovered that one of the main advantages of fieldwork for both educators and students that is not often discussed in the literature is that of social and personal development. In this study, it has been shown that particularly educators value this aspect of fieldwork as it allows the breakdown of the staff-student barrier and creates a more inclusive and supportive cohort. This study further supported the findings in the literature that fieldwork develops students' technical and soft skills (Kent, Gilbertson, & O'Hunt, 1997; Boyle et al., 2007; Krakowka, 2012; Hill, Walkington & France, 2016). Such skill development has often been championed as making geoscience students more employable, and at least in this study, 93% of students agreed or strongly agreed that fieldwork enhances their employability appeal.

While Kolb's experiential learning model is well researched in fieldwork (Healey & Jenkins, 2000), Lave & Wenger's situated learning and communities of practice ideas are less well researched regarding fieldwork. In this study, there is some evidence that a *community of practice* exists amongst students on fieldwork with 82% of students seeking advice and solving problems amongst themselves before seeking the help of a tutor. The researcher also witnessed this on fieldwork during the EVFG evaluation field trip.

Despite the many supportive findings in this research concerning fieldwork, a number of challenges and negative aspects have emerged from the data. To begin with, student pressures and mental health were a distinct concern from educators. What has emerged from the data is the attitude that fieldwork is not as inclusive nor as positive as the literature suggests. All lecturers in this study mentioned distinct challenges of supporting students who are anxious, have special requirements, or simply do not feel fieldwork is for them. Educators discussed at length the extra alternative field trips they have in place and as shown in this research, that such alternative field trips are often not the same learning experience. This, therefore, gave more reason to develop a bespoke educational tool for geoscience students.

One significant barrier that emerged from the data is about disabilities. Geosciences have often had fewer disabled students due to the nature of fieldwork being an integral part of the discipline. Higher Education has seen a 56% increase in disabled students in 2017 compared to 2010-11 (HEFCE, 2017). Inevitably, this has increased the number of disabled students on fieldwork and practitioners have talked about how they plan for such students that again often involves an alternative field trip. As disabilities are relatively new in geoscience, there are no set procedures or guidelines to include disabilities, and therefore educators are trying their best to include their students as much as possible. Nevertheless, with little research into this area and little research developing tools for inclusivity on fieldwork, it is a distinct challenge of modern fieldwork.

While disabilities and student mental health have been the biggest challenge, other challenges such as staff time pressures, loss of teaching and marking, planning, and costs are other significant barriers. Such barriers are rarely discussed in the literature that shows fieldwork in a positive light. This research, therefore, has shown that while fieldwork is still a critical aspect of education, it is not an educational utopia that literature often portrays. There are many distinct challenges that educators and students face on fieldwork and more research is needed to come up with effective strategies to combat such issues.

8.2.2 Mobile Technologies on fieldwork

Mobile technologies in the grand scheme of fieldwork are still a relatively new concept despite their main introduction in 2010. Technology is rapidly improving in both usability and affordability, and this provides a basis for their inclusion in fieldwork (France & Ribchester, 2004; King, 2011). Mobile technologies have been demonstrated to good effect in fieldwork through the use of podcasting, digital videos, remote sensing from tablets, geo-tagging and annotations, to list but a few (Jarvis & Dickie, 2010; Fearnley & Bunting, 2011; Welsh et al., 2012). Mobile Technology-enhanced learning has often shown that old methods of fieldwork can be updated due to these new technologies (Wills & Early, 2013). Findings from this study support the idea that students use such technologies for more efficient data collection and for updating old methods of fieldwork such as taking audio notes to replace a paper field notebook, annotating pictures to replace a field sketch, to using the devices to collect various amount of data and to share data collectively in the field.

What this research discovered is that today mobile technology is embedded deeply within the lives of students and in their use in education. All of the students in this research owned a smartphone, which is a significant increase on the early literature of mobile devices on fieldwork wherein 2012 just under a third of students owned a device (Welsh & France, 2012). Some literature argues that students feel that their personal space is being invaded when using their devices on fieldwork and while this was evident by some students in this study, the majority (88%) use their devices for educational purposes showing a shift in the attitude of students. In this study, students showed a high agreement to the likelihood of them using such devices on fieldwork.

Nevertheless, what did emerge from the study is a distinct cultural difference between Outdoor Education students and Geography and Geography Combined students, a finding that has not been discussed in literature before. In this study, Outdoor Education students were significantly less likely to use mobile devices on fieldwork ($p=.001$). They also were significantly less likely to state that using such technologies in their fieldwork enhanced their employability skills ($p=0.21$). Reasons for this can potentially be explained by the student's outlooks for future careers. Outdoor education students often enter degree level with BTEC and Vocational qualifications and as part of their course continue to gain such qualifications such as; mountain leadership, climbing instructor, paddlesports coaching, and first aid. Such students often enter outdoor service roles such as mountain leading or outdoor instructors. Therefore, they are more concerned with how to do something rather than the theory and are very outdoor focused in their personal lives, and this has some influence on their lack of need for technologies on fieldwork. Unlike their Geography counterparts that are made up of a number of students from different backgrounds, they rely on a more hands-on approach to fieldwork.

This study supports the many advantages that exist for using mobile technologies on fieldwork such as its ability to enhance data collection, increasing efficiencies on fieldwork, access to information and safer storage, enhanced learning, and an increase in employability. This research also highlights and supports the many challenges of mobile technologies in fieldwork such as distractions; technical difficulties and the debate of bring your own device versus institutionally owned devices. What this demonstrates is that despite the research in this area becoming mature, the issues that were present in the early days of adoption of mobile technologies in fieldwork continue to be an issue. More research is needed to investigate why such issues as highlighted in literature continue to exist with such devices today on fieldwork.

To conclude, this study has enhanced the understanding of the role that fieldwork and mobile technologies can play by reaffirming established literature but also offering the other side of the coin. Concerning fieldwork, this study has demonstrated a more holistic review of fieldwork by including and demonstrating the distinct negative aspects and challenges that educators and students face on fieldwork. Regarding mobile technologies, this study has refreshed and updated such literature to investigate this phenomenon in the present day. While changes have occurred such as an increase in uptake of students and their comfort of using such devices for their education and in fieldwork, many challenges still exist despite their embedded nature into education and technological advancements.

8.2.3 To Investigate And Document The Regulation, The Benefits And The Challenges To Using Unmanned Aerial Vehicles In Geoscience Fieldwork

Unmanned Aerial Vehicles have a long history, but their history has often been associated with military activities. Due to the advancement of mobile technologies, smaller sensors and cameras were developed which paved the way for commercial UAV technology (Harvey et al., 2014). This study outlined a brief history of UAV technology along with the two most common forms of UAVs in the commercial sector. Despite their extensive use in the commercial sector, for educational purposes little to no research has been conducted.

In order to understand the benefits and challenges that UAVs on fieldwork and in education have, it was vital to explore what legally can and cannot be done with such technologies. Laws and licencing in the UK is a complex and often-messy affair and as such has often proved a barrier to UAV operations in this study. Regulations for UAVs have been shoehorned into existing manned aviation laws and regulations for which for all intents and purposes are two entirely different things. What this has led to, is a jumble of regulations and a constant updating of the regulations that provided a distinct challenge to educators using UAVs in their teaching.

Before the commencement of this research the extent and complexities of the UAV regulations in the UK were not known, this was only discovered through the development of this research. Research to date for UAV uses does not mention the laws and licencing nor the need for permissions that this research outlines. In the UK, to operate a UAV for commercial purposes which can be classified under the umbrella of research, the operator must be a fully trained pilot and obtain permission from the Civil Aviation Authority called a Permission for Commercial Operations (PfCO). As this research aim was to document the regulations that exist in the UK, the researcher trained to be a Commercial UAV pilot and completed the PfCO process. This process was extensive lasting seven months. In order to become a commercially approved UAV operator, the researcher had to complete a 40-hour distance learning course followed by three days of written and practical exams followed by a flight test. The process is rigorous and extensive and finished with the completion of a 20,000 word Operations Manual. This manual once approved allowed an operator to operate commercially within the parameters and procedures as set out in the Operations Manual. This manual and the training exams is the equivalent of a Level 4 Diploma and as such is awarded to successful graduate pilots as a Level 4 Diploma in Remote Aircraft Systems, which the researcher successfully achieved.

While the process is extensive, there are still specific laws and regulations that UAV operators must abide by such as the minimum distance between people, environments and airports. It was only through this process did it become apparent to the researcher the extent and the complexities that UAV regulation have in the UK. The literature on UAV use for research gives the impression that anyone can use UAVs and that the processes are easy. While this may be the case for some countries, in the United Kingdom at least this is not as straightforward as literature portrays. To add to this, there are no set laws and licencing requirements across the globe, and therefore different countries have either stricter or in some cases non-existent regulation. This lack of clarity in regulation proved to be a challenge for educators when thinking about using such devices on international field trips. Therefore, this study has highlighted the complexities of UAV regulation, and it is hoped it provides potential users of UAVs in research in the UK with more of an idea of what's involved than this researcher initially anticipated.

Regulation played a large part in UAVs not being used effectively or extensively with students in this research. Of those who had experience with UAV technologies, none had completed the full PfCO process to become fully qualified UAV pilots. Their reasoning for this was often a lack of time to find sufficient flight hours and time to complete the exams during their normal working life. Regulation for one educator was the number one reason they decided not to pursue UAVs in their teaching.

Many practical barriers exist in the operation of UAVs in fieldwork. Under new regulations, it is not practical for students to fly the aircraft and therefore that eliminates any potential for the UAV to be used as a data collection tool by students. UAVs have minimal weather-operating windows, and with fieldwork in the UK often taking place between September and May, it can often be difficult for good weather to coincide with a field trip. For students, they held concerns such as privacy, distractions on fieldwork and most notably a concern about damaging the aircraft.

On a positive note, despite the many challenges of UAVs on fieldwork, there were plenty of perceived advantages as a education tool. Educators were keen to stress the idea that UAVs can offer their students a unique and different perspective of a landscape to aid their learning. UAVs offer high spatial and temporal resolutions that existing software such as Google Earth does not. Data collected by UAVs can be more accessible and cheaper than traditional manned aerial photography surveys and satellite images. UAVs allow the potential for data to be collected from inaccessible locations and this allows fieldwork to be safer and more inclusive. Students can be in an environment and still have access to data from areas that they cannot go to on safety grounds such as the intertidal zone or the top of a glacier, increasing their potential reach for learning. On traditional fieldwork, this area would have been out of touch for students, but now data can be collected and used from such an area providing more data and information for the students to use. UAVs also have the ability to collect a wide variety of data from aerial images to videos that can be used to create detailed orthomosaic, Digital Surface Models and through the use of SfM, 3D models.

While students showed concern of damage, privacy and distractions of using the UAV on fieldwork, encouragingly 21% strongly agreed that UAVs would enhance their engagement and interest on fieldwork with a further 42% agreeing to this. Students wanted the UAV to capture aerial photography of an area for their study but also indicated they believed it would enhance their complex data skills such as photogrammetry.

In conclusion to this aim of this research, regulation is the number one barrier and concern for the introduction of UAV technologies in fieldwork. The regulations are cumbersome, complex and continually shifting in the UK and have put some potential users off deploying them in their education and fieldwork. Those who see merit in UAV technology face a barrier of finding the time and the cost to complete the extensive training process in order to fly the aircraft for research purposes legally. There are other significant barriers to contend with in terms of UAV flying from the weather, to the equipment, to the lack of ability for students to directly fly the aircraft. Despite this, it is worth the perseverance by the educators due to the many advantages that UAVs can bring to education and fieldwork. High-resolution data and images, safer and quicker data collection and the ability to view a landscape from a different perspective are all positive attributes that UAVs can provide that no other current tool can.

8.2.4 To Explore And Refine The Creation Of An Enhanced Virtual Field Guide From Uav Data

While UAVs could not be used directly by students, their various outputs can be collated into one learning tool, the Virtual Field Guide. Virtual Field Guides are often web-based systems or files that replicate the environment virtually through pictures, videos and data but have elements of teaching led discussion and prompts embedded within them (Litherland & Stott, 2012). VFGs have varied in purpose, their scale, their detail and their effectiveness. However, VFGs have often been limited by technology and have recently in literature not been as well researched as they once were. VFGs were revisited in this research to investigate whether new technologies such as UAVs can provide sufficient data to create a new bespoke EVFG for students on fieldwork.

This part of the study was an exploration of VFGs before using the UAV to capture data through Structure from Motion to create a 3D virtual model of the environment. This study details the specific workflows that the researcher adapted and followed in order to create the VLM. This study outlined how to set up a UAV for data collection and discussed the merits of sufficient flight planning to ensure that effective images are taken from which formed the base VLM for the EVFG that was created. The data collection flight is outlined and what happened on the day of the flight before detailing the time-consuming process of creating a VLM.

The transformation of the VLM into a EVFG was down to the inclusion of bespoke integration of annotations, pictures, video and external data. A simple computer code was used to develop the model to include such aspects, which took it into the realms of a virtual field guide. Throughout this development process, educators were sought to develop the model as part of a broader interview series to investigate if the model had (1) sufficient resolution and environmental replication, (2) the effectiveness as a teaching and learning tool (3) areas for development and (4) how educators and students may use this model in their fieldwork.

What this part of the study demonstrated was that indeed UAV data could be used to create a 3D VLM which in turn through various workflows, could be turned into a highly detailed virtual field guide for students to use on fieldwork. While this proved that the concept worked, the final part of this study was the evaluation of the EVFG as a learning and teaching tool on fieldwork.

8.2.5 To Evaluate The Use Of An Innovative Enhanced Virtual Field Guide Generated From Unmanned Aerial Vehicle Data For Supporting Authentic Learning

The EVFG was well received by educators and students in this study. First impressions of the EVFG were positive, and discussion often focused around the surprise about the high quality and level of detail the EVFG offered. Educators were quick to link this high level of detail to areas of their teaching for which they could utilise this EVFG. They expressed that the detail and the ability to interact with the EVFG was unlike any tool they have currently available to them and therefore the EVFG has shown that it can be beneficial for its introduction as a learning tool. Not only this, but students also highlighted the high detail as an excellent attribute of the EVFG.

For educators, they believed that the EVFG has the potential to offer them a new tool for engaging students with external materials. As became apparent from this research, educators normally offer preliminary information on a paper copy or PDF field guide of a specific field trip. This form of information delivery to them is not the most engaging format of delivery; therefore, they see the potential in the EVFG being more engaging, and in turn, there is a hope that this will enhance their students learning. Educators also saw the potential of the EVFG to help them in some way tackle the issue of disability and inclusivity on their fieldwork. While no students in this research identified themselves as disabled, and therefore no direct conclusions can be made about its effectiveness to achieve this, educators believe that it had the potential to give the students the chance to be as close to the real field trip than what is currently on offer.

The EVFG showed its potential as a learning tool in a variety of ways depending on when the EVFG was utilised by students. Using the EVFG pre-fieldwork has been shown to potentially increase student efficiencies on fieldwork due to it facilitating the student to explore and feel more familiar with the landscape and gives the student the ability to plan their data collection, as supported by previous research on VFGs (Spicer & Stratford, 2001; Tuthill & Klemm 2002; Kingston et al., 2012; Litherland & Stott, 2012). The EVFG allows preliminary data from a site to be used by the students before visiting a field site as evidenced by Dykes (2000) is an effective strategy for efficiencies on fieldwork. Educators also expressed how the EVFG allowed them to help students visualise an area or to explain complex processes by showing the students the field site before taking them there.

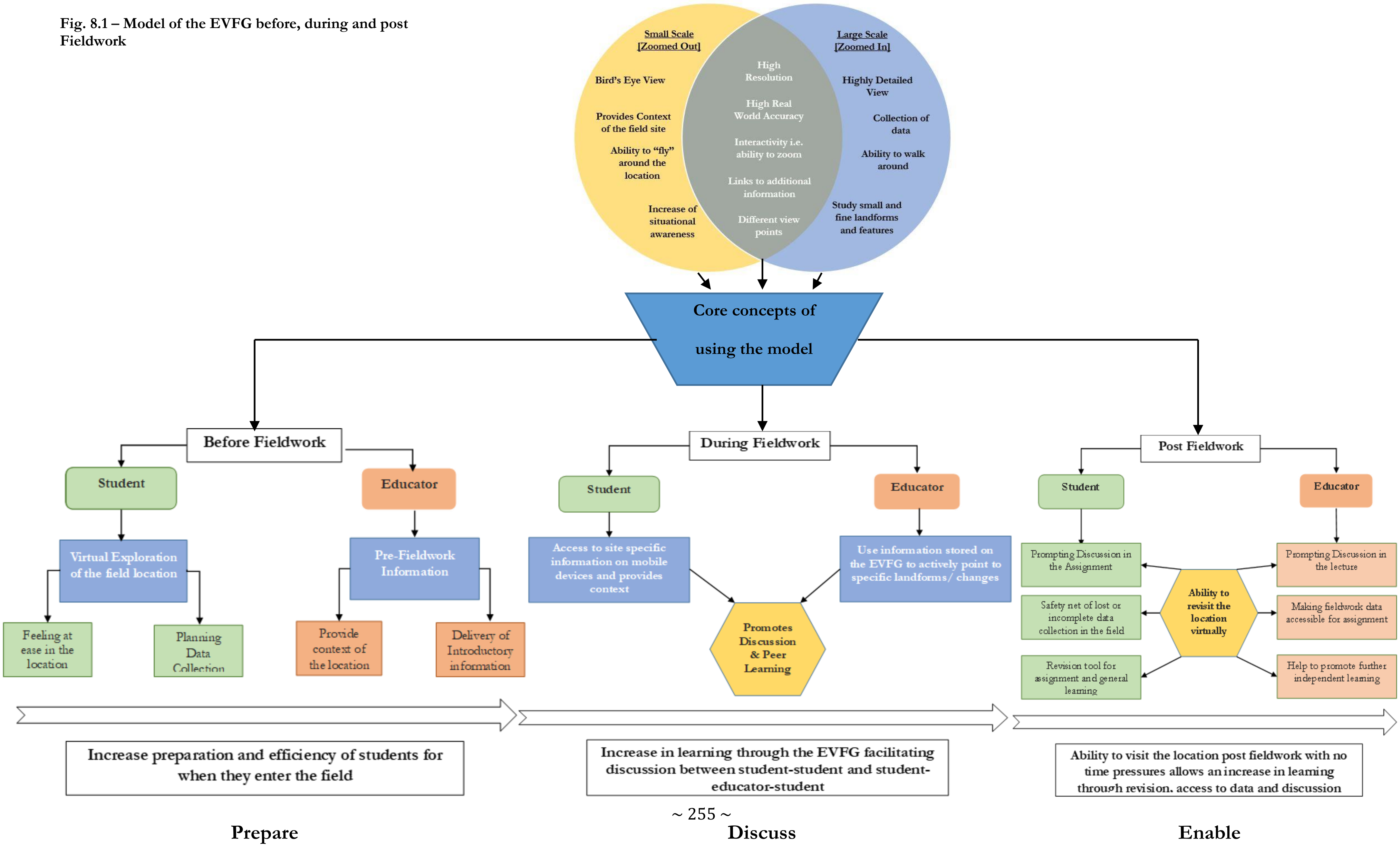
During fieldwork, as evidenced in this research, the EVFG proved an effective tool for the promotion of peer learning and discussion. During the field trip, students were quick to notice the new level of erosion in real life compared to the EVFG and without any prompting from the researcher or the educator present, began discussing reasons for this. Students used the EVFG and the supporting data to help select and deselect their ideas in their own communities of practice. Arguably, if students did not know that erosion had taken place or did not have access to the supporting data (such a topographical maps) this discussion and peer learning may not have occurred. While erosion was not the focus of the field trip, this tangent as witnessed by the researcher on fieldwork, was a positive learning tangent, with all students being involved in the debate amongst themselves. This impromptu debate demonstrates the EVFG's effective use at promoting discussion amongst students on fieldwork to increase their learning.

Post-fieldwork, the EVFG offered the chance to promote this discussion further and students appreciated the ability to revisit the field site virtually as many times as they wanted. For one student this was a valuable tool as it helped them to refresh their memory of the location for their assignment while another failed to take pictures on the day and so accessed the EVFG as a revision tool and to use screenshots in their assignment. All eight students used the EVFG to some degree in their final assignment. Some students used the EVFG's supporting data such as the context map in their assignments to help explain the location and to justify their conclusions. Other students showed higher levels of engagement by adding annotations to screenshots of the EVFG to support their findings but also to link to established research of the site. In the students' evaluation of the EVFG they all had very positive feedback, and this is from the cohort who are significantly less likely to use mobile technology on fieldwork. Therefore, if such a EVFG has so many perceived benefits from such technology adverse students on fieldwork, then it stands to reason that the more open to mobile technology students would have the same benefits and thoughts, if not more so.

8.2.5.1 The creation of an EVFG model for learning

To further enhance the understanding of this EVFG as discussed in the previous chapter there are a number of effective ways that the EVFG can enhance student learning, the efficiencies on fieldwork and the aiding of educators to maximise their time in the field and the classroom. The models high resolution and real world accuracy, along with the ability for the user to zoom in and out of the model provides many different advantages to educators and students. Therefore, in Fig. 8.1, is a model of how these core concepts of high resolution, interactivity and annotations have enabled the EVFG to be an effective tool to be utilised by students and educators pre, during and post fieldwork.

Fig. 8.1 – Model of the EVFG before, during and post Fieldwork



8.2.5.2 Negative aspects of the EVFG

While the EVFG was well received and in the eyes of educators and students in this study a worthwhile addition to their fieldwork, there are areas of development that need to be addressed. Navigation issues were a challenge for this EVFG, which is a similar issue faced in many VFGs. While in many VFGs students get lost or disorientated in these virtual worlds (c.f. Stainfield, Fisher, Ford, & Solem, 2000; Spicer & Stratford, 2001; Baggott la Velle, 2005; Garner & Gallo, 2005), a problem of this EVFG was the tendency for it to flip upside down. Usability depended on the device on which the EVFG was accessed. It became apparent that the EVFG would only work effectively on Chrome browsers although the reason for this has yet to be fully understood. Despite working on the Chrome browser, there was a discrepancy on how well the EVFG would load on various computers and devices. For one student it slowed their entire PC down while for another the EVFG was too quick. In order to solve these issues, extensive beta testing needs to be conducted to understand the minimum computer requirements for the EVFG of this type. It also came to light that navigation was more accessible with a mouse and click wheel than a trackpad of a laptop.

The EVFG was also not an exact virtual replication of the environment due to some stitching errors in the software. Rouge artefacts that could be misinterpreted by students were present in the EVFG, although more sufficient images could alleviate this problem in future editions. The one major factor that limited the EVFG was the lack of a visible scale. In the software, there was no way to incorporate this, and so students either vastly under or vastly overestimated the size of the location in question. Currently, technology limits this inclusion although there is an idea in a future EVFG to incorporate a physical scale during the data collection process such as a series of metre rules. Nevertheless, this needs to be explored further. Finally, while a useful tool for education it has been a challenge to create and has taken a considerable amount of resources, time, learning, and development to become ready for students to use.

8.2.6 ANSWERING THE RESEARCH QUESTION

Now that the aims have been concluded and achieved in this research the final aspect is to answer the research question which is, **How can an Unmanned Aerial Vehicle's data be used to create an Enhanced Virtual Fieldwork Guide for Geoscience fieldwork?**

Through the development of the EVFG and the evaluation of the device on fieldwork from both educators and students, this research can confirm confidently that indeed UAV data can be used effectively to enhance a virtual field guide for geoscience fieldwork, but with some caveats. While UAVs produce a variety of data, this research has focused on one aspect which is its ability to create 3D EVFGs from structure from motion. This research has demonstrated that the creation of a EVFG from UAV data has many potential benefits to educators and students on fieldwork. It has shown that it can make students more familiar and comfortable with a field site, it can increase their efficiencies on fieldwork, it can promote discussion and peer learning, and finally, it can be used as an effective tool within student assignments. While this research has showcased the ability of UAVs to create learning tools for fieldwork along with the many benefits they offer students and educators, there are distinct challenges that need to be addressed.

The future of UAVs in the UK commercial sector is uncertain, let alone in their limited use in education. Ever increasing and tighter regulation may well force those who have not yet persevered with the qualification and use of UAVs in education to not pursue their introduction in their teaching. Many educators wanted to use the UAVs with their students but increasingly this is becoming unfeasible through regulations, and despite the many distinct advantages that UAVs can provide for students, their implementation is a distinct barrier.

What this research has shown, however, is if UAVs are persevered with, they can be used effectively in education and particularly on fieldwork. This research has demonstrated that the output of UAVs have allowed innovative learning materials to be formed such as the EVFG presented here. Without UAVs as a data collection platform, the development of such a EVFG would not have been possible. Therefore, while there are many challenges with the implementation of UAVs, this research has shown that such challenges make the outcome of such learning tools worth it. To conclude, UAV data certainly can create effective enhanced virtual field guide for geoscience fieldwork.

8.3 Personal reflections, Limitations and further study

This research for me had a few limitations that are addressed in this section. The regulation aspect of this research was something that was vastly underestimated at the start of this research process in terms of the extent, and of the time it would take to become fully qualified. This meant a shorter period of time to develop the EVFGs, and therefore a EVFG of only one site was created. This research initially aimed to create a number of

EVFGs to assess the effectiveness of SfM in different environments and if students utilised them differently depending on the location. It was also envisaged that students would be able to fly the aircraft and that the plan was to collect data before and after they had done so on fieldwork to assess its learning value. It became apparent as the research process went on that this would not be feasible and so the development of the EVFG occurred. The challenges faced with this however have proved to be an effective source of discussion in this thesis.

Access to Geography students was limited during this research due to being in an education faculty far away on a different campus to where Geography students were situated. While links to be more involved in their fieldwork were sought, time pressures and logistics meant that this never occurred and therefore any direct fieldwork activities were with Outdoor Education students to which the researcher had easier access. Part of the challenge of research in a higher education setting is working around course logistics and staff time that the researcher had no control over.

Much time on this research was spent learning new procedures and techniques from flying the UAV, to learning to develop the EVFG from scratch with no expert guidance. As alluded to already, the process of becoming qualified as a pilot was a very extensive and stressful process. While I have previous aviation experience, gaining the PfCO and the subsequent work for the Level 4 Diploma was very extensive. I can only imagine that for someone with no aviation experience, along with juggling their own teaching and learning would find this process very challenging indeed. Nevertheless, the gaining of the PfCO I believe was a long but fundamental part of this research, as without it, the complexity of laws and regulations and the grey area of commercial work would have unlikely to have been uncovered. Not only this but I feel it has been important in this research to make potential users aware of these challenges so that they don't believe that using UAVs would be a very straight forward task. In the UK at least, that is far from the case.

A lot of trial and error occurred in the development of the EVFG as currently, such a tool did not exist. There was a challenge, that while I like to think I'm a tech savvy person, making models, GIS and photogrammetry I have limited experience with. Thus, learning new processes took a considerable amount of time. Therefore, there may well be processes that are more efficient and workflows for model making that exist, which may be more effective than those pursued in this research. A final limitation, and perhaps the biggest limitation is that I would have liked more engagement from students from different cohorts and disciplines to interview and have focus groups with. As reflected on previously I believe different strategies (as an example demonstrating to the students that being involved in focus groups and interviews would be a useful experience for their final dissertations) and planning (to better ensure data collection took place within the months that students were on campus) would be used if this research were to be done again in order to make this happen.

With all of this in mind if I, or others, were to continue this research there are some recommendations I would offer for future developments. Future work on the VLM and EVFGs should focus on the creation of models of different environments (i.e. valleys, mountains, glaciers, deserts, river systems and other coastal features (i.e. beaches, stacks and arches) and tested with a variety of cohorts of students to assess their value further. It would be useful to run a controlled trial perhaps to see if the introduction of a UAV generated EVFG does statistically increase students attainment in their assignments. UAVs, as shown, can produce a variety of different data for students to use and while the EVFG is evaluated here, the more simple data such as maps, photographs, videos and DSMs have not been evaluated as a learning tool in this research. Therefore, further research should investigate whether such data from UAVs are beneficial to learning; if they are this may well strengthen the case for UAVs to be implemented into educational practices on fieldwork.

This research has used relatively straightforward systems and software that are in the grand scheme of things, inexpensive and accessible. The reasoning behind this was two fold, (a.) a small budget by the researcher and (b.) wanting to create processes and use software that others could easily access (such as departments which don't have access to such funding or even schools or industry). It has been my thoughts throughout this process of trying to make this process as simple as possible so that others can recreate it without the need for expensive equipment. I believe this research has shown that effective learning tools such as the EVFG created from a UAV can be created, can be cost effective, and can be relatively straightforward. Therefore, I strongly believe that this has a lot of replication potential and exciting development potential as long as the enthusiasm is there to develop the expertise required.

8.4 Final words

What this research has demonstrated is that fieldwork is still an essential part of the nature of geoscience education and this has continued to be aided by the implementation of mobile technologies. This research, however, has discovered the less reported negative sides of fieldwork and mobile technologies that disagree with established positive literature. This research has also shown that while many practical challenges exist for UAVs, it is possible to create an EVFG from UAV data and for it to be a useful tool for both educators and students on fieldwork. It is the vision that these EVFGs are created for geoscience students in the future but can have lasting benefits for other disciplines and even different sectors from primary schools to the commercial industry. The use of UAV data to create an EVFG and their tailored annotations can be customisable to the needs of the user and can, as demonstrated in this research, further their learning.

This research has delved into the void of the literature of UAVs in education and has proven that they have worth and should be utilised in education despite their many present challenges. Like mobile technologies that were once a new and contested technology as a tool in fieldwork, this innovative research has taken this first step to evaluate how UAV data can be used in fieldwork as a learnig tool. UAV research highlights the many benefits for various industries and this research has added to this by showcasing the benefits for another industry, education. It remains to be seen if UAVs will ever become as established as mobile technologies as an effective tool in fieldwork. UAVs, unlike mobile technologies, have far greater regulation restrictions. It is the concluding concern of the researcher that while this research has demonstrated that UAVs have a great deal of potential to enhance fieldwork, ever increasing regulation and the uncertainty of the future of UAV regulation in the UK may well clip the wings of their potential in education, rather than enabling UAVs to be a flying success for the education sector.

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APPENDICES

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APPENDIX A: COMPLETED QUESTIONNAIRE

The investigation of the pedagogical use of mobile technologies and unmanned aerial vehicles in geoscience fieldwork education (copy)

Page 1: Page 1

You are being invited to take part in a questionnaire as part of a wider PhD research study. Before you decide to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish.

What is the purpose of the study?

This research explores the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education.

Why have I been chosen?

You have been chosen due to your involvement on Geoscience fieldwork at Liverpool John Moores University as a student.

Do I have to take part?

Completion of the questionnaire is entirely voluntary.Your decision to participate or not will not provide any advantage or disadvantage to you, however upon completion there is an option to leave your email address to be entered into a **£10 Amazon voucher competition.** I would be greatly appreciate you taking the time to participate. **It should take no longer than 5 minutes.**

Why do you ask me what faculty, department and course I am on?

This is part of the qualifying process to select potential participants from Geoscience based subjects e.g, Geography, Natural Hazards, Outdoor Education. If you are not part of Geoscience based subjects, unfortunately you will not qualify for taking part in this research.

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For completing the survey you can leave your email address to be entered into a £10 Amazon Voucher competition. Your email will be kept confidential on a password protected M drive. The email address will be randomly picked and the winners notified by the email given.

Who is organising and funding the research?

This research is being funded by Liverpool John Moores University.

What will happen to the results of the research study?

The results will be analysed by the researcher as detailed below. When any results and findings of this research project are presented or reported to others inside or outside of the University, **your anonymity is guaranteed.**

Contact details

If you have any questions then please feel free to email Anthony David Cliffe on A.D.Cliffe@2016.ljmu.ac.uk

What if something goes wrong?

If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this research, please contact my director of studies: Dr. Fran Tracy - F.E.Tracy@ljmu.ac.uk or If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Ethically approved

This research has been ethically approved by LJMU research ethics committee **No. 16/TPL/011**

I have read the information sheet provided and I am happy to participate. I understand that by completing and returning this questionnaire I am consenting to be part of this research study and for my data to be used as described in the information sheet provided

1. Based on the information provided, i agree to take part in the study.

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○ Yes

Page 2: Background Data

2. Gender

- Male
- Female

3. Age

- 18-19
- 20-21
- 22-23
- 24-25
- 26+

4. What is your level of study?

- Level 4 (1st year of Undergraduate)
- Level 5 (2nd year of Undergraduate)
- Level 6 (3rd year of Undergraduate)
- Level 7 (Post graduate)
- Level 8 (PhD)

5. What classification is your degree

- BSc
- BA
- MSc

- MA
- MPhil/MRes
- PhD or Equiv

6. What is the title of your Degree?

7. Which university do you attend?

- Liverpool John Moores University
- University of Chester

Page 3: Mobile Technologies in fieldwork

8. Do you own a smartphone?

- Yes
- No

8.a. What smartphone make do you own?

8.a.i. If you selected Other, please specify:

9. Do you currently use your smartphone for educational purposes i.e for lectures or in fieldwork?

- Yes
- No

9.a. If Yes - How do you use your device for educational purposes. Please select all that apply

- [ ] For checking University email
- [ ] For checking the University App
- [ ] For research i.e Journal articles
- [ ] In Lectures i.e Note taking, downloading lecture slides
- [ ] Social Media
- [ ] Fieldwork - i.e note taking, pictures, recording data
- [ ] Accessing material in the field i.e digital field guides and applications
- [ ] Other

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9.a.i. If you selected Other, please specify:

10. Do you own a tablet device?

- Yes
- No

10.a. What make of tablet do you own?

10.a.i. If you selected Other, please specify:

11. Do you currently use your tablet device for educational purposes i.e for lectures or in fieldwork?

- Yes
- No

11.a. If Yes, how do you use your tablet for education purposes?

- [ ] For checking University email
- [ ] In lectures i.e note taking, downloading lecture slides
- [ ] Accessing material in the field i.e digital field guides and applications
- [ ] For checking the University app

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- [ ] Social Media
- [ ] For research i.e journal articles and web searches
- [ ] In Fieldwork i.e note taking, pictures/video, recording data
- [ ] Other

11.a.i. If you selected Other, please specify:

12. How much do you agree with the following statements;

Please don't select more than 1 answer(s) per row.

	Strongly Disagree	Disagree	Agree	Strongly Agree
"I have a high level of competency with technology"	☐	☐	☐	☐
"Using new technology in fieldwork increases my skills and employability"	☐	☐	☐	☐
"Fieldwork is important for my studies"	☐	☐	☐	☐
"I enjoy going on fieldwork"	☐	☐	☐	☐

13. How likely are you to use your mobile technology device in fieldwork?

- ○ Highly Unlikely
- ○ Unlikely
- ○ Likely
- ○ Highly Likely

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14. What concerns/issues do you percieve there to be when using mobile technology in fieldwork? Please select all that apply

- ☐ The weather damaging the device
- ☐ Dropping or damaging the device
- ☐ Lack of technological skill
- ☐ Course or course tutor does not allow for the use of mobile devices
- ☐ Prefer traditional methods
- ☐ None
- ☐ Other

14.a. If you selected Other, please specify:

15. Would you encourage the use of institutionally owned mobile technology devices in fieldwork?

- ○ "Yes, its a great idea"
- ○ "Yes, providing there was no penalty for accidental damage"
- ○ "Yes, if tutors encourage it"
- ○ "No, I prefer using my own device"
- ○ "No, I am worried about damaging the device"
- ○ "No, I don't see the benefits of using mobile technology in fieldwork"

16. How do you think mobile technologies can enhance your learning experience in fieldwork?

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17. How do you think mobile technologies can hinder your learning in fieldwork?

18. Do you take time after fieldwork exercises to reflect on what you have learnt and experienced?

- All the time
- Sometimes
- Rarely
- Never

19. Rank the following in importance to you on fieldwork, 1 being the most important

Please don't select more than 1 answer(s) per row.

Please don't select more than 1 answer(s) in any single column.

	1	2	3	4	5
Social and Personal Development	☐	☐	☐	☐	☐

Developing skills such as problem solving, team work and communication	☐	☐	☐	☐	☐
Helps to place what is taught in the lecture into real world scenarios and make the connection between the two	☐	☐	☐	☐	☐
Developing technical skills such as data collection, use of specialist equipment	☐	☐	☐	☐	☐
Experiencing a landscape or area in person	☐	☐	☐	☐	☐

20. If you don't know something on fieldwork for an assignment, how do you normally go about finding the information?

- ☐ Look it up on the internet in the field through mobile technologies
- ☐ Look in academic journals/books post fieldtrip
- ☐ Discuss it verbally with fellow classmates
- ☐ Discuss it with fellow classmates on social media i.e Facebook, Twitter
- ☐ Ask the tutor
- ☐ Other

20.a. If you selected Other, please specify:

[ ]

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21. Do you use social media i.e Facebook, Twitter to discuss assignments?

○ Yes ○ No

Page 4: Unmanned Aerial Vehicles (UAV) in fieldwork

22. Have you used a UAV/Drone before?

- Yes
- No

23. Would you encourage the use of UAVs in fieldwork?

- Yes
- No

24. How comfortable do you feel about using UAV technology in your fieldwork studies?

- Very Comfortable
- Comfortable
- Uncomfortable
- Very Uncomfortable

25. How useful do you believe UAVs can be in your fieldwork?

- Not useful at all
- Not very useful
- Unsure
- Useful
- Very useful

26. How beneficial do you think UAVs can be in data collection in fieldwork? 1 - Not very

beneficial 5- Very beneficial

Please don't select more than 1 answer(s) per row.

	1	2	3	4	5
UAVs as a collection tool	☐	☐	☐	☐	☐

27. To what extent do you agree with the following statement: "I think using UAVs in my fieldwork studies could help to enhance my interest and engagement with the subject"?

- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly Disagree
- ○ Unsure

28. How would you like to see UAVs used in fieldwork? Select all that apply

- ☐ To collect pictures of fieldsites and fieldwork
- ☐ To collect video imagery of fieldsites and fieldwork
- ☐ To map the fieldsite for student use
- ☐ To collect data to create a 3D model of the field site to be used later by the student
- ☐ To create a 3D model of the field site that can be used in a virtual field guide before the trip starts
- ☐ Other

28.a. If you selected Other, please specify:

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29. What concerns do you have around the use of UAVs in student fieldwork?

30. What skills do you think UAVs can bring to your fieldwork experience? Select all that apply

- ☐ Practical hands on flying experience
- ☐ Planning skills
- ☐ Communication and Team work
- ☐ Data collection
- ☐ Complex skills such as photogrammetry and 3D modelling
- ☐ None
- ☐ Other

30.a. If you selected Other, please specify:

31. I am happy to be contacted for an interview or focus group run by the researcher about this research

32. Please provide your email address if you would like to be entered into a £10 Amazon voucher competition for completing the survey. The researcher will randomly pick winners at the end of the data collection process.

Page 5: Ending

Thank you for participating!

Thank you for taking the time to complete this questionnaire. If you have any questions please email:

Anthony David Cliffe on A.D.Cliffe@2016.ljmu.ac.uk

Key for selection options

8.a - What smartphone make do you own?

- Samsung
- Apple
- Windows
- LG
- Sony
- Other

10.a - What make of tablet do you own?

- Samsung
- Apple
- Windows
- Other

31 - I am happy to be contacted for an interview or focus group run by the researcher about this research

- Yes
- No

APPENDIX B: EMAIL TO GATE GUARDIAN FOR QUESTIONNAIRE

PARTICIPANT QUESTONNAIRE EMAIL

Email

Subject: Circular Email: Questionnaire 'Investigating the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education'

Circular email for the recruitment of volunteers for the study **'Investigating the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education'** approved by LJMU University Research Ethics Committee No. **16/TPL/011**. This research contributes to LJMU University roles in conducting research, and teaching methods. You are under no obligation to reply to this email, however if you choose to participate in this research it is voluntary and you may wish to withdraw at any time.

*** ENTER HERE*** https://chester.onlinesurveys.ac.uk/uavsinfieldwork

What is the purpose of the study?

This research explores the pedagogical use of mobile technologies and Unmanned aerial vehicles in Geoscience fieldwork education.

Why have I been chosen?

You have been chosen due to your involvement on Geoscience fieldwork at LJMU/Chester University as a student.

Do I have to take part?

Completion of the questionnaire is entirely voluntary. Your decision to participate or not will not provide any advantage or disadvantage to you, however there is an option to leave your email address upon completion to be entered into a **£10 amazon voucher competition**. I would, however, greatly appreciate you taking the time to participate. **It will take around five minutes to complete.**

Why do you ask me what faculty, department and course I am on and my email address?

This is part of the qualifying process to select potential participants from Geoscience based subjects e.g., Geography, Natural Hazards, Outdoor Education. If you are not part of Geoscience based subjects, unfortunately you will not qualify for taking part in this research. For completing the survey, you have the option to voluntarily leave your email address **to be entered into a prize draw of £10 amazon vouchers**, your email will be kept confidentially on a password protected M drive. The researcher will only have access to your email address but will not know which email is attributed to which survey response. The email address is needed to randomly pick the winners and to let the winners know once the data collection process is completed.

Who is organising and funding the research?

This research is being funded by Liverpool John Moores University.

What will happen to the results of the research study?

The results will be analysed by the researcher as detailed below. When any results and findings of this research project are presented or reported to others inside or outside of the University, **your anonymity is guaranteed**.

Contact details

If you have any questions then please feel free to email Anthony David Cliffe on A.D.Cliffe@2016.ljmu.ac.uk

What if something goes wrong?

If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this research, please contact my director of studies: Dr. Fran Tracy - F.E.Tracy@ljmu.ac.uk or If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Ethically approved

This research has been ethically approved by LJMU research ethics committee **No. 16/TPL/011**

I have read the information sheet provided and I am happy to participate. I understand that by completing and returning this questionnaire I am consenting to be part of this research study and for my data to be used as described in the information sheet provided.

*** ENTER HERE*** https://chester.onlinesurveys.ac.uk/uavsinfieldwork

APPENDIX C : OPEN ENDED QUESTION-CODING FRAME

OVERALL THEME **Sub-Theme** Code/node	DESCRIPTION OF THEME AND NODES
CONCERNS OF UAV	
Data Collection Concerns	**This theme is any concerns around the data aspect of UAV operations**
Accuracy in data collection	Concern over how accurate UAV data is over other methods
Hard to analyse data from UAV	Concern about usability of data from the UAV
None	**No concerns about UAV operations**
Safety and Legal Concerns	**This theme is concerned with any safety aspects of the UAV and UAV operations from distraction to Ethical concerns**
Acceptance by media and general public	Media and general public concerns
Damage to animals landscape or persons	Damage to either animals, people or landscape
Distracting	A mention that the UAV would be a distraction to students or others
Ethical concerns privacy and noise	Ethical concerns around privacy and noise
Health and Safety	Health and safety for those on fieldwork
Student Concerns Of UAV Use	**This theme is any direct issues students have expressed with their involvement with UAV operations such as a mention of a lack of knowledge to concern about course integration**

Course integration	Data collected from the UAV not being suitable or used most effectively on their course
Creates Laziness or reliance on technology	Over reliance on technology creating laziness and reducing practical hands on skill levels
Flying Skill	Lack of flying skill or not feeling competent in flying
Inexperience in UAV knowledge and or skill	Students have expressed a lack of knowledge about UAV operations or experience in operating a UAV
Over complicate learning	UAV complicated the learning process
Responsibility	High responsibility level of students using a UAV
Students mistreatment of UAV	Students may use the UAV for off task and may mistreat the UAV
Training	The need to be trained on the UAV
Technical Concerns of UAV	**This theme is concerned with any technical aspects of UAV concern from damage to cost of the UAV**
Cost	Cost of the UAV to acquire and operate along with the potential cost of repairing a damaged UAV
Damage to UAV	Any mention of damage to the UAV in some capacity
Technical Issues and reliability	Technical issues or reliability concerns of the UAV
Usability	How easy/hard the UAV is to use
Weather	Weather conditions restricting flying
MOBILE PHONE ENHANCE FIELDWORK	
Access To Information And Or Resource Benefit	**This theme is for mobile technology allowing ease of access to resources and the internet on fieldwork that would not be able to be achieved through traditional methods**
Adding to or qualifying knowledge in the field	Ability to qualify an understanding or seek answers to a question via the internet while out of the classroom on fieldwork

Immediate access to the internet or data or resources	Mobile technology and particularly the internet allows for instant access to knowledge or resources on the device
Data Collection Enhancement	**This theme is concerned with mobile technology and its ability to facilitate data collection on fieldwork. This includes data collection type, its ease of use and its benefits over traditional methods**
Benefit over traditional methods	Benefits over traditional methods such as accuracy and practicability
Data collection	Direct mention of data collection that mobile technologies allow
Georeferencing or GPS	Using mobile technology allowing the ability to geotag locations and photographs and using GPS that is built into the device
Note Taking-Ease of note taking	Using mobile technology for note taking
Photographs or video	Mentioning of photographs or video data collected by mobile technology
Speeds up data collection	Mention that mobile devices increase the speed or efficiency of data collection on fieldwork
Using apps to collect data	Applications such as Excel to app use such as for checking weather or maps
Data Storage And Use Benefit	**This theme is for any references made to storing data collected in the cloud and the safer nature of this digital based storage over traditional methods**
Data collection storage in the cloud	Data that has been collected uploading it to the cloud
Ease of access	Easy and quick access to the device usually located on the person
Safer storage	Mention of mobile technology and digital files being safer or more secure or less prone to damage than traditional pen and paper
Sharing of data	Due to the data being digital or on the cloud it makes it easier to share between others over traditional methods
Speeds up data analysis post fieldwork	Due to the collection of data onto the device in digital form it quickens up analysis post fieldwork over traditional methods
Enhanced Learning Benefit	**This theme contains any elements of mobile technology that enhance learning in some capacity for a student on fieldwork**

Data used for revision or assignments	Data collected used as a revision tool or ease of inputting directly into assignments
Different perspective of fieldwork	Mobile technologies offering a different perspective on fieldwork
Engagement	Mobile technology increasing engagement with fieldwork
Enhance learning	References made to mobile technology and its use enhancing the students learning in some form
Help with dyslexia and other learning issues	Mobile Technologies providing an alternative platform to help with learning issues such as dyslexia
Inclusivity	Mobile technology increasing inclusivity in fieldwork by everyone being able to record data
Increases your technological skill	Mention of increasing a student's technical skill
More Interactive	Mobile technologies allow information and fieldwork to be more interactive
Organisation and time management skill	Mobile technology increasing students organisational and time management skills
Other Benefits Of Mobile Technology	**This theme is for other generic benefits to using mobile technologies in fieldwork such as making the experience easier to device usability**
Emergency purposes	Using the device to call for help in remote fieldwork settings
Makes the fieldwork experience easier	Makes the experience or data collection easier using mobile technologies
Portability	Lightweight and small size of mobile technology
Quick and easy to use	Reference to familiarity with the device and it being a quick and easy tool to use
unsure	

MOBILE PHONE HINDRANCE TO FIELDWORK	
Distraction	**Distraction on fieldwork due to the presence of mobile technology, particularly social media distractions**
Distraction (Mainly Social Media)	Any direct mention of distraction while on fieldwork from mobile technologies or social media
Focus on the device and not fieldwork	A potential focus on the use of the device as the main task rather than the fieldwork
Going off task	Mobile technologies being used for other things that are not task related
Loss of Data	**Loss of digital data that is collect by the device due to either a technical fault or corruption not only losing data but the ability to collect it**
Data Corruption	Data may become corrupted digitally on the device leading to a lack of usable data
Fault in the device and can stop data collection	A fault in the device leading to no plan B or the ability to collect data from the device
Technical Faults - Loss of data	Technical faults leading to a complete loss of data collected
Practical Learning	**Other issues such as over reliance on technology reducing skill levels**
Can take longer than traditional methods	Increase time over traditional methods
None	No concerns about mobile technology on fieldwork
Reduction in skill due to over reliance	Over reliance on technology reducing practical and mental skills
Waste time	Mobile technologies are a waste of time
Technical Issues	**Technical issues from battery life to weather damage can be a hindrance to mobile technology use**
Battery Life	Lack of battery life hindering their use

Damaging the device	Damage to the device from either dropping, general use or weather
Fault in the device and can stop data collection	A fault in the device leading to no plan B or the ability to collect data from the device
Lack of signal to access internet or materials	Lack of connectivity to access external resources and information
Reliability	Reliability concerns not as robust for data collection than traditional methods i.e. pen and paper
Technical Faults - Loss of data	Technical faults leading to a complete loss of data collected
Technology useability (Lack of ease of use or information)	Issues with usability, ease of use or lack of instructions on how to use it
Weather	Weather issues such as damage to usability in rain and cold conditions

Appendix D: Interview schedule

Semi-structure Interview guide (staff)				
Introduction				
• Thank you for taking part in this interview investigating the pedagogical use of mobile technologies and UAVs in Geoscience fieldwork • This discussion should last no longer than approximately 1 hour • Purpose of this research: - To investigate the role UAVs and mobile technologies can play in fieldwork studies - To explore how staff feel about fieldwork and their use of mobile technologies and UAVs in fieldwork - To investigate how staff would like to use UAVs in their fieldwork and what benefits it can bring them to help answer the core principles of the discipline • Throughout our discussion, if you could provide as much detail as possible that would be greatly appreciated • I would like to check if you are happy for this conversation to be recorded • Introduce myself				
Research question	**Central question**	**Possible prompts**	**Possible follow ups**	**Notes**
RAPPOR BUILDING INTRODUCTIONS AND BACKGROUND	Rapport building	How's your term been so far? How's your day been?		
	1. Who are they and what has their journey been to here?	Can you tell me how long have you been in Higher Education? What discipline are you currently teaching? What is your current position here?	Have you always been in Higher Education? Have you always been in this discipline? What other disciplines have you been in? Any involvement outside of academia?	

FIELDWORK	2. What is their opinion of fieldwork in general and in their discipline?	Tell me about your opinion of fieldwork in general? What do you think about fieldwork in your discipline?	Can you explain a little more about why you think that? Is that a general observation or have you experienced that yourself? Do you think your students feel that way too? You seem to view fieldwork in a positive light, can you tell me some examples of why you find it to be a good thing? Can you give me three points that you think are good about fieldwork? You seem to view fieldwork in a negative light, can you give me some examples of why you find it's a bad thing? Can you give me three points that you think are bad about fieldwork?	
	3. How important do they think fieldwork is to their students and discipline?	How important do you think fieldwork is in your discipline? Do you think students think fieldwork is an important part of their studies?	Can you tell me why you think it is/isn't important? Any examples of this? How much importance do you give to fieldwork in your discipline? If you had to rank fieldwork in terms of importance to the degree, where would you rank it amongst other parts of the degree i.e compared to	

			lectures, lab work etc.? Can you tell me why you think that? What is it about fieldwork that makes it so important/unimportant to you and to your students? Do you have any examples/evidence of those student views?	
	4. What fieldwork do they do and their students do?	How much fieldwork do you do and your students get to do on your course? Do you run/help out on any fieldtrips? What are your core and optional fieldwork activities?	Can you tell me briefly what types of fieldtrips they do and what the objectives of those fieldtrips are? Does this change per cohort? Does the focus of their fieldwork and your delivery change as they progress through the years, such as a move away from look and see to more group based activities?	
	5. What are the current pressures and barriers to fieldwork in your discipline?	Can you tell me about any pressures that you think hinder your ability to conduct fieldwork?	Any examples of how this has hindered your ability to conduct your fieldwork? Do you think fieldwork is being more marginalised because of that pressure?	

		What would you say is the number one barrier to you conducting fieldwork? What barriers/pressures do you think students experience on fieldwork?	How does that make you feel? Do you think issues such as cost or disability/accessibility is an issue/barrier to students?	
MOBILE TECHNOLOGIES	6. Mobile technology use on fieldwork?	In your fieldwork teachings do you use any mobile technology?	Can you give me examples of how you use mobile technologies in your fieldwork teachings? Why do/do not use mobile technologies in fieldwork? What are the three advantages/disadvantages to using mobile technologies in fieldwork? Is using the devices in fieldwork a new thing or have you been using them for a while? What are your thoughts about mobile technology and its influence on a student's engagement and learning in fieldwork?	
DISCIPLIN E SPECIFIC/ CORE CONCEPTS	7. Key concepts and principles	In your discipline what are they key fundamental concepts/processes/knowledge that students have to acquire by the end of their degree?	What is the number one fundamental concept you hope your students will learn on their degree in this subject/module?	

			How do you get these fundamental concepts across? Does fieldwork help you to get these fundamental concepts across and to students? How does it enable this? Does fieldwork provide an environment to enhance their learning of these key concepts?	
UNMANNED AERIAL VEHICLES	8. Views and knowledge of UAVs	Do you have any experience with Unmanned Aerial Vehicles? What do you think UAVs are? What are your thoughts on UAVs?	Is that interaction with the UAV personal or part of your professional life? Do you use the UAV as part of your teachings? How have you gathered that view? For example media, friends etc.	
	9. What can UAVs bring to fieldwork and learning?	From your knowledge of UAVs, what do you think UAVs can bring to fieldwork? What outputs do you think a UAV could produce that would be useful for in fieldwork and your teaching? What would you like a UAV to do to help with your fieldwork and teachings?	How do you think it can achieve that? In what way would you use the UAV for that? Can you think of any outputs that the UAV could provide you? What would you like a UAV to capture to help you on fieldwork and in teaching? What resources do you think the UAV could provide?	

	10. What are the barriers to UAVs in fieldwork	How come you have not used a UAV in fieldwork before? What are the barriers and reasons for this? What barriers do you think there are to using or implementing a UAV in your fieldwork teachings? What limitations do you think the UAV will have on fieldwork? What concerns you about using UAVs on fieldwork?	Is it a time issue? A resource issue? A lack of knowledge? Too complicated and too much legal process? Cost issue? Don't see the value in the output of the UAV? Can you give me a potential example of that concern in action? How does that make you feel?	
	EXPLINATION AND DEMONSTRATION OF THE UAVS CAPABILITIES AND LIMITATIONS			
3D MODELS	11. What benefits to UAV inclusion in their fieldwork and teaching?	Now that you know what the UAV can do, is this something you think you can use for your fieldwork teachings? Out of those outputs which of them do you think would be most useful to your students? Which of those outputs do you think would be most useful from a learning perspective? How do you think UAVs will help you in fieldwork and in your teaching?	Why do you think that output is useful? How do you think that output will benefit students and their learning? How easy/useful would that output be for your teaching and their learning? How does that output compare to current outputs they have access to? Do you think that output could be incorporated into your current teaching easily enough? How would UAVs help you? Efficiency and time saver?	

	DEMONSTRATE THE 3D MODEL AND THE SKETCHVIEW DEMO FIELDGUIDE			
	12. Views on 3D models	What are your initial thoughts on the 3D model?	What are the models good points? In your discipline what would you use the 3D model for to help your students? Why do you think that? In what way would you use such a model on fieldwork and in learning? Do you think this offers a different perspective to students and their learning? Do you think this is a useful tool to have? Is the resolution and currently abilities of the system suitable for your needs? What would you improve about the model? What concerns/limitations do you have about the model?	
	13. Views on the scaffold learning virtual 3D model	What are your initial thoughts on the virtual field guide? What are the positives of this? What are the issues with this?	Why do you think that? Can you give me an example when you would use this in your teaching? Would you include this as part of your teaching? If so why and how, i.e in lectures, fieldtrips, both? Is this scaffolded/guided learning approach around the model something that you	

			think is beneficial to students and you as an educator? What benefits do you think students would get out of such a system? What are the key good and bad points about this system? As a practitioner, what learning benefits do you think this gives students?	
	14. Implementation of the 3D model/ Virtual Guide	If you could design a 3D model/guide for part of your teaching what would you like it to include? How would you use such a model/guide in your teaching?	What key things would you require for it to meet your learning objectives/key concepts? What would you like the model to do for students? How would you like the students to interact with the model? As a passive or interactive vessel of information? Would you use this before, during or after a fieldtrip? Is this beneficial for in class teaching or for students personal use outside of the lecture to help support learning and fieldwork?	

HELP EXPLAIN KEY CONCEPTS	15. How can the UAV and their outputs such as the field guide help to answer or explain the key concepts to students?	Now that you've seen the UAV, its capabilities, it's limitations and its outputs such as high resolution images, video, DEMs, ability to measure items, 3D models and virtual guides. How do you think that can help you as an educator to teach or develop students understanding of those key core concepts?	What output would be best for that key core concept? How do you think that will help you explain the concept? How do you think it will help your students understand the concept? How do you think this will benefit you/students compared to the traditional resources available? Do you see these resources as something that can replace or quicken up this learning process compared to traditional resources and methods? Do you see the UAV and its outputs as a complimentary resource to the traditional resources used?	
Any other questions or comments? Thank them for their time and give contact details out.				

APPENDIX E: OBSERVATION TRANSCRIPTS

Field trip A: Ingleton, Yorkshire. Final Year outdoor education students, 25th November 2016

Today's field trip was to Ingleton in North Yorkshire to do some practical hands-on work but also some caving. This field trip situated itself at the end of their fluvial module and the field trip was to observe what had been learnt in the classroom into practice. For me, the plan today was merely to observe and reflect on how the field courses are run here and hopefully spot some things that I can ask in my stage one questionnaire.

Before the fieldwork started, Tim sent over the field guide or handout that the students had been given and will have paper copies on the day. Looking through it was pretty much exactly the same as are given out in any fieldwork I've been to, I guess it's pretty standard format nowadays. It's great weather for fieldwork today I thought as I arrived at the canoe store for the 9 a.m. departure. I arrived at 8.45 a.m. but I was the only one there, and I started to question whether I had the right place! By 8.50 a.m., a few students arrived, and I introduced myself; apparently, they knew I was coming, so that broke the ice a little bit. A few minutes later Tim and Barry (the lecturer leading this trip) arrived in the minibuses, but we were still waiting on a few students. I guess not much changes regardless of institutions; there is always a few late students. Some had phoned ahead that they were meeting us there.

After loading the supplies up on the minibus and a register was taken (by one of the students) we boarded one minibus, and the leftovers came with Barry into the smaller one. The students seemed excited about the field trip, but that could just be that this is their last day in before Christmas. On the 2 hour drive to Ingleton, Tim would periodically point out landforms and places of interest as we drove. It was clear to see that Tim had a great rapport with the students (unsurprising after 2 years I guess). The students were asking me questions about drones and PhD life, and I think I gained some rapport by controlling the radio station for them!

Upon arrival into the foothills of Ingleton, we pulled into a layby, and the students got kitted up. What surprised me most upon thinking about it was how well the students were equipped, they had some quality gear. That's a different outlook from my experience, there have always been the outdoorsy students who come well prepared, but there is always a few in jeans.

Tim and Barry took it in turns to explain what was going to happen and pointing out different vistas and landforms. For this, one of them would stop and gather the students around to draw their attention to something important. The back and forth between the students was encouraging, the two of them would ask something and wait for a response, I guess an improvement on the Cook's Tour method.

After walking for a while, we reached the river, and the students were to be set off in groups to work out river velocity, deposition, salinity, amongst over indicators. This river disappears from view into the cave system so showing them these techniques they can follow the river into the cave and out again, quite handy! Certainly something I've never done before. It was interesting to see that Tim took the time to demonstrate with some student volunteers what they were required to do. I think most of them were engaged, but a lot were eating their lunches at this point!

The combination of Tim and the students demonstrating the techniques I think helped them all to understand what they were about to do. I do wonder however if there is a more efficient way of delivering this? I was conscious that its December and the light wouldn't be around forever while I see merit in going over the steps maybe this is taking too much time? I wonder if an app could demonstrate this to them before they went out into the field to make them more efficient.

The students broke up into their small groups, and each was assigned a point along the river. While walking through each group, they all worked well as a team and were discussing issues with themselves, what struck me most was a distinct lack of mobile technology on show. They were still recording data on paper, and if they used a mobile device they could have made this quicker and shared the data more efficiently between groups, it's something I'll raise with Tim next time I see him to find out why they don't. I asked some students, and they said they did see a benefit but that they preferred to use old methods on paper. I wonder if all the students are like that?

I left the students for a little bit to get on with their group work as I took a walk around this stunning area. My first thought was if they are doing data collection into the river that enters the cave system may be a map, photographs or even a model of it could be useful to students. The meanders are clear to see from the brow of the hill and the tiny valley its created, but I doubt the students working in their sections appreciate that. The drone could work well here but five RAF Hawks have flown by suddenly and low level, so I need to check that out, that could be an issue.

Students had a time they had to be down into the entrance of the cave, that time was about to lapse as I started walking towards the cave entrance. I was joined quickly by one group who were running late due to having to go back for a tape measure. Entrance the cave was tricky down a steep ravine. I don't think in my old place we'd have been allowed to go down here, but the students here don’t seem to care, they’re quick on their feet. It’s been a while for me, and one student very handily waits for me and points out the places to stand (I forget that outdoor ed students this is their bread and butter!). The cave entrance is stunning by the time I got down and notice that half of the students are in the cave already and half were suiting up and discussing who is going to do what in the cave. Nice to see a lot of student autonomy and group dynamics at play.

I really didn’t want to head up the steep rock climb, past the waterfall into the cave entrance but the students were very encouraging, and I was in safe hands. The climb up the rock face was scary for me without safety gear other than my hardhat, but again the students didn’t seem to be phased at all. I got a cheer for getting up which was nice! The view in the cave was dark, and head torches were needed, I pushed on through the narrow cave past the students who were busy on a task. I’m not sure if I was a student I'd be so on task in this place, its cold, pitch black and water above the knees in some places. Trying to communicate over the roar of the water is a challenge, but they seem to be getting on okay.

I’m unsure how long we were under but by the time we exited the cave the sun had dipped below the horizon and the temperature had dropped below freezing. Everyone seemed to be on a high as we walked back to the minibus for where equipment was placed back, students got changed and exchanged their group data between each other on the minibus. It was a long dark drive back, and that was just under a 12 hour field day. For me, I want to find out about their technology use or lack of it, if they see any benefit in it and if maybe geography students differ in their opinion. It was encouraging to see a lot of independent group work and problem-solving on this trip (this matches well with the literature so far), and I think the river would be a good place to map.

Overall, I’m surprised that while many things are the same from my experience, there are some subtle differences. Firstly, the lack of technology is alarming considering my experience of being in an institution where mobile technologies on fieldwork are encouraged and provided. These students are unlike geography students in my opinion from their equipment to their core skills such as rock climbing and caving and their attitudes to risk. I wonder what other differences might come up with this cohort of students compared to geographers? Overall, a good field trip that students seemed to gain a lot of experience and knowledge from.

Field trip B: Thurstaston, Wirral. Final year outdoor education students, March 27th 2017

This field trip today was to see if what data that is emerging from the questionnaire so far reflects what happens on field trips. Not only this, but today was my first look at the field site that the eventual model is looking like would be made from the cliff down in Thurstaston.

If the last trip was fantastic weather today was the same, clear blue skies, not too cold for March and most importantly, it was due to stay dry today. Like last time again some students were late and some students were meeting us there (apparently two live on the Wirral, so it made sense for them to meet us there). We were only 20 minutes late departing this time.

Students were quick to remember me from the Ingleton trip, and they were asking about how the research was going which is nice. Feels like I'm developing some good rapport with these students. I overheard much discussion on the minibus, not about the field trip but their impending dissertation. I felt their pain; I know what it is like! Interestingly though were those who quietly contested amongst themselves that they'd rather spend the day doing their dissertation whereas the other half was glad to have an excuse to step away from it for a day.

Upon arrival at the field site, we walked up to a place called Thor's rock. A high outcrop of land that gave a great vantage point of the Wirral, the river Dee and across to the Mersey and Liverpool. It also showcased how dynamic this area is and as spotted by the student's numerous kettle holes that were left over by the last ice age. This location proved well by orientating the students and given the context to the map on the handout. Students asked questions to Tim relating to the work, and a lot of it was Tim confirming their hypotheses about the direction of Ice. After another short walk, we came across what Thor's rock is, a lump of hard rock that struts out of the landscape with numerous caved erosion channels in it. No one really knows how it was formed as Tim read off some literature around the site. This prompted students to have a discussion amongst themselves and with Tim for how they think it may have been formed. It was interesting to note students selecting and deselecting ideas based on their discussions. It seems like a community of practice may exist here, but I'll have to look into it more.

Again I notice a lack of mobile technology here. There were some questions about what some landforms look like for me, I'd have checked on my phone, but these students seem happy to wait to find out. One or two are using them, however, to look things up and to show others in the group. What is good about this is hearing students relate what they see back to the landscape, I heard things like "now this makes sense" and "oh no that can't be that because it's the wrong shape". It seems that this hands-on experience does cement students ideas and theories about a landscape.

After half an hour investigating the site and the students looking at it in detail and after explanations from Tim we headed off on the long walk to the beach for the primary purpose of this trip. The primary purpose of this trip for students was to analyse clasts embedded within the cliff and to collect data to help in their assignment, which would help them to side with the literature on how the Irish Sea glacier retreated. From discussions with Tim and the way regulations with the drone are going it's looking like I could make a model of this site to help his students. So I was keen to have a look at it and see what perceived advantages it could give them.

Again the same pattern occurred on this field trip with Tim gathering his students around and using some student helpers to demonstrate what he required from each group. I still think this can be done more efficiently before a field trip, but I remember this happening to me also on fieldwork, so maybe lecturers think this is inefficient, but perhaps it’s the only way? That’s something to ask in the interviews.

The students worked well again in their groups, and for the most part, Tim let them get on with it, checking in on them every so often. This was a very hands-on fieldwork data collection process but again in my eyes inefficient. They were still collecting data on paper and having to send pictures of their data collection sheets to each other. If they had a linked up spreadsheet, this could be so much more efficient.

Regarding the cliff face I have no doubt a model could well be made of it, I think because of the height of the cliff a model would work well. I noticed that after talking to Tim and the students, they could only access what they could reach and therefore clasts that were embedded higher up where challenging to observe. The model would give them access to these inaccessible clasts, and this may help their learning.

By now the tide was coming in quickly, and so I think data collection was cut short. Tim mentions to me that ideally they'd need a hundred or so clasts analysis, but due to time constraints they could only collect 20 max each and then share. He noted that a model might well allow his students to collect 100 each, so that could be a potential benefit to a model. I guess, unlike here were the tide cut the fieldwork short, there would be no such pressures on a virtual model.

By the time it came to late afternoon we had headed back to the university and Tim took a picture of each data collection sheet and uploaded them to the university module site. This field trip seemed to be of two halves, the first a look and observe and the latter half being more physical hands-on and doing activities. Students continue to demonstrate teamwork, problem-solving and independent thinking and as the trip went on and they were in data collection mode relied less on Tim's input.

In terms of the model, I think I may well base my first model on this site. It's away from airspace and having witnessed the tide coming in and a lack of accessibility for the clasts in the upper cliff I feel students would benefit from this. When I floated the idea about that, they really thought that would be a good idea. Now I just need to learn about how to make a model from a potential drone flight!

Field trip C: Ingleton, Yorkshire. Final Year outdoor education students, 11th December 2017

This field trip was back to the same place that was my first field trip on the PhD, to Ingleton in Yorkshire. By this point, the questionnaire data were analysed, and I've had one interview with a staff member. Today's plan was to see if what the students say they did match up to reality. I still had a few questions to ask and observe on this field trip such as their mobile technology use and what it is about fieldwork they like so much. Questionnaire data suggests it's them being out in the environment; I was interested to see if that was the case especially today. Of all the fieldwork I've done in the past 8 years, this was the most adverse weather I've ever been in. I got an email from Tim early in the week to be prepared to cancel and rearrange the field trip. For the first time in a long time have I seen this much snow in Liverpool and the latest reports up in Ingleton where a lot worse. Thankfully, the forecast today was clear blue skies, but it was not predicted to get above -3c. Certainly, a challenge I've never faced on fieldwork, so it was interesting to see how it affected things.

Again we didn't get away on time, this time nearly 45 minutes late. While again some students were late, what took the most time was trying to get into the snowed in and frozen minibus. It was my task to clear the snow from the minibus, and while the driver's side was accessible, the other doors were frozen solid. I guess today highlighted a problem of hiring minibuses; they don't come with a de-icing kit!

The drive to Ingleton was scenic, and it was a carbon copy of the last trip. By the time we had gotten there the landscape was covered in at least half a foot of snow. Plenty of students were taking pictures of the view, and many of them commented on things such as "I love fieldwork for this" implying the view. It was hard to disagree with that and those vistas. Despite the challenge of walking in the snow, (again students were very prepared kit wise) the field trip occurred the same as last time with Tim explaining and the students demonstrating. Thankfully, the river was still flowing.

I intended to do some mapping here, but with the conditions and the temperature, there was no way I could map with the UAV. I asked students about using mobiles, and most of them brought up the fact that even if they wanted to use them, they couldn't in this weather as the touch screens don't work well with gloves on. Another technical issue I observed was a much faster rate of discharge on my phone due to the weather. I was grateful that I brought my portable battery charger with me.

The students finished up and then went on into the cave, due to the conditions I elected to stay outside of the cave. By the time they had exited it was bitterly cold and dark and due to this, it was decided to bundle everyone in the minibus and sort the data out another day (if the mobile tech was used this would not have been a factor).

What I did observe however was a trend from the previous two that students work well in groups, they're vocal to each other about issues, and they solve their issues themselves. They seem only to use Tim to qualify their solutions rather than facing an issue and then going directly to him for his answer. If I remember, that was something evidenced in the questionnaire data. Students also kept asking me if I was to fly the UAV today, they seemed very disappointed that I was not due to the conditions. Overall, there were no real surprises observed on this trip from the questionnaire data, it all seemed to match up reasonably well, except the lack of tech on show but I think that could be down to conditions rather than these new groups of students. One thing to take away from this was they loved fieldwork because they were outside and in the environment, even if that environment was below freezing and in the snow!

Field trip D: Thurstaston, Wirral. Final Year outdoor education students, 16th March 2017

Today was an important field trip to observe as this was the main field trip for the model in action. I was quite nervous about this field trip for a few reasons. Firstly I didn't know what the students thought about the model, if they'd engaged with it or whether they'd find any use to it at all. Secondly, Tim was meeting us there, and a student was to drive the minibus with the other students and me to Thurstaston. I'm thankful that I've grown to know these students a little, from the Ingleton trip and a lecture I gave about UAV technology a few months ago. They knew who I was and that helped facilitate conversations in the minibus on the way to the site.

For the first time, students were asking me a lot of questions about my fieldwork, research and dissertations. I'm not sure if this was to include me in their conversations if they saw me as a source of knowledge or they were just trying to find out more about me being apart of their group for a few hours. I saw my advice about dissertations and jobs as a way into developing more rapport, and I think they appreciated that. Chat on the way to the field trip was centred around their impending dissertation submission. While this occurred last year, this field trip the deadline was far closer and a lot of them would have preferred to have been working instead of doing this. Nevertheless, they seemed in principle to comment on liking the model although one student mentioned that it was really slow for them.

By the time we reached Thors Rock it was extremely heavy rain, and that made pointing out the kettle holes and orienteering the students a challenge. Again, they didn't seem to mind too much, especially as the rain was forecast to push through after midday. The students asked some really critical questions of the landscape, and this cohort was a lot more hands-on in their field enquiry than last year.

What I didn't expect to observe was the facilitation of the staff-student barrier. Tim suggested that as it was raining but it would clear in less than an hour that we should have lunch in a local pub at the field site. He put it to a democratic vote and unsurprisingly they all agreed. What came next around the large table as they had food was the banter, the wisdom offered by Tim and the questions students asked. Despite being in an informal setting, the conversation still revolved mostly around fieldwork. By the time we were ready to go, Tim had used this opportunity in the dry to explain what was going to happen next and it allowed me to get some signed consent forms for their assignments. They all seemed really keen to help.

By now we had arrived at the field site, and while Tim was showing the students some coastal landforms, I made a quick dash up to the location the students would be working on. I knew the cliff fairly well after all the revisions of the model, but to my surprise, the big gully had partially collapsed near the bottom, clearly evident from the spilling out of the material. It looks fairly recent too!

By now the students were very quick to notice the collapse, and this was confirmed by one female student looking at the model on her mobile device and showing her peers where exactly it had collapsed. What I witnessed next was quite possibly the best moment I've had seeing the model in action. Unprompted by myself or [name] the students started to discuss what might have caused it. Was it coastal erosion, perhaps some storm action as half of them thought or as the other half argued it was rainwater from the top of the farmer's field that caused it, they used the map from the model to help explain their point. While this was not the main purpose of the field trip to discuss erosion, I think such debate and tangents are necessary and most importantly for me, I don't think such an in-depth conversation would have occurred had the students not known the cliff was different from the time the model was captured to what they saw today. I feel the model alone has demonstrated today to be a useful learning tool to promote discussion. I can't remember which lecturer mentioned this, but I know he alluded to the model having the potential to promote such discussion in the field. I think today has proven that.

I noticed more this time than any other the use of mobile phones and the students echoed the positives of this as shown in the questionnaire data. Despite this, the process of data collecting was still analogue, and literature and my experience would suggest that using digital tools would make this more efficient. Students who used the model said to me that they were surprised how lifelike the model was, so I guess that's some qualification for its ability to replicate the environment well. Overall I think the model has been a success on this trip; I'm still surprised at how well it facilitated the discussion of the collapse. I think the success is also that students seemed a bit quicker at getting down to work this time than last year whether that was the model or the cohort effect I'm unsure, but I am noting it. I'm interested to see now how the students go on to use the model in their assignment post-fieldwork.

APPENDIX F: QUESTIONNAIRE CODING FRAME

Question Code	Identifier
Q1	Based on the information provided, I agree to take part in the study.
1	Yes
Q2	Gender
1	Male
2	Female
Q3	Age
1	18-19
2	20-21
3	22-23
4	24-25
5	26+
Q4	What is your level of study?
1	Level 4 (1st year of Undergraduate)
2	Level 5 (2nd year of Undergraduate)
3	Level 6 (3rd year of Undergraduate)
Q5	What classification is your degree
1	BSc
2	BA
Q6	What is the title of your Degree?

1	BSc Single Hons Geography
2	Natural Hazard Management
3	Geography and NHM
4	Outdoor Ed
5	IDS and Geography
6	NHM and Geography
7	IDS and Sociology
8	Geography and English
9	Geography and History
10	Geography and Economics
11	Geography and French
12	Geography and psychology
13	IDS and History
14	IDS and Economics
Q7	Which university do you attend?
1	Liverpool John Moores University
2	University of Chester
Q8	Do you own a smartphone?
1	Yes
2	No
Q8_a	What smartphone make do you own?
1	Samsung
2	Apple

3	Windows
4	LG
5	Sony
6	Other
Q8_a_i	If you selected Other, please specify:
1	Huawei
2	Blu
3	ZTE
Q9	Do you currently use your smartphone for educational purposes i.e. for lectures or in fieldwork?
1	Yes
2	No
Q9_a	If Yes - How do you use your device for educational purposes? Please select all that apply
1	For checking University email
2	For checking the University App
3	For research i.e. Journal articles
4	In Lectures i.e. Note taking, downloading lecture slides
5	Social Media
6	Fieldwork - i.e. note taking, pictures, recording data
7	Accessing material in the field i.e. digital field guides and applications
8	Other
Q9_a_i	If you selected Other, please specify:
1	Attendance monitoring
Q10	Do you own a tablet device?

1	Yes
2	No
Q10_a	What make of tablet do you own?
1	Samsung
2	Apple
3	Windows
4	Other
Q10_a_i	If you selected Other, please specify:
1	Kindle
2	Asus
3	Ienova
Q11	Do you currently use your tablet device for educational purposes i.e. for lectures or in fieldwork?
1	Yes
2	No
Q11_a	If Yes, how do you use your tablet for education purposes?
1	For checking University email
2	In lectures i.e. note taking, downloading lecture slides
3	Accessing material in the field i.e. digital field guides and applications
4	For checking the University app
5	Social Media
6	For research i.e. journal articles and web searches
7	In Fieldwork i.e. note taking, pictures/video, recording data
8	Other

Q11_a_i	If you selected Other, please specify:
1	Scan documents to keep a virtual copy
Q12	How much do you agree with the following statements;
Q12_1	"I have a high level of competency with technology"
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree
Q12_2	"Using new technology in fieldwork increases my skills and employability"
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree
Q12_3	"Fieldwork is important for my studies"
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree
Q12_4	"I enjoy going on fieldwork"
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree

Q13	How likely are you to use your mobile technology device in fieldwork?
1	Highly Unlikely
2	Unlikely
3	Likely
4	Highly Likely
Q14	What concerns/issues do you perceive there to be when using mobile technology in fieldwork? Please select all that apply
1	The weather damaging the device
2	Dropping or damaging the device
3	Lack of technological skill
4	Course or course tutor does not allow for the use of mobile devices
5	Prefer traditional methods
6	None
7	Other
Q14_a	If you selected Other, please specify:
1	Signal out in the field to be able to use some pieces of software
2	Unable to clearly hear voice recording
3	Device may have a technical fault
4	Apps not available for smartphone
Q15	Would you encourage the use of institutionally owned mobile technology devices in fieldwork?
1	"Yes, it's a great idea"
2	"Yes, providing there was no penalty for accidental damage"
3	"Yes, if tutors encourage it"
4	"No, I prefer using my own device"

5	"No, I am worried about damaging the device"
6	"No, I don't see the benefits of using mobile technology in fieldwork"
Q16	How do you think mobile technologies can enhance your learning experience in fieldwork?
1	journal access and easy note taking
2	Speeds up data collection and processing and accuracy
3	Collecting images (to be used in fieldwork/geotag)
4	Makes experience easier
5	Creates the ability to student with dyslexia the chance to have a more interactive learning experience, even possibility could be classed as multi-sensory learning which academic material says help dyslexia learning
6	More interactive with students and environment
7	Enhancement of learning
8	Note taking
9	Check information in the field
10	Increase your technical skill
Q17	How do you think mobile technologies can hinder your learning in fieldwork?
1	Battery life
2	Distraction
3	Takes longer than traditional due to set up
4	Weather
5	Fail/Break/Less robust than traditional methods
6	Lack of signal
7	Complex
8	No/None

9	Reduces skill level due to reliance of tech
Q18	Do you take time after fieldwork exercises to reflect on what you have learnt and experienced?
1	All the time
2	Sometimes
3	Rarely
4	Never
Q19	Rank the following in importance to you on fieldwork, 1 being the most important
Q19_1	Social and Personal Development
1	1
2	2
3	3
4	4
5	5
Q19_2	Developing skills such as problem solving, team work and communication
1	1
2	2
3	3
4	4
5	5
Q19_3	Helps to place what is taught in the lecture into real world scenarios and make the connection between the two
1	1
2	2
3	3

4	4
5	5
Q19_4	Developing technical skills such as data collection, use of specialist equipment
1	1
2	2
3	3
4	4
5	5
Q19_5	Experiencing a landscape or area in person
1	1
2	2
3	3
4	4
5	5
Q20	If you do not know something on fieldwork for an assignment, how do you normally go about finding the information?
1	Look it up on the internet in the field through mobile technologies
2	Look in academic journals/books post fieldtrip
3	Discuss it verbally with fellow classmates
4	Discuss it with fellow classmates on social media i.e. Facebook, Twitter
5	Ask the tutor
6	Other
Q20_a	If you selected Other, please specify:
Q21	Do you use social media i.e. Facebook, Twitter to discuss assignments?

1	Yes
2	No
Q22	Have you used a UAV/Drone before?
1	Yes
2	No
Q23	Would you encourage the use of UAVs in fieldwork?
1	Yes
2	No
Q24	How comfortable do you feel about using UAV technology in your fieldwork studies?
1	Very Comfortable
2	Comfortable
3	Uncomfortable
4	Very Uncomfortable
Q25	How useful do you believe UAVs can be in your fieldwork?
1	Not useful at all
2	Not very useful
3	Unsure
4	Useful
5	Very useful
Q26	How beneficial do you think UAVs can be in data collection in fieldwork? 1 - Not very beneficial 5- Very beneficial
Q26_1	UAVs as a collection tool
1	1
2	2

3	3
4	4
5	5
Q27	To what extent do you agree with the following statement: "I think using UAVs in my fieldwork studies could help to enhance my interest and engagement with the subject"?
1	Strongly Agree
2	Agree
3	Disagree
4	Strongly Disagree
5	Unsure
Q28	How would you like to see UAVs used in fieldwork? Select all that apply
1	To collect pictures of field sites and fieldwork
2	To collect video imagery of field sites and fieldwork
3	To map the field site for student use
4	To collect data to create a 3D model of the field site to be used later by the student
5	To create a 3D model of the field site that can be used in a virtual field guide before the trip starts
6	Other
Q28_a	If you selected Other, please specify:
Q29	What concerns do you have around the use of UAVs in student fieldwork?
Q30	What skills do you think UAVs can bring to your fieldwork experience? Select all that apply
1	Practical hands on flying experience
2	Planning skills
3	Communication and Team work
4	Data collection

5	Complex skills such as photogrammetry and 3D modelling
6	None
7	Other
Q30_a	If you selected Other, please specify:

APPENDIX G: SHAPIRO WILKS NORMALITY TEST DATA

The following table is the data produced in the Shapiro-Wilk test of normality as conducted within SPSS 24 explore option. As shown, only one variable was greater than 0.05 and therefore parametric. The rest are less than 0.05 and therefore are not normal so the decision was to use non-parametric tests on this data.

	Shapiro-Wilk		
Variable	Statistic	df	Sig.
Gender	.507	19	.000
Age	.801	19	.001
Level of study	.749	19	.000
Degree Classification	.445	19	.000
University of attendance	.507	19	.000
Smartphone make	.709	19	.000
Using smartphone for educational purposes?	.244	19	.000
Use smartphone for checking university emails	.445	19	.000
Use smartphone for checking university app	.445	19	.000
Use smartphone for research purposes i.e. Journal articles	.362	19	.000
Use smartphone in lectures i.e. note taking, lecture slides	.633	19	.000
Use smartphone in fieldwork i.e. note taking, pictures, recording data	.507	19	.000
Use smartphone for accessing materials in the field i.e. digital field guides and applications	.641	19	.000
Make of tablet	.794	19	.001
Do you use your tablet for educational purposes?	.555	19	.000
Use tablet for checking university emails	.591	19	.000
Use tablet for checking university app	.633	19	.000
Use tablet for research purposes i.e. Journal access	.633	19	.000
Use tablet in lectures i.e. note taking, lecture slides	.616	19	.000
Use tablet in fieldwork i.e. note taking, pictures, recording data	.641	19	.000
Use tablet for accessing materials in the field i.e. digital field guides and applications	.616	19	.000
Use tablet for other	.244	19	.000
High level of competency with technology	.708	19	.000
Using new technology in my fieldwork increases my skills and employability	.731	19	.000

Fieldwork is important for my studies	.685	19	.000
I enjoy going on fieldwork	.751	19	.000
Likelihood of using mobile technology in fieldwork	.733	19	.000
Concern: Weather damaging the device	.362	19	.000
Concern: Dropping or damaging the device	.244	19	.000
Concern: Lack of technological skill	.244	19	.000
Concern: Prefer traditional methods	.244	19	.000
Encouragement of institutionally owned devices on fieldwork	.768	19	.000
How can mobile technologies enhance your learning?	.752	19	.000
How can mobile technologies hinder your learning?	.789	19	.001
Does the student reflect on fieldwork?	.793	19	.001
Social and personal development rank	.799	19	.001
Developing skills such as problem solving, team work and communication rank	.902	19	.052
Helps place what is taught in lectures into real world scenarios and help make the connection between the two rank	.855	19	.008
Developing technical skills such as data collection and use of specialist equipment rank	.878	19	.020
Experience a landscape in person	.884	19	.025
Assignment/Task issue on fieldwork: Look it up on internet in the field	.362	19	.000
Assignment/Task issue on fieldwork: Look in academic journals	.616	19	.000
Assignment/Task Issue on fieldwork: Discuss it verbally with classmates	.445	19	.000
Assignment/Task Issue on fieldwork: Discuss on social media with classmates	.591	19	.000
Assignment/Task: Ask the tutor	.591	19	.000
Do students use social media to discuss assignments?	.445	19	.000
Used a UAV/Drone before	.362	19	.000
Would the student encourage the use of UAVs in their fieldwork?	.244	19	.000
Comfort Level with UAV on their fieldwork	.796	19	.001
How useful do students think UAVs can be in their fieldwork?	.794	19	.001
How beneficial do students think UAVs can be for data collection?	.835	19	.004

Agreement with the following statement: "I think using UAVs in fieldwork studies could help to enhance my interest and engagement with the subject"	.760	19	.000
Use UAV to collect pictures of field sites and of fieldwork	.244	19	.000
Use UAV to collect video imagery of field sites and fieldwork	.362	19	.000
Use UAV to create 2D aerial maps of field sites	.362	19	.000
Use UAV to create a 3D model of the field site that can be explored before the fieldtrip	.445	19	.000
Use UAV to create a 3D model of the field site that can be explored after the fieldtrip	.616	19	.000
UAV skills on fieldwork: Hands on flying	.616	19	.000
UAV skills on fieldwork: Planning and Data collection planning	.616	19	.000
UAV skills on fieldwork: Communication and team work	.616	19	.000
UAV skills on fieldwork: Data collection	.362	19	.000
UAV skills on fieldwork: Complex skills such as photogrammetry	.555	19	.000

APPENDIX H: CHI-SQUARE TEST EXAMPLE

The Chi-Square test was used in this research when follow up questions from the descriptive statistics were needed. Chi-Square was used when the researcher wanted to test for independence between variables e.g. Do males own tablet computers more than females?

In order to employ Chi-Square the data must pass certain assumptions: (a.) The two variables that are to be tested must be either 'Nominal' or 'Ordinal' i.e. categorical data (b.) Each variable must have two or more categorical or independent groups and (c.) each cell of the cross tabulation must have an expected count greater than 5 (Laerd Statistics, 2018).

Chi-Square tests can be a test run while formulating a 'Cross tabulation' in SPSS. Cross tabulations are an effective tool for assessing the frequency or percentage of data across variables. The cross tabulation on SPSS will run the test with a Chi-Square test box displayed below it. If the Pearson Chi-Square row is greater than 0.05 in the Asymp. Sig (2-sided) column then there is a statistically significant association between the two variables.

Step one:

Ensure the assumptions are met for the data.

(a.) Both 'gender' and 'tablet ownership' are *Nominal variables*

(b.) Gender = *Male/Female* Tablet ownership = *Yes/No*

(c.) Are greater than 5

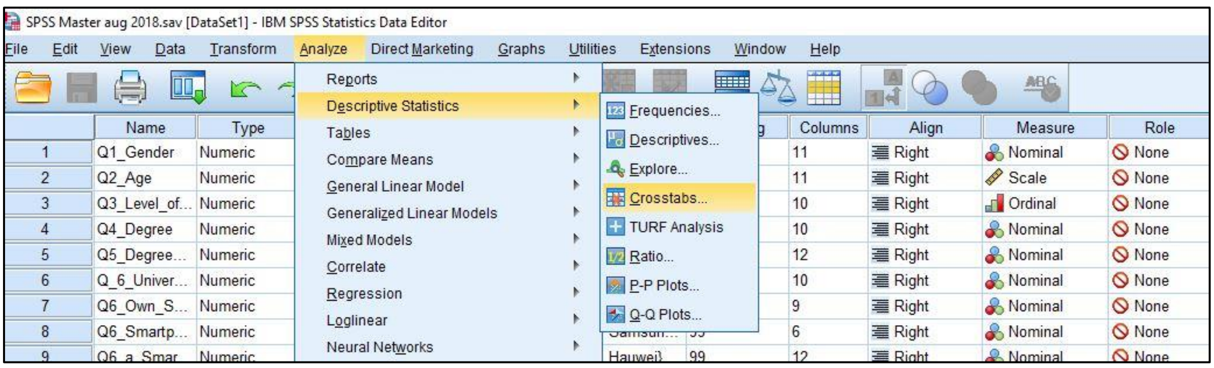
Step two:

Formulate a Null Hypothesis. For this example the H_0 is:

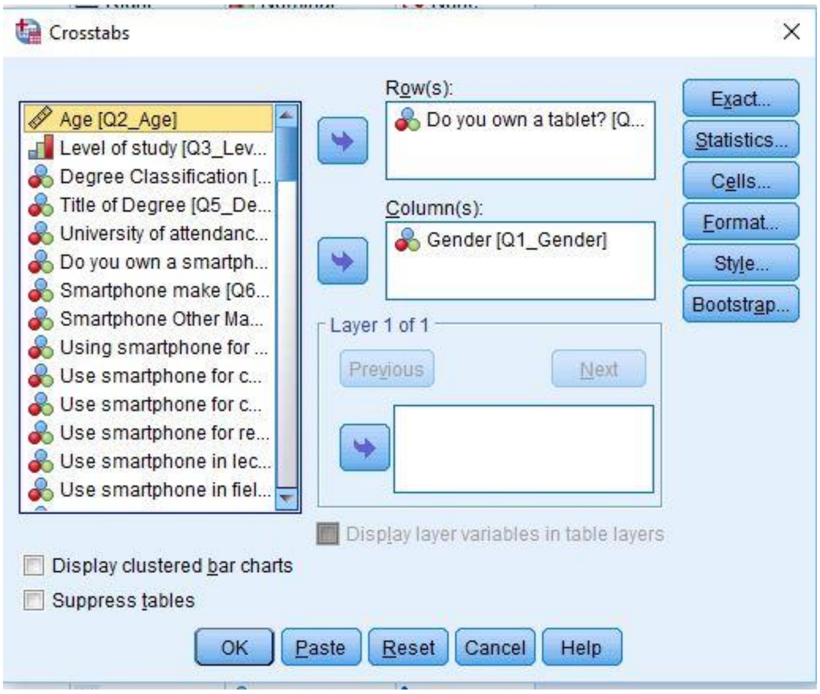
There is no significant association between gender and tablet ownership

Step three:

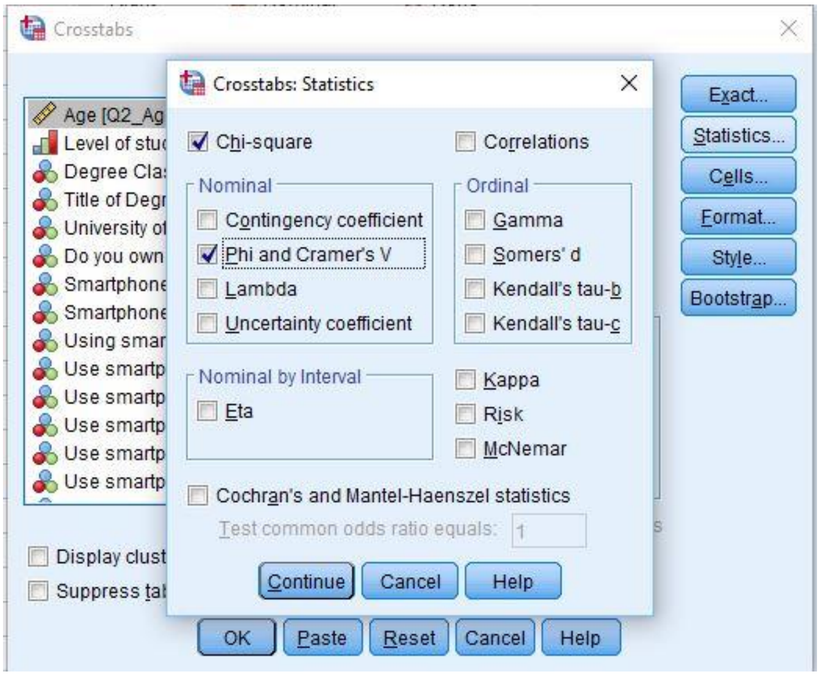
Set up SPSS (providing coding has been completed) to run a chi-square test. In order to do this, the researcher selected *Analyze> Descriptive Statistics > Crosstabs* from the top bar of SPSS.



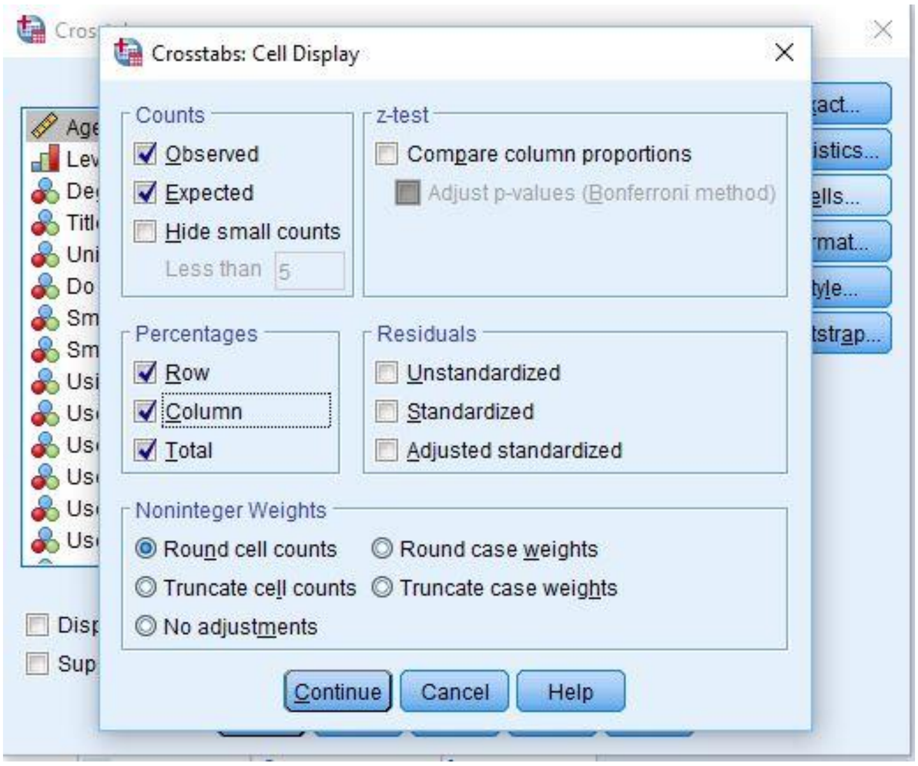
Following on from this, *gender* was placed into the Column(s) section and *tablet ownership* in the Row(s) section.



Following on from this Chi-square was selected in the Crosstabs statistics menu along with Phi and Cramer's V.



In the cell display option, *Observed, Expected, Row, Column, Total* where all selected.



SPSS then ran the Chi-square test and produced the following crosstab.

Do you own a tablet? * Gender Crosstabulation

			Gender		
			Male	Female	Total
Do you own a tablet?	Yes	Count	15	25	40
		Expected Count	15.4	24.6	40.0
		% within Do you own a tablet?	37.5%	62.5%	100.0%
		% within Gender	42.9%	44.6%	44.0%
		% of Total	16.5%	27.5%	44.0%
	No	Count	20	31	51
		Expected Count	19.6	31.4	51.0
		% within Do you own a tablet?	39.2%	60.8%	100.0%
		% within Gender	57.1%	55.4%	56.0%
		% of Total	22.0%	34.1%	56.0%
Total		Count	35	56	91
		Expected Count	35.0	56.0	91.0
		% within Do you own a tablet?	38.5%	61.5%	100.0%
		% within Gender	100.0%	100.0%	100.0%
		% of Total	38.5%	61.5%	100.0%

What is most important to observe is the follow Chi-Square statistics produced by the test.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.028[a]	1	.867		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.028	1	.867		
Fisher's Exact Test				1.000	.521
Linear-by-Linear Association	.028	1	.868		
N of Valid Cases	91				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.38.

b. Computed only for a 2x2 table

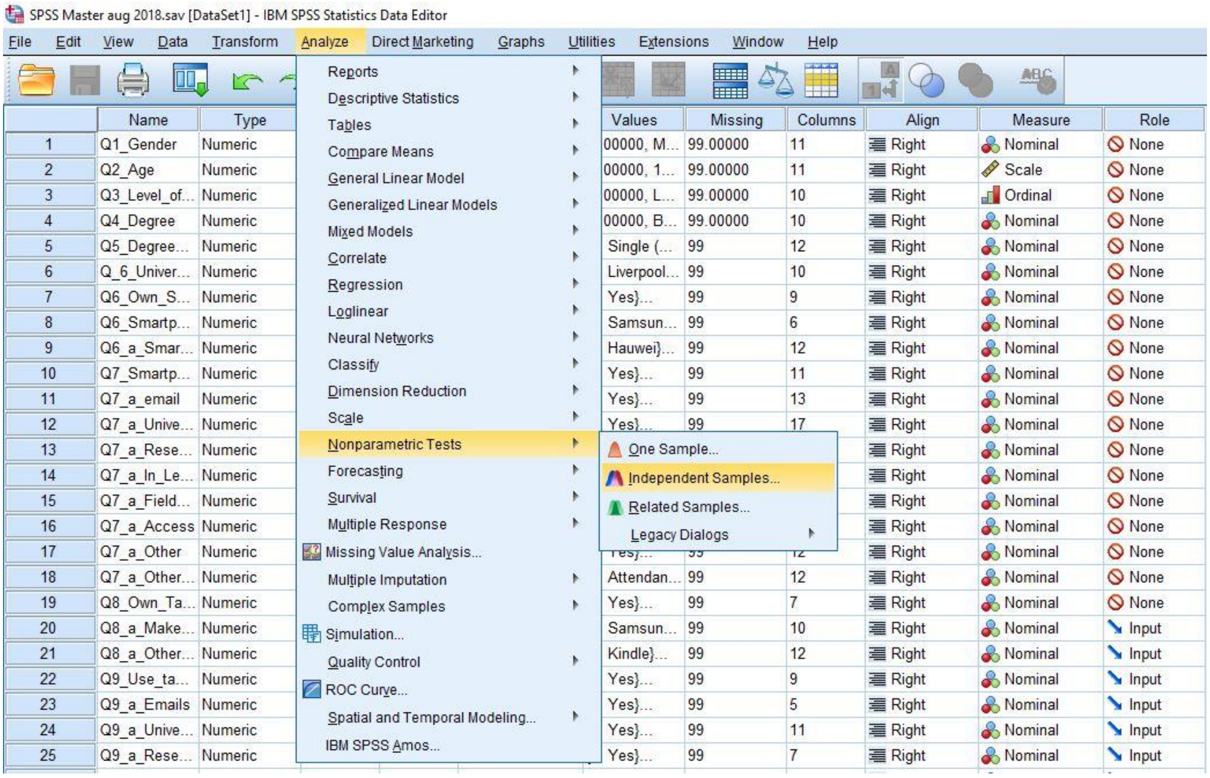
In order to ascertain whether there is a significant difference between the two variables firstly it was important to note that as shown in a. 0 cells had an expected count less than 5 and therefore the assumption was met. As highlighted, the Asymptotic Significance (2-sided) column is read off at the Pearson Chi-Square row. If this value is less than 0.05 then there is a significant difference in association between the two variables. However, as shown in this example, the p value was 0.867, therefore there is no significant difference in association between gender and tablet ownership and the null hypothesis is accepted.

APPENDIX I: MANN-WHITNEY U TEST EXAMPLE

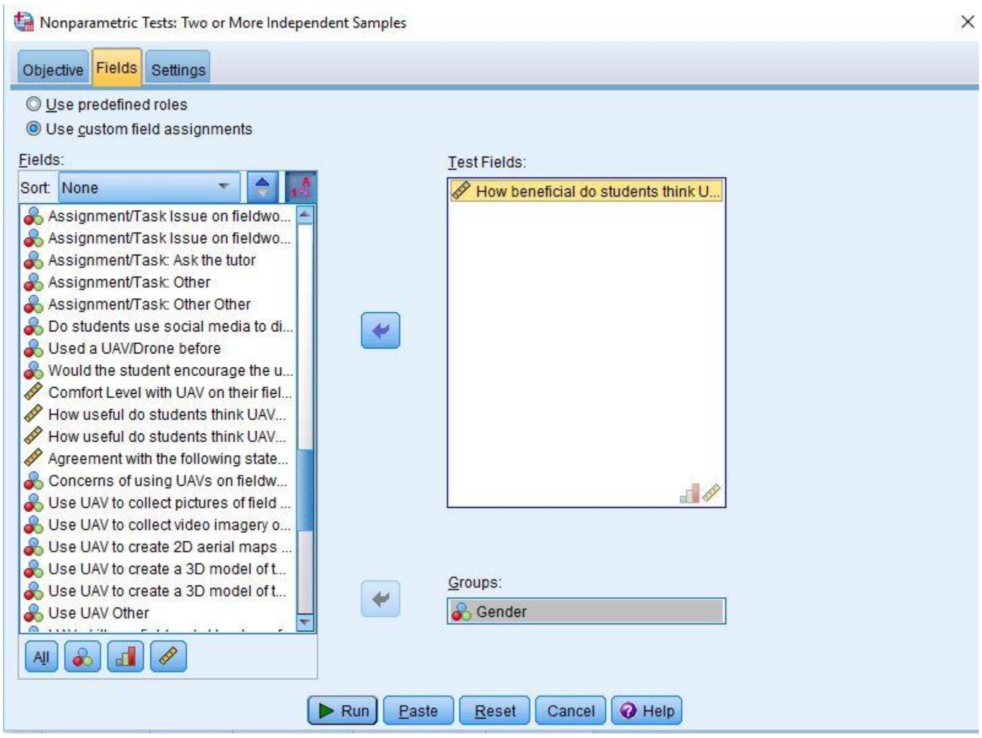
While Chi-Square is an effective statistical test for association between nominal variables, it is not suitable for when variables between two independent groups are continuous and not normally distributed. Mann-Whitney U tests are the equivalent of the independent samples T-test employed when data is parametric and seeks to observe differences between two discrete groups or populations along an ordinal/ranked scale (Laerd Statistics, 2018). As with the Chi-Square test, there are certain assumptions the data must meet in order to be able to be run with any validity. The Mann-Whitney Test stipulates four different assumptions:
(a.) The dependent variable should be either continuous or ordinal (i.e. Likert).
(b.) The independent variable will consist of two independent groups that are categorical (i.e. Gender).
(c.) There must be different participants in each 'group', for example there can be no Female Geographer who is also an Outdoor Education student.
(d.) Must be run on not normally distributed data.

For this example in this research, the researcher wanted to investigate whether there was a difference in perceived benefit of UAVs in fieldwork across gender in this study. The assumptions were met with (a.) The dependent variable was a Likert scale (e.g. Not very beneficial to very beneficial), (b.) The independent variable was gender, (c.) The groups had different participants and (d.) the data is not normally distributed.

Step one: Setting up the test
There are two option in SPSS to run a Mann-Whitney U test, they are via the *Independent Samples* function or the *Legacy* function. The Legacy function provides more flexibility but more steps and is useful for when there are more than two groups in the independent variable. For this example due to only two independent groups, the Independent Samples function was used.

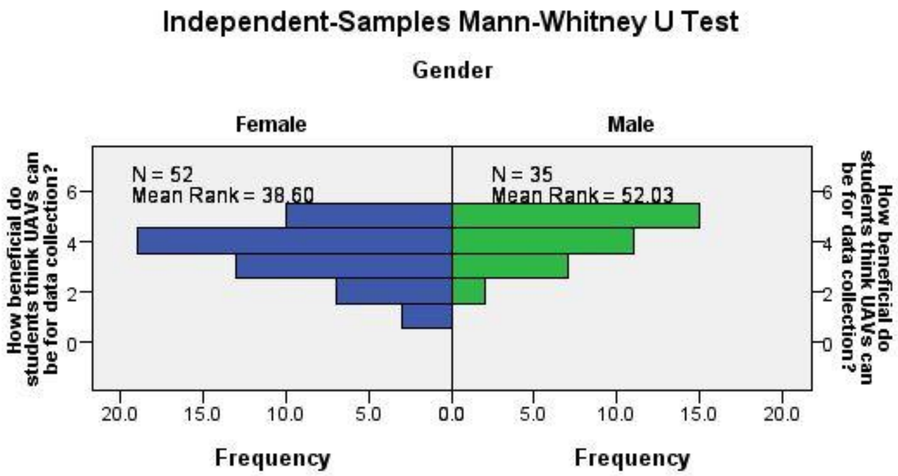


This then opens a select field where the independent group in this case gender, is placed into the groups function and the dependent variable in this case the *Benefit of UAVs in fieldwork* variable is placed into the test field. All default settings stay the same and the *Run* button is clicked to run the Mann-Whitney U test.



Step two: Interpreting the test results

While this then produces a Null Hypothesis and whether you should accept or reject it, it is important first to determine whether two distributions are of similar shape. A population pyramid is produced through this test and is visually inspected by the researcher. If the population distribution is the same then median values can be used alongside the mean rank, however, if the distribution shape is not the same then only mean rank can be used.



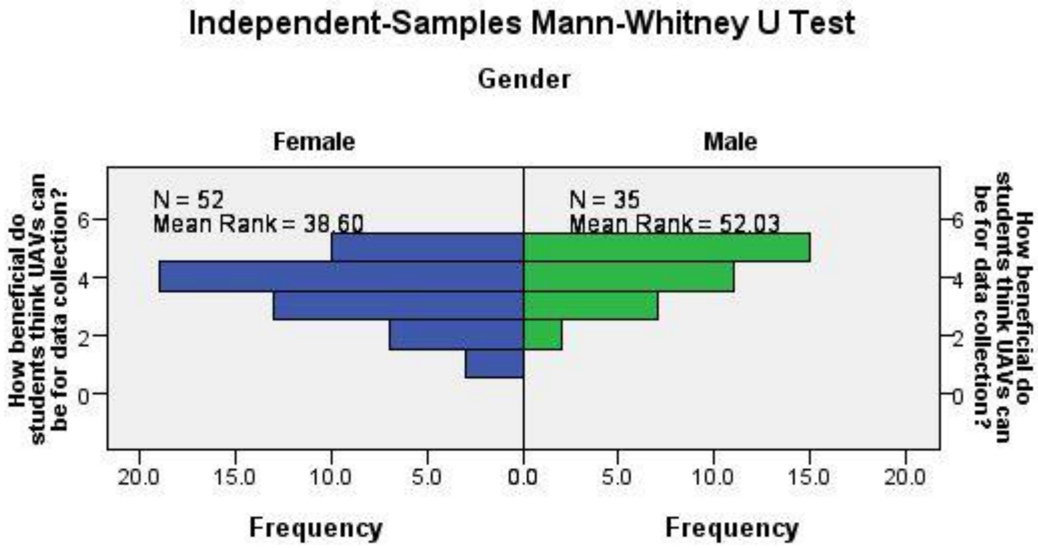
As shown above it could be argued that the shapes are similar although with the bottom missing from the male side. Nevertheless, due to the Likert scale being a 4-point scale, the mean ranks were used. SPSS after it has ran the test will tell the researcher whether to accept or reject the null hypothesis. In this example, the Null hypothesis would be H_0 *the distribution of how beneficial students think UAVs can be for data collection is the same across categories of gender.*

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of How beneficial do students think UAVs can be for data collection? is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	.011	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

As shown, the null hypothesis in this example can be rejected due to the significance being 0.011. If the significance level was greater than 0.05 then the Null Hypothesis would be accepted. By double clicking on this box brings up the distribution of both groups along with extra data needed for the reporting of the test in the thesis.



Total N	87
Mann-Whitney U	629.000
Wilcoxon W	2,007.000
Test Statistic	629.000
Standard Error	110.936
Standardized Test Statistic	-2.533
Asymptotic Sig. (2-sided test)	.011

Step three: Writing the test results

For this example, the following would be reported.

A Mann-Whitney U test was run to determine if there were differences in [Likert scale question] score between [Variable a] and [Variable b]. Distributions of the [Likert] scores for [Variable a] and [Variable b] were [either similar or not similar], as assessed by visual inspection. [Likert] scores for [Variable a] (mean rank = *) [were/not] statistically significantly [higher/lower] than for [variable b] (mean rank = *), U [Mann-Whitney U score] = *, z [standardised test statistic] = *, p [significance level] = **.

For this, the variables and scores are known. Variable [a.] is Males and [b.] females. Mean ranks for each are located in the table that is produced by SPSS. The Mann-Whitney U score is located in the table as is the Standardized Test Statistic. Due to the scale with Not very beneficial being 1 and very beneficial being 4, the higher the mean rank, the higher the agreement of UAVs being beneficial in fieldwork. Taking this into account, as presented in this thesis, the test for this example is displayed as.

> A Mann-Whitney U test was run to determine if there were differences in benefit of UAVs on fieldwork score between males and females. Distributions of the benefit of UAVs on fieldwork scores for males and females were not similar, as assessed by visual inspection. Benefit of UAVs on fieldwork scores for males (mean rank = 52.03) were statistically significantly higher than for females (mean rank = 38.60), $U = 629.00$, $z = -2.533$, $p = .011$

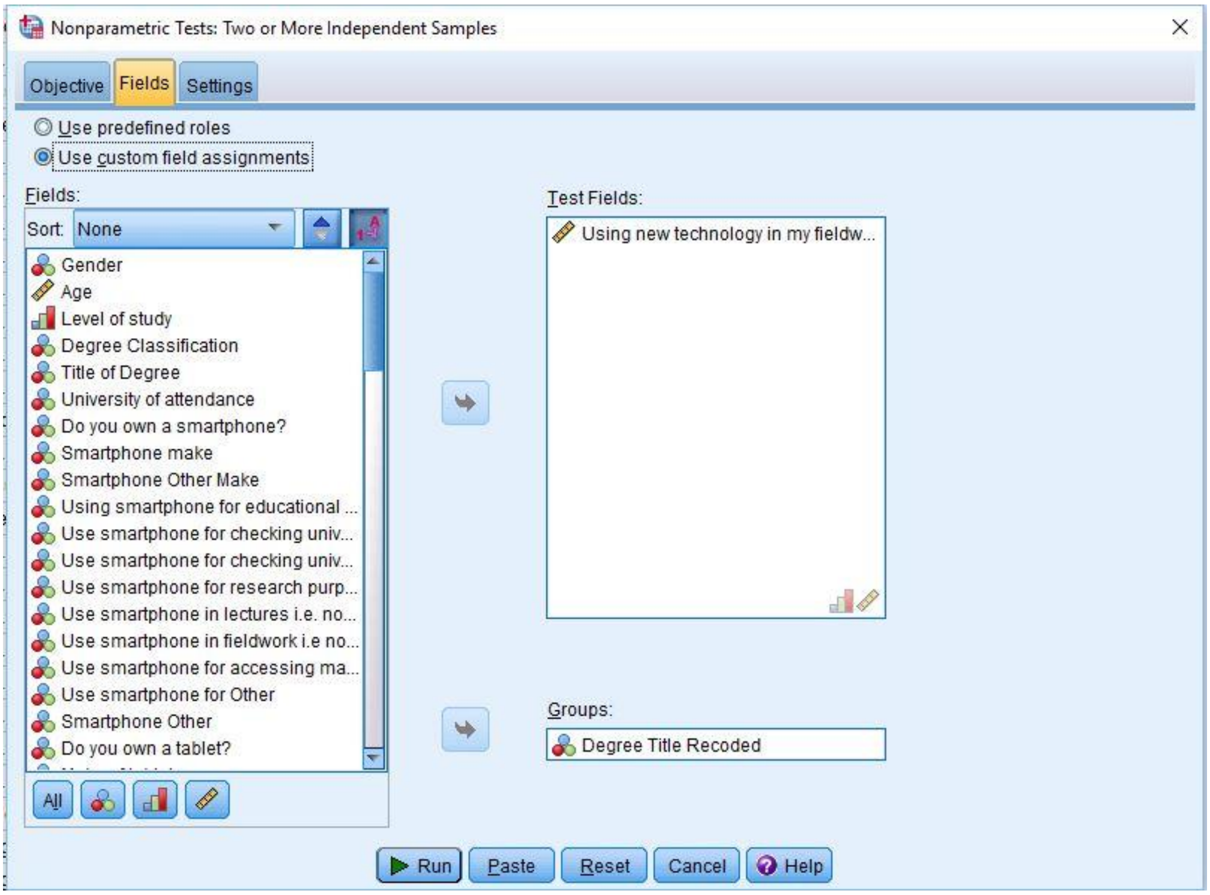
APPENDIX J: KRUSKAL-WALLIS H TEST EXAMPLE

Mann-Whitney U is an effective nonparametric test to determine the statistical difference between two variables within a population i.e. Male or Female, Kruskal-Wallis H is also a rank-based nonparametric test that seeks to determine the difference within a population of more than two independent variable groups (Kruskal & Wallis, 1952). This test was most often used in this research to assess differences in student levels of study i.e. 4-6 and in student cohort i.e. Geography, Geography Combined and Outdoor Education students. While there are many similarities to the Mann-Whitney U test, there are differences in the workflow and how the test works as explained below. As with all tests, Kruskal-Wallis H has a series of assumptions that must be met in order for the test to be valid. This test has the same assumptions as that of the Mann-Whitney U test.

In this example, the null hypothesis was that H_0 *the distribution of using new technologies in fieldwork increases my skills and employability score is the same across categories of degree type*.
The assumptions as per the Mann-Whitney U test were made.

(a.) The dependent variable was ordinal on a 4 point scale from Strongly Disagree to Strongly Agree
(b.) The independent variable consisted of two or more independent groups they were; *Geography, Geography combined* & *Outdoor Education* students.
(c.) No two groups or participants overlap
(d.) Shape of distribution has been attained and is not normal data

Step one: Setting up the test
The test set up is the same set up as the Mann-Whitney U test, with the independent samples function, followed by the degree type in groups and the dependent score in the test field.



Step Two: Interpreting the results

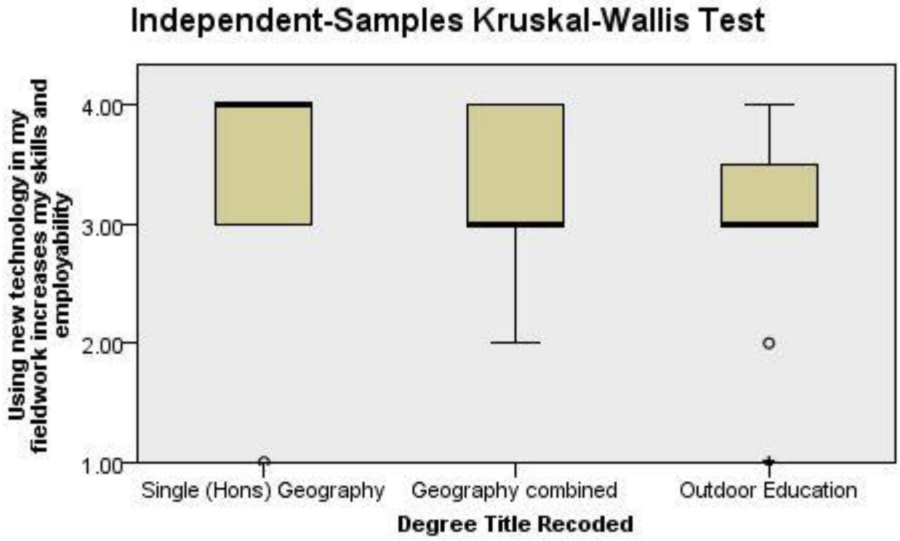
As with the Mann-Whitney U test, SPSS tells the researcher to reject or accept the null hypothesis. As in this example, the null hypothesis was rejected due to the significance value being less than 0.05. While this tells the researcher there is a significant difference between the three groups, it does not highlight where such a significance is and therefore a posthoc test is needed as outlined in appendix J.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Using new technology in my fieldwork increases my skills and employability is the same across categories of Degree Title Recoded.	Independent-Samples Kruskal-Wallis Test	.026	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

As with the Mann-Whitney U test, instead of a population pyramid being used to visually inspect the distribution of the groups, a boxplot is created instead. Again here, if the distributions are similar then medians can be reported from the test, if they are not then only mean rank can be used.



Total N	88
Test Statistic	7.263
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.026

1. The test statistic is adjusted for ties.

Step Three: Writing the results

The results for this part of the test are written as follows:

> A Kruskal-Wallis H test was run to determine if there were differences in [Independent Variable Name] score between [number and names of the Dependent Variables]: “Name 1” (n=Number of cases), “Name 2 " (n=*) and "Name 3" (n=*). Distributions of [Independent Variable Name] scores were not similar for all groups, as assessed by visual inspection of a boxplot. The distributions of [Independent Variable Name] scores [were/not] statistically significantly different between groups, $\chi2$ (Degree of Freedom) = Test Statistic, p = Asymptotic Sig. (2-sided test) value.

For this example this would written as:

> A Kruskal-Wallis H test was run to determine if there were differences in likelihood of using mobile technology on fieldwork score between [three student disciplines]: “Geography Single Hons” (n=33), “Geography Combined" (n=19) and "Outdoor Education" (n=38). Distributions

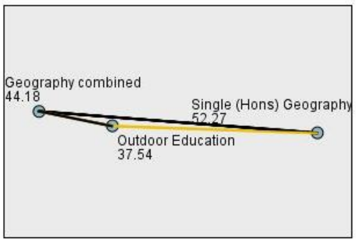
> of Likelihood of using mobile technology on fieldwork score were not similar for all groups, as assessed by visual inspection of a boxplot. The distributions of the Likelihood of using mobile technology on fieldwork scores were statistically significantly different between groups, $\chi 2$ (2) = 13.838, $p = .001$.

As outlined previously, while this tells the researcher that there is a significance it does not tell the researcher where this significance lies. Therefore, a posthoc test is needed.

APPENDIX K: POST-HOC TEST EXAMPLE

Following on from the example above, a Post-Hoc test is needed to determine where the significance between the independent groups exists. This is a relatively straightforward process on SPSS by selecting the *PairWise Comparison* view on the table.

Pairwise Comparisons of Degree Title Recoded



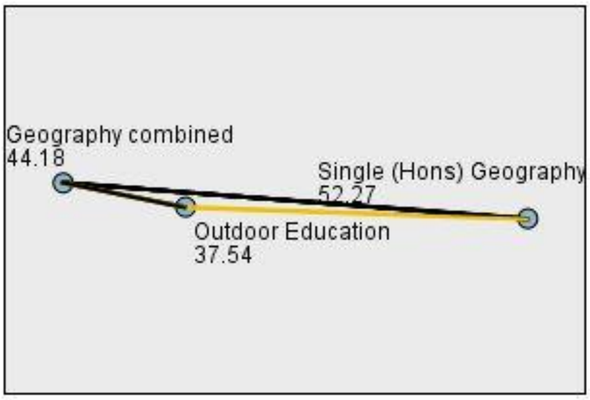
Each node shows the sample average rank of Degree Title Recoded.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Outdoor Education-Geography combined	6.643	6.434	1.032	.302	.906
Outdoor Education-Single (Hons) Geography	14.731	5.468	2.694	.007	.021
Geography combined-Single (Hons) Geography	8.089	6.534	1.238	.216	.647

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

This table produced and the subsequent graph shows to the researcher exactly where the significance is between the groups. The significance is highlighted in yellow in the table and as a yellow line between the groups.

Pairwise Comparisons of Degree Title Recoded



Each node shows the sample average rank of Degree Title Recoded.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Outdoor Education-Geography combined	6.643	6.434	1.032	.302	.906
Outdoor Education-Single (Hons) Geography	14.731	5.468	2.694	.007	.021
Geography combined-Single (Hons) Geography	8.089	6.534	1.238	.216	.647

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

As displayed above, it can be seen that single honours geography students are statistically significantly higher in their agreement to fieldwork increasing their employability skills than outdoor education students. This is demonstrated by the yellow significance but also the difference in mean rank with Single Hons students with 52.27 and Outdoor Education with 37.54 (with higher numbers meaning more agreement). Due to the Bonferroni correction, the significance value presented in Yellow 0.021 is used in the write up of the test. This part of the test is written up after the Kruskal-Wallis H test as outlined in the previous appendix.

> Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented. This post hoc analysis revealed statistically significant differences in [Independent Variable Name] scores between [Dependent Variable a.] (mean rank = *) and [Dependent Variable b.] (mean rank = **) (p = [Adjusted significance value]), and between [Dependent Variable c.] (mean rank = **) and [Dependent Variable a.] (p = [Adjusted significance value]).

In the text for example this would look like the following:

> Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented. This post hoc analysis revealed statistically significant differences in Likelihood of using mobile technology on fieldwork scores between Outdoor Education Students (mean rank = 35.97) and Geography Single Hons Students (mean rank = 57.03) (p = .001). There was no significant difference between other combinations.

Overall a completed write up of a Kruskal-Wallis H test in the test is as follows:
A Kruskal-Wallis H test was run to determine if there were differences in agreement of using mobile technology in fieldwork enhancing a student's employability score between [three student disciplines]: "Geography Single Hons" (n=33), "Geography Combined" (n=19) and "Outdoor Education" (n=36). Distributions of agreement of using mobile technology in fieldwork enhancing a student's employability score were not similar for all groups, as assessed by visual inspection of a boxplot. The distributions of agreement of using mobile technology in fieldwork enhancing a student's employability scores were statistically significantly different between groups, $\chi2$ (2) = 7.263, p = .026. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented. This post hoc analysis revealed statistically significant differences in agreement of using mobile technology in fieldwork enhancing a student's employability scores between Outdoor Education Students (mean rank = 37.54) and Geography Single Hons Students (mean rank = 52.27) (p = .021). There was no significant difference between other combinations.

APPENDIX L: INTERVIEW AND FOCUS GROUP TRANSCRIPTS

LECTURER A: Interview Transcript

	Timespan	Content
1	0:00.0 - 6:48.1	AC: Right okay then so can you tell me a little bit about your background and how you go to where you are today in education? AM: Yeah okay so I guess I started at undergraduate really with a degree in environmental sciences actually rather than geography over at the University of East Anglia so that was a pretty broad course that gave me well more focused on the physical side of things quite a lot of geophysics earth sciences that kind of thing but also going into some of the social side of things... AC:...ah okay... AM: Then I kind of went into that as most a lot of students do not particularly knowing what I wanted to take it I think I had a vague ideas of possibly environmental consultancy or something like that and I came out of it and sort of struggled immediately to find a job in the area that I wanted so I ended up working with something that was tangentially related for a while which actually turned out to be quite useful as for a while I was a bibliographic data assistant for a book whole sellers... AC: ...Ah okay that's interesting AM: Which didn't seem useful at the time but actually a lot of data managing querying has fed into my GIS aspect of things so a lot of my understanding of databases and the computer side came from that job and that was my first attempt at you know scripting and programming and the actual sort of things I've used quite a lot since [Laughs] so what I thought was sort of you know quite an unrelated job has actually turned out to be quite useful in the long run. AC: Ah nice AM: But I did want to get back into doing something more directly related to my undergraduate so I actually applied for a masters in Lancaster in Environmental Informatics so very much focused around kinda' the GIS remote sensing side of geography and environmental science but also the kinda' broader issues of data quality handling uncertainty and fuzzy boundaries and all those sorts of issues that come up a lot when we're dealing with kind of geographical and environmental data so yeah that really highlighted that I really enjoyed the technological side of geography and environmental sciences so at that point I was thinking about PhD study but there was nothing immediately available or interesting so I ended up going into a job with Blackpool council as the GIS officer in their planning department so again very much on the GIS side managing their spatial data mapping the kind of planning areas involved in their consultations and that kind of thing but then after I'd been there about a year I actually got a phone call from one of my masters supervisors at Lancaster saying we've got a PhD project that's come up basically somebody had taken it but dropped out and they said well its right up your street so if you're interested in picking it up you know it's pretty much yours.. AC: If you want it yeah? AM: Yeah so and I thought about it for a bit and thought no see ya' I'd quite like to go down the academic route so yeah I went back and that's what sort of took me to the coastal processes side which I consider my specialism now but actually up until the PhD I'd never worked in that area, so my background was very much

the kind of broader GIS remote sensing geographical data side of things and then coastal processes was kind of a an application to apply those skills to as oppose to I think a lot of people go from the other angle and have an interest in you know one particular area and then move into GIS as a way to look into it. Yeah, so that took me into the PhD which was interesting, it was quite applied it was funded by Wyre borough council.
AC: Ah okay
AM: So looking at basically their coastline and using a whole range of so ranging fieldwork to GIS remote sensing looking at historic data airborne LIDAR data basically bringing together lots of different datasets that cover different timescales so the idea was to get an integrated picture of what was happening on the coast so from the instantaneous what has happened on the coast from one low tide to the next up to what's happening you know over the last 30 years and trying to integrate our understanding what has happened at all of those spatial and temporal sort of scales so that was kind of where my interest came in the GIS side of it was yeah that challenge of integrating that data and all of those spatial and temporal scales into one coherent picture and conceptual model of what was going on the coastline
AC: Nice
AM: and that basically led me directly into the role at [university name], so I actually started here just before I finished my PhD I was still writing up at the time that I started here, so they advertised for a lecturer in physical geographer with GIS which was pretty much you know
AC: You!
AM: [Laugh] Yeah and my area! So I thought I'm still writing up, and it's probably a bit ambitious, but I'll go for it anyway and yeah got the job and been here ever since

AC: How long is that now?
AM: Oh four years now
AC: Four years I bet that's gone quick? [Laughs]
AM: [Laughs] It is scary how much it flies by but you know then again I've developed a lot since then I've taken on a lot more responsibilities
AC: So just to confirm what is your official title now?
AM: I am now a senior lecturer
AC: Senior Lecturer okay
AM: So as of last summer yeah so senior lecturer in physical geography and GIS but like I said now I'm sort of assigned two days a week to this new project the CREST project so much more industry linked research basically supporting small and medium enterprises in the environmental sector so again my main speciality there is the kind of GIS and remote sensing so moving away from coasts again as Shropshire is not very coastal! So broadly projects ranging from mapping and visualisation of green space to mapping of food poverty and that sort of thing also hoping well it doesn't actually officially launch until February so it's in the early stages, so we're getting a various bits of equipment so a range of equipment including drone kit so hoping to bring that side of things
AC: Well we'll definitely come onto that later
AM: So yeah drone monitoring to model generation from drones as we'll come onto I guess
AC: Yeah super
AM: So yeah that's me in a nutshell really and my background

	Timespan	Content
2	6:51.1 - 10:36.5	AC: Brilliant thank you. So we'll move onto a bit about fieldwork now can you tell me what your opinion of fieldwork is in general and then we'll talk a little bit more about the specifics of the discipline AM: Yeah well I think fieldwork is great [laughs] you know you can't well you can talk about things in a classroom as long as you want but it doesn't kind of you can't recreate that experience of going out to seeing these processes in the real world seeing the features that these processes create for me coastal fieldwork actually seeing the waves and the tides in action and the fact that you never quite know what you're going to see when you get out there it changes day today and I think from a broader pedagogic point of view I think fieldwork is one of the things that makes geography and related disciplines so kind of powerful. I think something I've never really looked into that I think is interesting is in terms of retention, so I know within [university name], the Geography department does a really good job of student retention, and I put, and we work hard to build that relationship, and I put a big part of that down to fieldwork and the opportunities for both staff and for students to bond with you know staff and their peers particularly around first-year residential fieldwork to me that plays a critical role and that kind of draws from my own experiences really I did first-year residential fieldwork when I was an undergraduate at UEA we went away for best part of a week and you know a lot of friends who I still regularly go on holiday with now were people who I met on that first year residential fieldwork AC: Ah yeah AM: So to me that student experience and building that student unity is important AC: So it is that social aspect of it yeah? AM: Yeah you get to know essentially you get to know your peers in a different way because you live with people at University but they're not necessarily the people on your course, and you may sit in a lecture theatre with them, and over the three years you might build up a relationship but going away in the first year for a week or whatever kinda builds that group identity and sense of community. AC: Yeah I'd have to agree like you from my own experience it was the same AM: Yeah I think and that relationship with staff also so like I said you see staff in a different light you sit with them at meal times you probably go the pub in the evening and you see that different side to them and you realise actually they are people they're not just a distant presence up there at the top of a lecture theatre and even you know day fieldtrips to some extent you kind of chat to people as you walk along you talk to students about how they're getting on how they're settling into [university name], in a way you probably wouldn't in just a lecture based situation or even in smaller tutorials and lab classes, so I think aside from the academic benefits I think the broader benefits that fieldwork brings are fairly substantial so yeah academically there is nothing like showing these processes happening in the real world and it also brings home some of the complexities so you go out and somethings don't always look like you expect you know particularly in a coastal situation if there has been a big storm and I'm expecting to show the students all these coastal features and if there has been a storm on the beach earlier in the week and it's just flattened everything, and there is nothing there! AC: That's a learning tool in itself though right? AM: Exactly yeah it highlights how dynamic these environments are and it

highlights the sort of challenges you come across in the real world, and things don't always go to plan

	Timespan	Content
3	10:36.4 - 11:53.0	AC: Do you think students think the same way about that in fieldwork in terms of the social aspect and the seeing it for themselves? AM: I think they do yeah certainly the social aspect in terms of feedback we get from students is always really positive around the fieldwork and throughout all the three years so I do think they appreciate that, but I think the fact that they get to see these processes first hand you'd miss out on a lot if you didn't have those opportunities. AC: Brilliant. So how important would you say that fieldwork is in terms of the whole degree? AM: I think it's very important I mean you could do it without you'd lose a lot I think I mean you can teach almost anything in the abstract if you have to! But I think its definitely not ideal and like I said I think it engages the student with the topic and seeing it first hand and realising this is on their doorstep and you know it leads them to the opportunities for them to do their own research dissertations as well quite often students will go back to locations as they might have looked at or been on field trips to look at in more details for things like dissertation research.

	Timespan	Content
4	11:53.0 - 15:41.8	AC: brilliant thank you. Can you tell me briefly what sort of field trips you do here specifically for your coastal modules? AM: Yeah so as I mentioned briefly we do some residential field courses a particular one I'm involved with is the first year residential out to Snowdonia so there is a coastal strand as part of that so in that one we go out to Llandudno on the Welsh coast and look at a whole range of issues so you've got the physical processes going on you've got the management and the hazards and the risk associations there so a whole range of different things that students can look at in that environment and I mean at first year it's a pretty basic level they've not had an introduction at that point to the theory behind the coastal processes and what's going on unless they've done it at A level actually a lot of them that is their first encounter with understanding processes and coastal environments but it also allows you to demonstrate some of the methods and the fieldwork techniques you'll use later like beach profiling sediment analysis and you know the practical and analytical skills then on the coastal side of things for second year I take them out again to the North Wales coast a sort of half day fieldtrip to Talacra, so I'm actually going out there next Wednesday AC: Ah okay AM: Great time of year for it [laughs] AC: [Laughs] Absolutely! Nice and warm! AM: Again that's another challenge of coastal fieldwork, in particular, is the issue of working with the tides so it's always slightly challenging and an issue working with timetabling for it. Fortunately, you can get long-range tide predictions but the... AC:...The weather? AM: [Laughs] we can't even hope to match the trip with the weather! We have to

try to fit the tides into the timetable, and that is a bit awkward so yeah that's at that point sort of focusing on coastal processes and looking at the different features and looking at how we can use those features to tell us something about the processes that are going on so actually taking sediment samples down the beach and looking at how the distribution varies and looking at what does that tell us about how the sediment is being transported you know is it being transported up or down the beach and looking at the bedforms and what does it tell us about the wave or how the waves are acting on different parts of the beach where we've got channels flowing out, and that sort of thing and that also forms the basis for the assessment for that module, so they do their fieldwork they come back here and analyse it in the lab you know do some analysis on the computer, and then ultimately they put together a presentation explaining their findings as an assessment.

AC: Is that a group exercise or is that individual?
AM: It's a group exercise
AC: Brilliant
AM: Another coastal field trip that I do is a final year one that I do I used to do two but one that didn't link to assessment and that's always one of the challenges with fieldwork as obviously there is a cost implication
AC: Of course yeah
AM: But also students often think in an assessment focused way particularly in final year when they're working on dissertations they can view I think fieldwork as a sort of negative thing if they don't see it as directly feeding into some of their assessments I used to basically do a full day field trip up to the coast of Blackpool to look at different processes and defences up there but that didn't directly feed into any of the assessments, so some of the students really enjoyed it, but it also got some negative feedback such as why did we need to go out for a full day when it's not directly linked into something we're being assessed on.

	Timespan	Content
5	15:41.7 - 17:59.9	AC: Ah interesting so do you think that students are quite assessment focused that unless they see a benefit of being tested on it, they don't see the point in it? AM: They certainly can be yeah I think you know probably not every student AC: Of course yeah AM: But there is a significant minority, and you know comments did come up at the staff-student liaison meetings and things that some students had fed that back and like I said it could just be the timing of that trip being in final year and being around their dissertation time AC: Of course yeah AM: As you know it's a high-pressure time, and anything that takes away from that is viewed negatively so yeah there are some limitations to that so my other more physically orientated final year field trip I don't run anymore instead I run that as more of a virtual field trip now, so I run an in-class exercise so using google earth ArcGIS online various other secondary data sources and look at the same sort of stretch of coastline I would have taken them to but looking at it with a different perspective virtually so you know it's not as good in some ways but on the other hand they're looking at datasets they wouldn't have been looking at in the field so its swings and roundabouts a little bit. AC: Nice AM: The other field trip that I do that I do still run is more management

orientated, so that's out to sort of around Llandudno, and we go to several different locations, and we look at the management techniques but looking at assessing the value of the coastline it's sort of linked to how do we determine what is appropriate management in different areas of the coastline so thinking about the financial value of the assets you're defending but also thinking about things like the aesthetic value of the coastline and the ecosystem services and the value of those ecosystems can relate that so although that fieldwork isn't assessed its techniques they need to use in order to complete the assessment, so there is more of a direct link with assessment in there
AC: Brilliant yeah
AM: So they're the main ones that I'm involved with yeah

	Timespan	Content
6	17:59.8 - 19:44.8	AC: In terms of fieldwork then what skills certainly in terms of the discipline of coastal ones when they go out there what skills do you try to get them to develop that fieldwork offers them that a classroom environment doesn't? AM: I think there is quite a range really certainly there is team working skills because they are almost always working in small groups trying to organise themselves in more of a sort of spontaneous way to some extent than you do in say a group presentation where it's done over a period of weeks, so I think that's useful and obviously the sort of practical data collection skills so fieldwork data collection skills be that beach profiling or sediment sampling carrying out surveys all those sort of things putting them into practice into the real world and seeing the trials and tribulations of dealing with weather conditions if it's getting dark early or if the tide is coming in and its gotta' be done efficiently before all that happens and all those sorts of issues and I think on some of the fieldtrips it's that responsibility of you know going off into towns that they don't know they are university students they are adults it's not like a school trip were we say hold hands, so we want them to go off but be back here at this time, and there was another one in my head and nope it's gone!
7	19:44.7 - 21:00.4	AC: It might come back to you! So you mentioned before about the cost implications of fieldwork is that barrier to fieldwork that you see or? AM: It can be I think increasingly so to some extent you know the university sector is sort of in a reasonably challenging time having to justify the money we spend and what we do with student fees and I think that means yeah that we do occasionally like to go out on a few more trips and also it depends on the approach that you take so [university name], has always taken the approach that if the field trip is compulsory then the department will cover the costs so the majority of fieldwork is directly coming out of our budget so we're not charging that onto our students so we do have to think about if we do have a limited budget where is the best use of this. AC: So it's trying to make those field trips as efficient and as beneficial almost? AM: Yeah it's trying to maximise the benefit that the student can get out of it say you have three trips and we can only afford two then we have to work out which of those is going to have the bigger benefit

	Timespan	Content
8	21:00.3 - 22:32.3	AC: Do you find any other challenges or barriers to you as a practitioner on fieldwork and for students as well? AM: I mean time is one well timetabling is one there is a challenge particularly for residential fieldwork they've run for quite a while so they can be incorporated into the University year especially with the different combinations of degrees timetabling residential fieldwork can be a challenge but they're pretty good at fitting in day trips but for me personally the tides add an extra challenge because I can't be as flexible as some other people so I can't say to timetabling just I need to go half a day within these two weeks because there may only be two or three half a days where the tide is out which enables me to do the fieldwork that I need to do so that does make it a bit more of a challenge in that particular environment I'd say most other fieldwork doesn't quite have that level of constraint that you get from tides I think that's not too much of an issue but yeah like I said yeah to a small extent showing students the benefit of them if they feel it's not much of a benefit and they feel their time could be better used doing something else but again I think that's a relatively minor one you know, but yeah cost is AC: You'd say cost is the biggest one then? AM: Yeah cost is the biggest barrier yeah

	Timespan	Content
9	22:32.2 - 24:33.2	AC: Brilliant thank you very much so we'll move onto mobile tech in fieldwork now so can you give me a couple of examples of any mobile technologies that you do use on fieldwork with students AM: Yeah increasingly using iPads and tablets for data collection that's probably the most prevalent one that we use really instead of bits of paper that can get wet and soggy and fall apart whereas an iPad will collect it electronically and also saves a step for data entry when you get back to the lab as well you know it's really useful doing it that way because you can have all of your information on there your data collection spreadsheets you know it can calculate your beach profiles as you go along as well so you can see how your data looks in the field as opposed to having a series of measurements and not knowing till they get back to the lab whether that actually looks accurate or not and for supporting information as well you can put a PDF or a PowerPoint slide on there that will give them guidance on what they're doing what to look out for how to take their measurements AC: So it's almost like a field guide and electronic field guide? AM: Yeah yeah you know it's not a huge development you probably would have done that before in paper format but again its that ease of not having something that is going to get wet and would fall apart like I said the biggest benefit in some ways is the time saved in terms of data inputting and things like that but you know the students like it they enjoy it it makes it feel somewhat up to date when you're using this technology if that makes sense? AC: Yeah yeah AM: But you know I do think they find it easier than having to deal with bits of paper and having to come home and input that.

	Timespan	Content
10	24:33.2 - 27:19.1	AC: So the iPads they're all departmental owned? AM: yeah yeah we've mostly done it that way we've mostly not done the bring your own devices model of fieldwork

AC: How come you've not gone down the BYOD route?
AM: I think partly because we've had the iPads in the department for a while so I think partly you can see potential hassle...firstly in terms of making sure it’s got the data on it because you've got to go the extra step to make the data available you have to download it so by using departmental devices we can make sure everything is there and prepared and also the standardisation in terms of getting it back off and processing it afterwards people using their own devices okay most of them are pretty standard, but someone may hit an issue with getting the data off and there is a risk of something going wrong and people losing their data if we use our own device with our own set up we know it’s pretty failsafe and set up the way it needs to be. Other things we've done and mostly using iPads but it’s actually more linked to directly data collection, and that’s using apps like ArcGIS collector to collect photographs and take notes GPS points in the field which they can use to generate story maps and those kinds of things
AC: And that's all on the one device yeah?
AM: Yeah
AC: So traditionally would that have to be achieved by using numerous devices or could you not have done that originally? AM: It would have been a lot more of a workflow I think you’d have to have a handheld GPS and written down the coordinates and taken pictures on a digital camera and then at some point make notes that had supporting information and then at some point brought it all together so it basically allows all of those things to be done in one coherent sort of way and again it can be easily downloaded and used afterwards so yeah they're the main ones... I think the the only BYOD type thing that I do do and it’s not large scale its within GIS practical’s when I’m teaching about GPS because we have 40 maybe 50 students on the course we don't have 40 or 50 handheld GPS' to use so I encourage them to download a GPS app on the phone which allows them to do the same data collection that can be done by the handheld GPS and I think that’s also quite good because it shows them if they also want to use them for their own data collection for dissertations you've got this you can do it on your phone it’s quite capable of collecting what you need

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11	27:19.1 - 28:34.9	AC: Brilliant do you think students have...so one reason students don't use their own device on fieldwork is that they have a fear of damaging their own device with the weather so do you have any sense from the students that they have that issue when they borrow these departmental devices at all? AM: Not really no I think that’s again something we can make sure when we use our own departmental devices is that they are all weatherproof ruggedized cases so that they are you know if they're dropped or rained on there is minimal risk of damage and I mean you do get issues of students losing their , but that’s more students not paying as much attention as they could do for looking after them. I'm not sure being worried about their own devices is that much of a barrier as I know students take lots of pictures when they're out on fieldwork anyway so I’ve not seen anything that sort of suggests you might get the odd one who's a bit precious about it but I think most of them don't see that and increasingly mobile phones are dustproof and waterproof and those kind of things and as that becomes more prevalent there is less and less of a barrier to kind of being worried about the device being damaged

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12	28:34.8 - 30:04.1	AC: Brilliant my final question on this section you mentioned there about one of the benefits is the time saving and the efficiency element what would you say is the number one negative to using mobile technologies on fieldwork if you have one at all that is? AM: I've not got any major ones I suppose if it's got to have good preparation and making sure that things are set up properly on the device they're all fully charged it's not going to run out of battery half way through or something like that but beyond that for the sort of data collection we're doing I don't think there are any major negatives to me its is easier than working with paper and that you know the staff who are on the trip know how to use the technology you know in case the students do have any problems they can help them again a lot of it is down to preparation a piece of paper and pen is pretty failsafe everyone knows how to use it you're not going to have a technical failure other than it getting wet and falling apart so there is a slightly more of a risk with that with mobile devices but as long as you're prepared you've made sure the devices are charged and set up, and that staff can show the students then yeah there aren't many issues, so I think it is just a preparation thing proper preparation is a positive there are not many negatives

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13	30:04.0 - 32:35.5	AC: That's good to know brilliant. So we're going to move onto this question now, and that is in your discipline certainly the coastal side what are the key concepts and processes and fundamental skills that you want your students to have by time they leave in final year? So maybe the two most prevalent concepts and skills that you want them to have? AM:... [Long Pause] That is a tricky one! AC: Yeah it always is when I ask this one! AM: There are so many things you want them to have and some of them are subject specific and some are much broader skills I mean on the coastal side I guess I always say I want the students to understand the main processes that are influencing the coastline but on the more practical side you know how they can manage those processes, but that encapsulates an awful lot of knowledge in that broad point. More specifically I think it's probably that critical thinking really every coastline is different and I encourage them to have those skills to look at the coastline and understand what's going on look at the situation and make an informed decision about what is likely to be going on here and what would be the best way to manage it so in some ways what I'm ultimately trying to get to is what I'm trying to get them to do is critical thinking and I think that's what the assignments are trying to lead them towards is making those decisions and being able to justify those choices that they've made. AC: So you mention the assignments you use those assignments to qualify those skills and concepts to make sure they understand them? AM: Yeah yeah very much so and you know the way all degrees work you have your learning objectives and your assessments are trying to meet those learning objectives is what I want them to get out of that side of the course, and the assessments should be made to make sure they're meeting those learning objectives so yeah I do try to make them as applied and testing those skills that I want the students to have when they come out.

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14	32:35.4 - 34:52.7	AC: Excellent thank you very much. Now we'll move onto UAVs do you have any experience of UAVs at all? AM: I have some I have some I say that I need to get more flying time in really [laughs] AC: [Laughs] Yeah me too! AM: Yeah I've done my theory part, but I need to finish my Ops manual and get my practical test done, so it's mostly time constraints at the moment so maybe after Easter or into the summer when things calm down... AC: And the weather gets better [laughs] AM: [Laughs] Yeah that does help so yeah I've used them a little bit not too much in anger at the moment it's mostly working towards that. SM has been out and done some flights on the Wirral and I'm hoping with this CREST project that we've got that we get a reasonable amount of drone equipment and I've spec'd out for a range of different sized drones with different payloads from a kind of small fixed camera equivalent to a Phantom type thing maybe more something along the lines of a eugh what is it called? AC: The Inspires? AM: No maybe even going up even bigger than that because we've also put in for a range of sensors so optical thermal maybe even near inferred and maybe a LIDAR sensor so particularly the LIDAR sensors are slightly heavier and you need something capable of carrying a bigger payload so yeah I am hoping to use that a bit more in the future and I think for coastal environments there is an ideal tool as again working with the tides you want something which is quite responsive that allows you to look at a reasonably large area get out there and do it quickly and I think drones are ideal in that sort of situation because you can you know get it out there and get it ready as the tide goes out and make the most of that two hour window or whatever it is you've got to collect as much data as possible before it comes back in

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15	34:52.6 - 37:45.4	AC: yeah that was going to be one of my questions actually as you mentioned about tides and stuff I was going to say how do you think UAVs can help that so are you planning to use UAVs in teaching at some point? AM: Yeah I mean we do use a bit of teaching with them at the moment mostly teaching them about drones and the technology so with the GIS and remote sensing modules you know we show the students some of the drones we have in the department and take them out onto the hockey pitch and show them the basics of drone operation you know the Dronecode and the things you're meant to think about and as they're very much an up and coming technology if you're teaching about GIS and remote sensing then you need to make students aware of drones and their capabilities is a key part of it now I think AC: Brilliant so what benefits then do you think so you mentioned the benefit of collecting data in a quick time on fieldwork can you think of any other benefits that UAVs can bring to you as a practitioner and to students on fieldwork? AM: Yeah to me as a practitioner I think they fill a kinda...like I said going back to the PhD one of the things was trying to integrate processes at different spatial and temporal resolutions and I think UAVs can fill a nice gap in that and can cover

quite large areas but at very high resolution and potentially quite good temporal resolution so airborne LIDAR is very expensive and they maybe only get flown a few times a year beach profiles surveys are similarly quite time consuming if you're doing them over a large area and councils collect them but again about twice a year there might be other systems, so some coastlines do have video camera technologies for monitoring, but they're restricted in term of the extent and well the spatial resolution deteriorates the further away you get from the camera so they probably can look as a kilometre or so of coastline but that would be quite high resolution close to the camera but that will degrade as they get further away whereas drones allows us to look at that scale with a consistently high resolution across the area and a potentially relatively quick return period if we can get back there once a month its actually not that time intensive to collect that data once a month. So on the research side of things, it fills a nice niche of that spatial and temporal scales that we want to look at and understand and give us that high spatial resolution and fairly high temporal resolution over reasonable large extent that nothing else can easily do at the moment.

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16	37:45.3 - 38:44.4	AC: Do you think that will help in your teaching with students then? AM: Yeah definitely from a research point of view like I said it just helps us fill in that gap in the understanding of what's going on over those scales and how those coastal features are behaving I think on the teaching side I've not thought too much about their integration I'll have to go out and use it more in the field like I said our main teaching at the moment is about drones themselves and making them aware of the technology and the role that it can play in geography and geographical topics but certainly I can see the potential for it to feed into teaching as an aid and I guess that's kind of leading into your example here! AC: It will do indeed yeah [laughs] AM: I think those kinds of models and the outputs they produce have a lot of potential to engage students with some of the topics.

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17	38:44.4 - 41:41.7	AC: before I move into that I've got one more question about UAVs, and that's can you think of any negatives or barriers to UAV use in fieldwork? AM: I think partly it's the safety and insurance issues especially with students as long as they agree to be under your control and do what you say with the drone then you should be reasonably safe but a lot of field environments there may be members of the public and things coming by so there are some safety and insurance issues to be considered I wouldn't say it's a barrier, but it's something that needs to be thought through. I think one of the biggest barriers generally is public perceptions I think some people just have a big issue with drones for no reason and they don't really know what they're doing and you know you hear all sorts of stories of people out collecting data for perfectly innocent reasons and they assume that they're spying on them and comes over yelling and whatever so at the moment it is that public perception and the insurance and safety element that links into that that is a real barrier to their use. AC: Yeah interesting that you mention that I had an interview with a student on UAVs and they were very adverse to using UAVs and throughout the whole

interview when I showed her the outputs and the models she changed her mind because she thought like you said just people spying and taking pictures and she didn't realise you could use them for this and like you say it’s that awareness isn't it?
AM: yeah and I don't know what the answer to that is really I think there will become increasing regulation I know there is talk of it and the big manufacturers are kind of against it because it will I guess...
AC: Reduce their sales
AM: exactly yeah and I know DJI and things they are constantly increasing the safeguards built into their software in the hopes that it will mitigate against the actual regulation of drone sales and licencing and drone flying and that sort of thing, but I think inevitably it will get stricter until we get to that balance point
AC: Yeah and who knows when we'll that will be, but yeah I think it’s coming
AM: Oh yeah it is yeah they're just figuring it out I know doing the drone theory test that at the moment it’s still based off the regulations for manned aviation and obviously it’s a very different beast with very different purposes so I think the various aviation authorities haven't quite got their heads around how to handle it and trying to shoe-horn it into existing regulation eventually someone will have time to look at it properly and come up with a sensible way to deal with it, but it's not quite happened yet!

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18	41:41.6 - 43:07.5	AC: That is true! Right we'll move onto the model some might as well use this... AM: Sorry I’ll get rid of that error message that is floating on my pc! AC: So my first question is what do you think of it? What are your initial thoughts of the models? So this was created by one drone flight up in Thurstatston, and this is a slightly refined version, so the original version was just the cliff, and then I’ve added in stuff such as the annotations and made it a higher quality so first of all what's your general impressions of the model? AM: I think general impressions is it's really good the level of detail that you can get out from it, and the sort of features you can pick out of it is really good as a coastal person there are all sorts of things you can pull out of it so my eye gets drawn down to the beach because that's my area of study so the fact that you can pick out the different sediment sizes you know you can see the bands of fine sediment distribution pebbles and cobbles and shingle in different areas all those sorts of features which is really useful in a kind of potential teaching aid to highlight those sorts of things to students.

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19	43:07.4 - 44:48.0	AC: So zooming in as a teaching tool would it need to be a higher resolution or is that actually alright? AM: I think that's sufficient for most purposes like I said you can distinguish everything from fairly smaller shingle down to sand and you know you can pick up a lot of detail within the cliff you know erosion patterns drainage wearing away eroding small areas in the cliff vegetation you can see in the cliff right down to fine detail you know you may even be able to identify species from that so yeah I don't think there is any need for any higher resolution everything I’d want to talk about I can pick out AC: Oh brilliant okay AM: So looking down here I’m trying to pick out those lines there whether they're

an artefact of the model or whether they're a real feature...just looking now if you can pick out any bedforms but I guess we're above the tide level here so maybe that might be the only issue having looked at it in more detail now I think these are possible some artefact of the model generation instead which could confuse students with a bedform in a coastal environment but that is easily pointed out to students so yeah I think other than that slight issue I think the quality and the details you can pick out cover everything I'd want to talk about

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20	44:47.9 - 46:52.6	AC: that's good to know, so you mentioned there about a potential teaching tool would you use this potentially before you went on a field trip? Say you were going to this location do you think there is a benefit for the students seeing this before they went or would you prefer this after as a little teaching tool AM: I guess it depends what the focus of my field trip was I can see it both ways one thing would be is that this has been taken at obviously some point in time and as I said coastal environments change quickly so actually to say this is what it looked like three months ago let's see what it looks like and different this time when we go out say tomorrow and I also think as a discussion tool afterwards so it's got a lot of power to say okay we saw all of those things and we talked about them in the field now let's relate that back to the theory now that we're back and they'll have the context because they've seen it AC: Because they've seen it in person yeah? AM: yeah they've been in that environment and what's caused this what's the implications of this what does this mean for how we might want to manage this coastline so I think one of the other thing is we're always trying to think of equality for students and accessibility if we had any students who couldn't access the field site and beaches if someone was in a wheelchair it's not ideal there is no solid path to go on so if we went out to this environment if someone had access difficulties wouldn't be able to come down so this kind of model gives them as close as you can get to being there you know? AC: Yeah so you can have this set up to Oculus Rift and have it set up to VR as well if need be, so that is good to know

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21	46:52.6 - 48:48.2	AC: What do you think could be further improved with the model for your teaching and your students? AM: I think in this specific example as it's in a coastal environment I'd like to extend it further on, and I guess in general giving it more context so maybe even overlaying it on an ordinance survey base map or something you know if you've only got a model of this area it will give it some wider context where you can zoom out and say well you've got the country park here or the post office there and you can see it's on the mouth of the estuary and that sort of thing you know with a bit of thought there could be some more additional annotations on there AC: In terms of the annotations there is a way although I'm yet to learn you can add pictures and further links to images or data do you think that is a tool that will benefit students looking at higher detailed images or maybe links to articles for example? AM: No yeah I think that's good I think it's something that is interesting and different and the use of 3D models isn't something that is done in teaching and I think we can add additional information on PowerPoint slides or Moodle pages

and that kind of thing but maybe they're more likely to engage with it with something which is more interactive and more exciting to look at than if they would if it was just stuck under a heading on a Moodle page

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22	48:48.1 - 50:04.6	AC: So you mention a little bit there about the practical element of students using it on fieldwork with that critical thinking do you think that model may help you to get your students to understand those processes? AM: yeah I think that ability especially within the wider context to zoom out and look at this area and see what are these influences oh look there is the Irish sea it’s on the estuary so this process is going to be feeding in, and we've got this town down here and we've got defences in this section so I think that ability to visualise it in a wider context that you can't do in the field, so I mean we can look at this cliff and look at this beach with all of these individual features and you know have a map in front of them but it might make it easier for people to visualise that big picture to actually have that model in some context to be able to zoom out and have these things in relation. AC: So this needs to be situated within something...a context? AM: Yeah as useful as it is it would be even more useful if it had some context or resources with it, yeah you know even if it’s an ordinance survey base map you could zoom out to see what's in a kilometre around it for example.

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23	50:04.6 - 52:30.1	AC: Excellent that’s good to know! What I will show you now is well we have the model but I want to get the thoughts of this because to make the model you have to take loads of images, and this is kind of a follow on from this, so the model is the final output, but I want to get your thoughts on these external resources and how you think it may help in your teachings. So we've got the model and the high-resolution images. One of my concerns was that the model would not have enough resolution so it’s good to know that it is but having 4K high-resolution images attached to this students could zoom in to a much higher level, so I wanted to check that was a good thing to use and it has the ability to create these aerial 2D maps which students can annotate and link to the wider data so I’m interested... AM: Yeah it’s really useful to get that view, and again you can see those different zones as we head across the beach and those kind of features so as an additional resource that's really useful yeah AC: Excellent this is one thing that you can use in this software is make a beach profile, so again one of the critiques is when you're on the software you can run your mouse along there, and it will give you heights, but it doesn't yet have the ability to export that into excel, but again I don't know if as a teaching tool that might be useful to show and see if the students profiles match up with that? AM: Yeah again the point I said before this is taken at one point how will it be different when they go out there so you know it may not match up to what they get, but it will provide I point for discussion to look at yeah.

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24	52:30.1 - 54:38.9	AC: So finally from a GIS perspective you can create Digital Elevation Models, and this was all created from the one flight, and you can change the resolution, and the intensity of the model I don't know is that something that is accurate does

it look accurate is it useful?
AM: yeah it looks accurate I think if you were to use this in anger in a peer-reviewed journal you'd probably need to take a differential GPS with you to get a measure of the accuracy but yeah just looking at it I can pick out the sort of features you'd expect it looks sensible and realistic and with this you can calculate a whole host of things you can calculate the profiles and the change over time and how different features are moving around the beach.
AC: Again do you think students would benefit from this?
AM: Yeah I think it would help to highlight the things that are going on and you know potentially something they can carry further analysis out on and one of the key things I try to do is cross their skills across modules, so I try to give them the opportunities within the coastal modules to use their skills they've learnt in GIS for example, so it's a great opportunity to cross over those skills and realise this isn't just something you do in GIS it has applications elsewhere
AC: Yeah I know for this software you can export it into Arc or QGIS obviously I don't have those skills, but I know there is a way for students to use that raw data and that sort of stuff, so that's good to know, so that's me pretty much!

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25	54:38.9 - 56:21.9	AC: So it's good to know that those external resources are useful as educational tools AM: Yeah I say that I think the only downside to it is whether you'd ever get any student saying why do we need to go out and see it in real life AC: Do you think students would say that? AM: There might be a few may be the ones who say they don't like going on fieldwork while working on dissertations like I say I'm just trying to think of both sides of the argument AC: Yeah of course AM: I don't think many would and if you couched it in the right way with the changes and things like that AC: Yeah because that is one of the question points is due to the time pressures and cost pressure as you say if this trip to the coast had to get cut because of funding could that physically replace the trip AM: Yeah! AC: Some would argue no because they like to be out there physically but if you have VR and the noise can it replace it? AM: Yeah I don't think you can ever fully replace being there and seeing it and in the real world its constantly changing and the waves are hitting the beach but on the other hand yeah if the pressures meant like I said you have to cut down to two out of three trips maybe you know you can use something like this to replace the third trip that you can't run and at least cover the same material in as close an approximation as possible

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26	56:21.8 - 56:31.4	AC: Excellent thank you AM that's great do you have any other pointers or questions? AM: No I think that's great it's all interesting stuff thank you.

LECTURER B: Transcript

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1	0:00.0 - 2:00.8	AC: Right so can you just tell me a little bit about yourself in terms of what discipline you teach and your background of how you go to where you are today JK: Yeah so I'm the head of Geography, and I'm a physical geographer, and my background is well BSc in Geography PhD in physical geography focusing on quaternary environmental change really AC: Ah okay JK: Coastal and coastal river valleys, so that involves reconstructing floodplain development sea level change and the influence of sea level change on tidal valley development and that sort of thing AC: Brilliant JK: Then I did a postdoc on sea-level change using salt marshes in North America using it as a geological tide gauge to reconstruct recent patterns of sea level change over the last few hundred years which overlap with tide gauge records so most of the stuff I teach has been stuff like coastal geomorphology coastal environments a little bit about rivers and floodplain developments through participation in overseas field trips I've sort of broadened my I suppose at least interest areas in teaching and we visit semi-arid Mediterranean environments every year so I've become quite converse on femoral river systems and semi-arid landscape development and that sort of thing, so I do quite a lot of landscape teaching fieldwork particularly in semi-arid landscapes and I do coastal stuff with them as well, but obviously it's much drier than in the UK... AC: Absolutely JK: So I have an interest in sort of temperate and semi-arid environments in environmental change as well, so that's basically me

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2	2:00.8 - 3:10.1	AC: Brilliant thank you very much, so you mention there about fieldwork overseas is there other fieldwork that you go on? JK: With students or? AC: With students yeah JK: Ok so yeah we do day field trips with students on nearly every module we run in Geography AC: Right okay JK: That may be human geography field trips we go to Sheffield we go to Manchester, and obviously we use Liverpool as a key location to look at regeneration and urban change and that sort of thing, and we do a day field trip to the Wirral North Wales Derbyshire Lake District the Howgils where else… basically lots of upland and coastal areas Sefton coast so yeah upland areas in and around the North West we visit quite regularly, and we take the second years to Spain and the third years go to Iceland and Greece AC: Nice JK: So we take them to Glaciated landscapes as well

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3	3:10.1 - 4:37.1	AC: Ah okay brilliant in terms of fieldwork what's your opinion on fieldwork are you positive or negative? JK: Well obviously I think we're in a privileged situation to be able to do

fieldwork and get outside
AC: Yeah
JK: Geography is fundamentally about understanding how processes in the world work and how they can be affected by people and how those processes, in turn, affect people and lives, so I think as geographers its fundamental that you get out of the classroom, and you learn the practical skills and you learn about the environment that you live in by you know being in the field
AC: Yeah Yeah
JK: So I think its philosophically for me it’s crucial to the discipline and it’s also recognised its crucial to the discipline as being a core component to the new A level GCSE curriculum
AC: Ah okay
JK: It's part of the QAA subject benchmark statement that fieldwork is an essential written component of geography provision so whether you approach it because you enjoy it or because you know not the regulations but the recommendations with what you do within in Geography all include fieldwork you know it’s an absolutely central part of Geography
AC: Brilliant so to you it’s very important then would you say?
JK: I'd say it’s more than very important it’s absolutely fundamental yeah

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4	4:37.0 - 6:16.9	AC: Do you think students feel that way at all about fieldwork? JK: We assume that they do AC: Yeah JK: I think the majority of students pick geography because they like fieldwork and they like getting out and doing something a bit different, but actually I recently surveyed the students and asked them specifically about fieldwork and whether they thought fieldwork was a key component of a new MSc programme that I was proposing and we've written into that as a core component is an overseas residential field trip AC: Ah okay JK: So I think 80% recognised that that was you know a good selling point and they recognised that fieldwork was very valuable, but 20 25 percent of them responded with "*You know what? Yeah, it's nice, but I don't actually think it’s absolutely crucial.*" AC: Ah okay JK: So there is mixed opinions and certainly some students find fieldwork they get quite anxious about the unfamiliarity of going out in the field certainly if it involves residential or overseas that there was a bit of nervousness about that some students certainly don't like that, so it isn't for everybody, but I think the vast majority of students both recognise the importance of it and both fully enjoy... AC: Being out there JK: Yeah and when we survey students, or we look at the comments that students say in module evaluation surveys or in the National Student Survey they single out fieldwork as being the highlight experience, so we know that it's popular and that students appreciate the value of it as well AC: That's brilliant JK: It's not 100% across the board

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5	6:16.8 - 9:26.9	AC: So those students who are nervous or anxious or reluctant to go on fieldwork how do you guys get around that? JK: Yeah so we generally take the approach that we will support and encourage and mitigate that anxiety so in extreme cases we've allowed a student to not go on a field trip AC: Ah okay JK: And provided them with an alternative field trip assessment which was as close to going to Spain as an experience as you could get [Laughs] AC: Yeah [Laughs] JK: But essentially they did similar fieldwork tasks in you know in local locations which replicated the kind of practical techniques that they were doing and observations they were using but in a completely different landscape and context so yeah we would not you know some students have got such severe anxiety that they don't want to go on field trips so we'll give them an alternative otherwise we would give them their own room or ensure they can share with somebody they're close to or happy to share with you know those sorts of things AC: Yeah JK: Occasionally students have gone on a field trip and a few days in realised they're not enjoying it, so we've allowed them to go home, so we try and support and provide some sort of pastoral care so we're not forcing somebody to have a desperately unpleasant time but there are students who are unable to access fieldwork at times, and we recognise that and try to work around that when that happens AC: So for that, you start using digital computer based stuff or? JK: Yeah well we don't actually well we have had we did have a virtual field trip which was developed by I think initially by two colleagues CS and TS I think developed the first iteration of it AC: Is that the virtual alps one? JK: No that was the second one I think the first one was Ingleton AC: Ah the waterfalls trail? JK: Yeah and then we developed the Alps one and we developed that with AN and TS but neither of those two resources well we don't use either of those two resources any more but we you know I think we could and would use a virtual field trip resource if we had one available and some of the things we have got are physical models of landscapes to demonstrate things so you know we've got sort of a scaled down version of North Wales AC: Okay JK: It's got corries, and U shaped valleys and Glacier [????], so we can simulate how they've gone down that so we've sort of go a non-digital virtual trip [Laughs] AC: Yeah [Laughs] JK: So we do have some alternative illustrative resources that we can use to kind of mimic the sort of landscape in the field, but we don't have any digital resources that we're using at the moment

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6	9:26.8 - 10:04.6	AC: Ah okay so you mention there that the virtual field guides you would use them if you had one available JK: Yeah AC: So those Alps ones do they not exist anymore or? JK: Well we don't go to the Alps any more

AC: Ah so it's not relevant?
JK: We go to Iceland, and we've never had a situation whereby we've had a student who wanted to go to Iceland who couldn't go to Iceland, so they then go, and they see the glacier and the landscape for themselves so yeah there is no real need to use that you know resource really so that's the reason why I think we would use it otherwise

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7	10:04.6 - 11:10.1	AC: Brilliant in terms of fieldwork what would you say is the most important skill that a student gets out of going on fieldwork? JK: Yeah just being developing confidence and you know the ability...teamwork and confidence to be able to landed any landscape in the world and be able to to have the confidence to know what questions to ask and what sort of things to observe and measure to get an understanding of the landscape they're in basically it's those things really. Working collectively because no one ever works in the field on their own and certainly students never do and all the field trips they do it together, so group working skills are really important to develop in that non-confrontational sort of way informal kind of environment and yeah some problem-solving skills having the confidence to measure basic things to categorise where they are

	Timespan	Content
8	11:10.1 - 16:00.8	AC: Do you have any challenges as a staff member while on fieldwork? JK:...Yeah, many...I think one of the biggest challenges is actually managing student numbers AC: Ah okay JK: So you know for example we go to Spain in January with 65 students we've been with as many as 95 students AC: Right JK: And the challenge there is avoid it being a lecture outside where you drag around a massive group and talk to them they write it down and you get back on the coach because when you've got massive numbers you must somehow devise activities to get the group into smaller units because we the value of the field trip fieldwork is getting the students to do stuff and find stuff out for themselves and you can do that easily with 20 students and getting them into groups of 4 but it's difficult to do that with a large bunch of students because there is a limit in resources and equipment and stuff like that. I would say getting the students gainfully busy and doing stuff is a challenge and that's a challenge we haven't fixed yet perfectly we do try and make sure everything activity based at least to some extent ultimately they're becomes a bit of fatigue when you say sketch that again or count 50 of them stones over there and compare them to those 50 stones over there and they're like '*Oh we did that*' so you know it can get a little bit repetitive, and it can get difficult because of numbers. Sometimes it's difficult with just sort of the logistics of herding students around you know? AC: [Laughs] Like herding cats at times? JK: [Laughs] Yeah definitely a bit like that and the risk assessment sometimes can be...well not doing the risk assessment is not a problem but anytime something happens on a field trip, and seldom it does, but it's obviously an area in my position that I'm responsible for in leading field trips and planning them you want to take 50 students there and bring 50 students back with no incidents

AC: Of course
JK: But sometimes somebody does something that you just don't anticipate, and you know breaks an arm or whatever so there are some health and safety things that you need to negotiate even when you're not doing anything risky or inherently risky accidents happen, and I think that is a bit of an issue other issues I suppose is drinking...
AC:...Ah okay...
JK:...Is something I would say is often not a problem whatsoever every student we take is an adult, and we treat them as such and they're normally well behaved and respect each other and others but sometimes it cannot be so, and there are one or two individuals who are not like that, and that gets you know quite difficult in those circumstances especially when you're away from the University, and you're not in the same country it makes me quite nervous at times for those sorts of things...What was the question again?
AC: Any challenges that you have on fieldwork
JK: [Pause] I think that's it really I suppose with the numbers it's not just getting the students it's the staff so staff-student ratio's so if you have number of students on a overseas residential you're going to get them into smaller groups then you're going to have to get a suitable number of staff to get them to facilitate them, so there is a staffing resource issue as well I suppose as well which is a challenge

AC: Brilliant thank you so when you go...
JK:...Oh there is another challenge as well which is through circumstance really, but we'd like to have neutral gender representation of staffing on a field trio
AC: Ah okay
JK: In other words, the same number of male and female and that is a challenge because currently our staffing gender balance is not 50-50 so we tend to have you know 5 males on a field trip and 1 female because we've only got three in the entire geography team
AC: Ah okay
JK: So we end up taking a female technician or a female post-grad to try and even out and make sure, but that is a challenge that I don't think should be overlooked because I think gender balance and gender representation is important particularly our student cohort is predominantly female
AC: Okay yeah
JK: To the tune of 60-40 if not 75-35
AC: Wow okay
JK: Of female to males and staff is the opposite, so that is a challenge as well

	Timespan	Content
9	16:00.8 - 17:06.3	AC: Brilliant thank you just to clarify the overseas field trips are they compulsory or optional? JK: The second-year Spain trip is compulsory AC: Yep JK: The third-year trips to Iceland and Greece are optional AC: Do the students pay for them? JK: They pay a contribution at third year AC: A contribution JK: So the second year trip we book the flights we pay for them and book the hotel and pay for it book the coach and pay for it so and we put them on break...so we put them on half board we give them breakfast and a packed lunch to take out every day but they need to get their evening sustenance at their own

cost.
AC: Ah okay
JK: Third years get their own flights, and they pay us a contribution to book the necessary hotels, and we pay for the in-country transport, so the coach the ferry to get us from Crete to Santorini the University pays for that. So we pay for the in-country expenses, and the students pay for their travel to get to and from the location, and they pay for their food
AC: Brilliant
JK: So it's partially subsidised
AC: That's brilliant thank you very much

	Timespan	Content
10	17:06.2 - 21:36.4	AC: Okay so we'll move on now to mobile technology in fieldwork do you use mobile technology in your fieldwork at all? JK: Depends what you count as mobile technology so we use handheld GPS which may or may not be counted as mobile technology well I guess its technology that is mobile AC: That is true! JK: We use standard Garmin Etrex ones which just give you a waypoint or whatever and we don't use it for anything more sophisticated than that, but we also use oh god...Juno...Trimbles! Yeah Junos which are again handheld sort of odd mobile GPS devices but they interface with ArcPad, and you can actually bring up a map and expand it and bring up your location on the map as well as plotting your coordinates and all the rest of it AC: I see JK: You can then download that stuff very easily into Arc GIS and whatever you've surveyed or plotted into the field is straight there. So we use those...we use…what else...Laser rangefinders well they're sort of not digital I suppose well laser range finders are a digital mobile device that enables you to do basic surveying and angles and that sort of thing looking at slopes and river cross sections long profiles and that sort of thing using those sorts of instruments we have got some tablets that we use them for...I can't think of any examples of how we use them in physical geography fieldwork, but we do in Human geography fieldwork AC: Right JK: They use them in qualitative kind of analysis of survey...yeah...questionnaire type surveying although there is an issue in terms of we don't often send students out to do that because of the ethical and the need for ethical approval to do that makes it logistically problematic to get students a lot of students on a field trip to go ask questions we don't do that because we'd need to go through university ethics AC: Right okay JK: But we do get them to use tablets to note down observational information from an urban environment AC: So like a digital notebook? JK: Yeah a digital notebook yeah so building type building age sustainability indicators tourism that kind of stuff so yeah a digital notebook essentially we have used it on field trips as part of surveying on green infrastructure and going on parts of going to places where there is no green infrastructure showing a digital image of that same place with trees and things put onto that image and

asking people or interviewing people who we've had approval from to do so and asking them if they think it adds value to the area, so we've used tablets and iPads on qualitative human geography fieldwork
AC: Brilliant
JK: We have demonstrated…we will probably come onto that in a minute, but we have demonstrated the use of a drone on fieldwork this year
AC: Ah okay
JK: But literally that was a qualified staff member essentially saying this is what we can do with this really it's not fully integrated into the student activity, but it's still you know used to showcase the different types of technologies, so I think in terms of digital mobile technology that's what we're using...I suppose another thing to say is that we have had a discussion of whether we should bother to take GPS to Spain in January because essentially anyone can get coordinates from a mobile phone and when you're in Europe you can access your own data so we thought why don't we just use our mobiles so that's what we're going to use in Spain we'll take some GPS' as well, and we'll just say to students look wherever you are just geolocation yourself and note that down and if you want to use your phone to do that that's perfectly fine

	Timespan	Content
11	21:36.4 - 22:10.1	AC: Do you think students will have any issues with that at all? JK: Well if they do we'll give them a GPS at the moment I don't think they necessarily would if they did they would be more than happy to just use a GPS so there is that option really it's probably going to be better because we never have enough GPS' for the students and you know 1 GPS per student group and they're shouting out the coordinates and sharing the coordinates but if they all have it on their phone then they can write it down themselves so it would make life easier for them I suppose they shouldn't have too many issues but if they did it wouldn't be a problem

	Timespan	Content
12	22:10.1 - 26:42.4	AC: This next question now is potentially a difficult one to answer as there can be many different answers to it, so it's what are or do you have key concepts or fundamental principles that students have to know in your discipline before they leave in final year? JK: Okay so they need to have demonstrable professional standard all the general professional graduate skills like writing academic writing report writing in a proper report structure they need to do professional standard presentation skills individually in pairs and groups and different styles of presentations informal presentations in the field we get them to do that regularly so that they're confident about speaking about things as much as they are about writing about things we are fastidious about getting some excel capability so that they're not scared of spreadsheets and the ability to manage reasonable large datasets within excel so getting them to develop a formula to be able to do stuff as you know they come to us saying I can use a spreadsheet but what they actually do is write something into a cell and they don't get that you can actually manipulate it a thousand times and we do basic numeracy and quantitative data analysis using excel regression basic colouration causation statistics, so a little bit of quantities analysis capability is important. Some of the softer skills group working team working those sorts of things we do that via fieldwork practical's tutorials that's

really important that they get that. GIS skills are really probably top of the list actually!
AC: Ah okay yeah
JK: So their geospatial skills are utterly crucial we find that students get the best jobs and the most common jobs that students go into besides from like teaching and stuff which is still very common using GIS and GIS skills is you know has such wide applications that getting them into GIS understanding the basics and being able to use GIS to analyse data to use it as a visual tool to use it as an analytical tool. So we teach them that sequentially through the years so to quite an advanced level in the third year where they interface the GIS with the models hydrological modelling and they're mapping flood risk on GIS that they've modelled through a separate package
AC: Ah okay
JK: So developing sort of technical skills that have got real-world applications and I guess last thing is practical skills so giving them those opportunities to solve problems to develop those hands-on doing stuff skills so that they don't graduate as kind of monotonic robots that have got graduate skills the same as everyone else that they've actually been out and...
AC:...Applied it...
JK:...Applied it yeah so it might be surveying skills, so you know students being able to unravel a tape measure and do stuff in a geographical context isn't necessarily what an employer wants but just having someone with some common sense the ability to be able to think before they act and the ability to think before they act to plan and design and execute and do something which is methodical and they've thought about and that sort of skill is what you get by doing fieldwork and doing practical work and that's I think is also really important element of what we try and educate students in so we are trying to get this kind of rounded really profile of skills which aren't just your normal graduate skills those are very important of course, and I think that's one of the competitive advantages that geography has over other disciplines
AC: I agree
JK: Students have the opportunities to evidence that they've got this set of broader skills that they've got from just being on their course, and the fact that they're in our course is not an accident they're here on purpose because they're valued and they recognise they're important

	Timespan	Content
13	26:42.3 - 29:37.3	AC: Brilliant thank you, so we'll move onto UAVs now so you touched on it briefly before about a member of staff using it so what is your experience of UAVs do you have any yourself? JK: Okay so we bought a drone last year and received it probably this time last year and it sat in a box because nobody could fly it legally we then trained a number of academics and technical staff over the summer and did their written tests and then the pilot's license so now they have CAA approval so they can now fly you know now essentially unaccompanied or whatever legally or with somebody of course, but we have still not yet embedded that fully within the curriculum there was a plan...we did take a drone on a field trip about a month ago… AC: Ah right okay JK: …Just to demonstrate to students its utility and what you can get from above, and they were working on the ground, but there was an opportunity to

show what the drone could do so we've done that as a sort of demonstration exercise the plan is to take the drone to Iceland in May
AC: Ah okay yeah
JK: So one colleague who has the licence goes leads the Iceland field trip so the plan is to fly the drone across some open glaciated Icelandic landscapes and use that to capture data that students can use in projects or you know have some fun with the data. We plan to begin to implement that into the curriculum but at the moment its very embryonic
AC: Right
JK: Simply because we've only just become qualified, and we only have one drone, and we're looking to find opportunities to go and do it within our modules and that's going to take some time to bed in and we've also got some new academic members of staff who are due to start next early year who have some drone flying skills and remote sensing capabilities as well. An aspect of it as well is drones are wonderful but unless you are quite good at remote sensing and GIS then the data other than the wonderful aerial photography if you actually want it to do anything analytical or process the data in other ways you need to have some quite good geospatial skills in remote sensing so I haven't got that so I might be able to fly a drone and take wonderful photos but I'd be pretty stuck with being able to do anything more productive with it but we've got a number of academic colleagues who can do that and new ones who can do that, and I think that's when it will become more embedded within the curriculum

14 29:37.2 - 33:04.6 AC: Brilliant in terms of data then that you want the students to have fun with what data are we talking about? Is it videos photos or as you mention there the whole remote sensing element the GIS aspect?
JK: Yeah well I suppose all of the above really initially we'll use photographs so photogrammetry basically
AC: Okay
JK: And using the you know photos to import into GIS and overlay attributes and things like that ultimately we have colleagues who are working with interdisciplinary projects across the university and I'd actually like to see the development of sensors that we could use on drones to develop their capability so not just photographs and videos but things that are a bit more potentially powerful like LIDAR and working on the development of other sensors that can sniff carbon dioxide or air quality and those sorts of things and I think there is potential but at the moment its simply taking photos and videos etc.

AC: So what do you think then having that extra data when you go to Iceland...what's the reasoning behind that is it so that the students can get a different viewpoint is it because you can get data from something you just can't usually get?
JK: I just think studying landscapes is really hard when you're stood in it because the landscape is massive and you can't see a lot of the morphology features because they are such a big scale because you can see their form and shape and morphology more easily from above than you can on the ground, and you can take a map into the field and you can you know all the rest of it and you can get it static and I think maybe it's out of date and I think that a drone has the potential to utterly transform the way in which you teach and understand a landscape and how it functions and how its shaped because you can get such

amazing visual impression of it from a drone.

AC: Thank you that's brilliant so in terms of having that experience are you planning on using that before they go on the field trip or maybe after or during? JK: Potentially both because if we…a lot of what students do in third year is little projects so it's very difficult to plan a project in a location you've never been to and I think if you have some drone video or footage that you can show students this is what this valley looks like and they can think about where they might sample what they might do through a glimpse of what that place is like from the drone footage from a previous year so you can use it for planning and even if you can't use it in planning for that sense you can still use it for planning because you can fly the drone and have a look over there without having to go over there and you can use it to work out what you're going to sample what your strategy is going to be for mapping, so I think it's a tremendous tool for that it helps with the planning of what sort of project work you're going to do in the field because you can get to see stuff so much more easily from above than you can on the ground.

	Timespan	Content
15	33:04.6 - 35:55.3	AC: Thank you very much do you think you'll have any challenges with using the UAV, so you mentioned about the regulation and how you only have one is there any concerns? JK: Yeah so the challenges are still only a small number of people are qualified to fly it weather restriction is an issue particularly going to Iceland you can get days were we can't even get off the ground overseas countries some of them are unregulated but a lot of places are quickly becoming regulated, and that's inconsistent across international borders so you can't just assume that you can go to South Africa and fly a drone because I don't know whether you can, but you need to check all of that sort of stuff, so there is certainly tighter and tighter legislative requirements that you know could potentially be a hindrance and I suppose ultimately the students unless they're postgraduates the undergraduates we're a long, long way away from undergraduate students being able to fly the drone AC: Of course yeah yeah JK: Because of the implications of things going a bit wrong and that sort of stuff and we haven't got enough anyway so again it's going to be a bit like the lecturer flies the drone and the students will watch and it might be quite exciting for five minutes or so but then you know what I mean they're not really doing it, but they're getting the data AC: So it's more not so much the UAVs it's what you get from the UAV that's the important part for them? JK: Yeah yeah that's it exactly and that's valuable and I think that students might to actually want to get more into the drone flying part of it and that's something we can't really facilitate but it is something we're doing on the postgraduate programmes, but we're talking about undergraduates really aren't we? AC: We are yeah JK: Any other issues with drones...Yeah not many of them not many staff can fly them, and students can't fly it weather and legislation. I suppose the other thing as well is I still get a little bit nervous if some idiot flies one of these into an aeroplane all of a sudden its band. All drone flying is band! AC: [Laughs] Yeah JK: You cannot fly it and I'm thinking I'm a bit reluctant to go whole scale we're

going to do this everywhere because if something catastrophically unfortunately but I hope it doesn't happen but if it does the consequence will be grounded until further notice and that could be quite a big risk in terms of if we've got stuff assessments or promise students things and all of a sudden we can't deliver it so at the moment we're dipping our toe into it and using it in a non-essential way we're using it as an added value rather than be all and end all of if you don't do that it's not going to work.
AC: No yeah I've had the exact same concerns because that would be my PhD done! [Laughs]
JK: [Laughs]
AC: So yeah that would be terrifying for me!
JK: [Laughs] yeah your last chapter would be a bit short wouldn't it!

	Timespan	Content
16	35:55.2 - 41:37.3	AC: It would yeah! So we'll just finish up with UAVs now, and I'm going to load up one of the models I created from the UAV this was up in Thurstaston the cliffs up that way, and TS takes his students out there to do some glacial stuff JK: Yeah I know that place well! AC: Brilliant so he just said I want you to see if you can make a model of the cliffs and I'll show you that once it loads but the UAV there you mention they've done all their licence and stuff do they operate under LJMU ops manual yeah? Rather than their own? JK: Yeah AC: That's good to know have you flown one yourself? JK: Yeah...my son has a toy drone he's ten we buzz that around the garden, so I've sort of flown that I've never flown ours but I was with a friend on the weekend who has a phantom, and he flew it in somebodies back garden, and I held the controls and went up and down a bit, and that's the limit of it really AC: Would you like to at all? JK: I would like to get stuck in...do you have a licence? AC: I do yeah JK: Did you have that as part of your PhD training then or have it anyway? AC: No I got it as part of the training, so they paid for my licensing, but they didn't pay for the drone, so I had to go buy the drone, but they said we'll pay for your licence, so we looked at flying under LJMU ops manual, and we found it quite restrictive JK: Oh god yeah tell me about it! I think it's in the process of being kind of updated its now in the hands of the health and safety unit it's not engineering as they used to hold it it was DB wasn't it and his team it's not that anymore so yeah it is very restrictive actually but it's now not in the hands of an academic it's in the hands of a team which is how it should be really, so it is being updated, but no we're conforming to that at the moment and adhering to everything else really AC: Yeah so we looked at it and found it like yourself too restrictive for what we wanted to do so especially for me because I was training they wanted to book the drone out and use the simulators and stuff, and I bought the drone in February and my exam was in May so to work under their ops manual was just it wouldn't have happened we just didn't have the time, so in the end we said right well I'll fly under my own ops manual which is less restrictive but still conforms to all of the regulations

JK: One thing I was going to say having given it some thought is one of the other advantages of it that I didn't mention was that you can use it to observe places that you can't get to so like in Iceland you can use it to fly over Glaciers where students ain't going to go or terrain they can't access that might be of interest, and from my point of view I take students to coastlines and beaches and you never go into the inter-tidal zone very far because there is an obvious danger sometimes, and it’s difficult to access, but you can look at flying a drone over that no problem, so I think that’s one of the advantages, is you can get data from locations that otherwise you wouldn’t be able to access it provides that capability
AC: Any plans to use it for your coastal?
JK: Yeah I’ve had a few project proposals looking at it using a drone to look a repeat surveys of high resolution coastal morphological change and looking at pre-post storm change and particularly looking at the impact of intertidalology so where there is important archaeology in the intertidal zone that’s at risk from coastal erosion and sea level rise using a drone to map and repeat map and characterise what are the coastal process that are most detrimental in the preservation of those archaeological features so at the moment I haven't got the ops manual off the ground but that’s the kind of thing I would like to use it for yeah.

AC: Sorry about this my internet isn't working we'll see how far we can get without this is...sorry can I move that?
JK: Yeah sorry I’ll remove my cacti!
AC: Brilliant thank you so this is Thurstaston Cliffs
JK: Looks familiar!
AC: So this was all taken from the drone, and the idea is potentially from this is similar to what you mentioned before in terms of giving a different viewpoint that you can't access
JK: You can't get there...that's excellent

	Timespan	Content
17	41:37.3 - 43:22.2	AC: So it’s generally what's your thoughts and feelings about that is the quality something that is useful would you like more resolution? JK: Is that as close in as you can get? AC: I can get closer in you do lose a little bit of resolution though it is easier with a mouse with a trackpad it’s not as good that is as probably as close in as I can get JK: Oh that's good...can you go down to see where the gravel layers can you see the individual clasts quite well in that section? AC: Yeah JK: Okay so zoom in AC: Around here yeah? Okay JK: Oh yeah yeah that's pretty good yeah AC: So when we mapped this the conditions were not perfect there was quite a bit of wind so I reckon if I was to do this again I could probably... JK: Get it sharper? AC: Yeah a better resolution and obviously the images we've got the stills are much clearer

JK: But you can still tell though that that is limestone I know that's limestone, and I know that the cliff is a general red colour because it's from sandstone and you can still see that's non local material within that section so although it is a bit fuzzy some of the important things you can see it's a big clast

AC: Do you think students would pick that up at all?
JK: I think they would they probably wouldn't know its limestone I'd have to tell them that but its grey compared to the rest of the colouration of the rock...What about scale how do you get a scale on it?
AC: Well that's the thing
JK: You'd have to put one it?
AC: Yeah we'd have to put one in

	Timespan	Content
18	43:22.2 - 45:02.3	AC: So you mention there about you'd have to tell the students, so one of the things you can do is on this you can put annotations in so they can click on it, and that can stay up, and you can move it around of course one of the issues we have with this model is because its cut under you've got those little black bits JK: The shadow zones AC: That the software has not quite got, but I reckon JK: Oh I see that bit there yeah AC: Yeah it's not quite matched it, but I reckon if I went again with a normal camera and took detailed images of the underneath and I could stitch them in so you could potentially get that better, and one of the main things is you can use these links here to go onto extra resources JK: Oh yeah that looks pretty good AC: So and stuff like that do you think this would be beneficial to you and your teaching from using the drone? JK: Yeah definitely yeah I think in a paparitary lecture when we teach students about you know cliff erosion or glacial landform you could use that really nicely as a resource and then take them out to see stuff or do stuff in the field so that they're familiar with what they're going to get when they get there which they can get straight into the job at hand which might be well when we go down here we get them to sketch and all the rest of it but what we really want them to do with it is some clast fabric analysis on the till and they could plan where they want to do it before they go out we could show them some of the key features before they go out to show...I could use that for coastal erosion completely ignoring the fact it's of glacial origin it doesn't matter so I think we can use that quite nicely yeah.

	Timespan	Content
19	45:02.3 - 47:38.2	AC: So I know you guys are going to use the drone in Iceland has this ever occurred to you guy to do any of this 3D modelling at all from the drone? JK: No well it has occurred to us but we haven't done any of it for time and like I said we've only just started to get people licenced from August, so it's still quite early days for us, but that is the kind of thing that would be great if we do that AC: Ah that's good to know so this was the combination of two software's Drone Deploy, so I used that for the mapping of that and then I used Agisoft Photoscan JK: Agisoft yeah we're using a mixture of Pix4D and Agisoft, but I don't...there

was a problem with Agisoft there wasn't an institutional licence for it
AC: Yeah there is one apparently but it's only for four LAN computers, so I'm going to have to...
JK: Do you have your own licence or shared version of it?
AC: I downloaded the free version which was only 30 days to create this I have to go and buy a standalone one which is a bit of a shame
JK: Yeah that is a bit of an issue at the moment for us AC: DroneDeploy that costs me £80 a month but Agisoft is very hands-on whereas DroneDeploy you just give it to them and that software and it's all done externally but for the model, it's not as clear as Agisoft, and you can't put in annotations and stuff

JK: Is that interactive? Is there data behind that that you can like work out slope angles and gradients and volumes
AC: Not on that one but on the DroneDeploy software yes you can do because on the DroneDeploy software you can do digital elevation models and you can do slope profiles and they're not perfect because you get the slope profile and you can use your mouse along that, and it will give you heights and stuff, but it would be great if you could export that into Excel to get a graph. One of the benefits of DroneDeploy is someone pays the £80, and you give the link, and then students can access the PDFs from it, so we're hoping that that model they go there in March I think so I'm hoping to integrate that into their lessons around March time to just see what is the benefit of having that model does it work on DroneDeploy or not so we're hoping summertime next year we'll have a good idea of how students feel about using these models with students
JK: Which students?
AC: The outdoor Ed ones only because I have easy access to them.

	Timespan	Content
20	48:34.8 - 52:38.0	AC: I took the drone up to Ingleton yesterday to do a bit of mapping but with the contrast in the snow it wasn't having any of it so in the end, I decided to do a bit of flying but it was very cold, so it took ages to get the temps up to speed on the batteries...right I've found it...drone lecture here we go this one definitely has some images of what you get on the drone deploy software. So this is one of the stills JK: That's just the still yeah? AC: Yeah that's the still this is your 2D map...here we go measurements...so yeah you can get the profile so if you move your mouse along there it gives you the different heights, but again it's good to look at but what students can physically get from that is I'm not entirely sure JK: Well I think they could! They could get some profile shape that one is nicely concave other places might not be like that you can look at longshore variability and beach slope and shape AC: Okay so you think they would yeah? JK: Oh yeah definitely AC: See here they can add comments so you can areas volume and add location so when they do that they get a co-ordinate and they can add an annotation and then export that as a PDF JK: No the best value will be to have that one year then another year then another year and you've got three great...you can see how it changes over time

and throughout the year so no that's good there are a lot of things you can do with that
AC: For us there is an error rate of plus or minus 3% or 3 metres something like that but if you add ground control points that comes right down to a couple of centimetres so I didn't have access to a differential GPS to do the ground control points but if you guys have that you can get that down to like 2cm. I think using DroneDeploy using a Phantom 4 Pro which I've got you can get an error rate of 1cm which for a slope profile I think is
JK: It's very good
AC: Yeah

	Timespan	Content
21	52:38.0 - 54:28.1	AC: So yeah you can also do the elevation models so this is with different intensities so you can I kind of like it because you get to see the little channels that you don't get to quite see on the images and you can see the bits of rocks there...any benefit to that at all? JK: Yeah definitely you're looking at [????] morphology there that's really hard to capture otherwise AC: Again that is all done on the dronedeploy servers so you just upload it and you just don't touch it, and it comes back to you in a couple of hours, so that's them all really JK: You could even use that to investigate Stralers stream order AC: Ah okay JK: About how many tributaries how many first-order streams second order streams I know they're not streams but you know you could test Stralers theory so there is some philosophical things in geomorphology that you can use that for AC: Ah okay yeah JK: Especially if you treat that as a mini catchment yeah AC: And that was overall I think in terms of setting up getting the data the flight was maybe ten minutes, and then this comes back to you in four to six hours so you can get quite instant data so yeah that's me done really in terms of questions do you have any? JK: No not really there is an offer there if you ever want to try anything out on us and our students then just drop me a line!

LECTURER C: TRANSCRIPT

	Timespan	Content
1	0:00.0 - 0:33.8	AC: So can you tell me a bit about your opinion of fieldwork in general before we get down to fieldwork in your discipline SM: Well I think fieldwork is fab I think when you can get students to go out in the field and actually visualise the things they learn in the classroom I think it makes a significant difference and I think fieldwork, on the whole, allows students to express themselves much better be themselves a bit more so I think it’s a fab thing I think it's something that we need to be doing more of

	Timespan	Content
2	0:33.7 - 1:33.5	AC: Ah okay in terms of that that you want to do it more we'll come onto pressures a little bit later on but to talk about it there how come you can't do more? SM: I don't think it’s a case of can't do more but like every other thing there are limitations in terms of resources limitation in terms of time so that in itself presents challenges it’s about balance as well taking students out on fieldwork for an extended period of time that disrupts other modules if they are combined honours students so you can do that maybe twice a year and get away with it but beyond that other departments will start complaining students also work and trying to get time off that can be quite challenging as well so yeah a lot of them that's the constraints

	Timespan	Content
3	1:33.5 - 4:03.0	AC: Brilliant so in terms of fieldwork then what do you think are the key important aspects that students get out of being on fieldwork? SM: I think the first one is putting theory into practice that's the main thing things they learn in the classroom actually seeing it visualising it I think that makes a big difference I think the physical if I call it exercise getting out I think you see students become themselves a bit more and I think there is a social aspect of fieldwork both between students as well as student staff and I think in terms of improving student experience I think fieldwork makes a significant difference AC: Is that from your own personal experience or is that something that you get from students? SM: I think it’s a combination from my personal experience and what I get from the students also general feedback you know if you ask a final year student when they're graduating you know what made them want to stay for example in [university name], or Geography at [university name], and they say Slapton which is a first-year residential fieldwork experience or Snowdon and I think that is when it sort of gives them that sort of identity to be able to meet their peers a bit more and meet staff and realise that staff are human as well you know [laughs] AC: [Laughs] Yeah. So you think residential fieldwork, in particular, has got quite an importance to the student then? SM: I think it has significant value to the student especially in terms of the student experience in terms of identity in terms of commitment to the department I think it makes a big difference if it's managed properly that is AC: Speaking to AM I believe you guys go down to Betwsy Coed now and

Snowdon it sounds nice
SM: Yeah it's a nice little field trip it's a much shorter one than Slapton, but the flip side is you don't spend a day travelling down and back which has a few negative consequences so yeah it's a good field trip

	Timespan	Content
4	4:02.9 - 5:02.8	AC: Excellent so can I ask in general what sort of field trips do you do in your discipline? SM: Well it's a range between residential one day field trip to a couple hour field trips residential for example the final years go to Naples to look at Volcanic hazards and that's international overseas to UK based which is Snowdon currently to one day, for example, looking at flood management strategies in Wales somewhere to a couple of hours where you're taking students out with a drone or a GPS mapping unit around campus or around [university name], to going to the VR the virtual reality centre. AC: Oh you have one of them? SM: Well it's just on the roundabout of Northgate street it takes different forms AC: Oh very nice. So if we look at the UK based ones, for now, are they all compulsory and are they all paid for? SM: Yes the residential ones are the one days ones are compulsory and linked to assignments the shorter ones are more to enhance the theory of the class such as GPS mapping AC: So the practical hands-on skills? SM: Yeah the practical skill AC: So for your Naples one is that an optional one or is that compulsory as well? SM: That's compulsory well it's a core I won't use the term compulsory its core to the module and as such it paid for by the department, and therefore we expect all students to attend AC: Ah okay so it doesn't really cost them anything? SM: It costs them nothing to attend yeah AC: So they just bring their own spends? SM: Yeah just whatever they want to spend it on usually booze [laughs] AC: [Laughs] SM: But yeah the fare the accommodation breakfast and dinner they'll have to pay for lunch, but yes it's all free of cost to them

	Timespan	Content
5	6:11.4 - 8:57.6	AC: Very nice! Moving on now to some of the barriers and the pressures on fieldwork so we'll talk about students first and then move onto the practitioner side so can you think of any pressures or barriers that students face on fieldwork? SM: On fieldwork I think there is a barrier in terms of time for some students and I think taking them out for a week there are challenges there both in terms of if they're combined honours programs even within single honours itself and how that impacts other modules so I think there are challenges there I think there are challenges in terms of work there are challenges for students who have never been away from home and try to reassure those students can be challenging at times. Every year I have a student who's never flown your friend was one of them [Laughs]

AC: [Laughs] yeah she was
SM: And that takes a lot of reassuring. There are disability issues which increasingly I'm seeing a lot more of now with more students with some form of disability
AC: Is that physical or...
SM:...both physical mental disabilities and that in itself in terms of preparation and ensuring students that's challenging in terms of the legal requirements that's challenging and that takes a bit more time to get the paperwork going through getting there is challenging because you've got to take extra resources and an extra member of staff to deal with that and especially for the international one there is that unsuraity you don't know if it break down on top of mount Vesuvius how...
AC:...How you get out...
SM:...How you get out yeah out of the situation I mean we plan for it but it's always a barrier in terms of language and you know you're not going to get the same response times as you'd get in the UK and there is always the worry that they don't get the right medication or treatment and that's {???} for the university and you know [university name], might be a little bit more risk averse than some Universities and as such if something goes wrong you do worry are they going to pull the field trip
AC: Ah yeah okay
SM: So there is that always playing in the back of your mind there is always that. On the field trip itself once you get going its fine but you know you just deal with some of those
AC: When it happens yeah
SM: Yeah and there are incidences where there are disciplinary issues I've never had those...
AC:...Ah good okay...
SM: So that needs careful management before you go out there with a few subtle threats writing student agreements student staff agreements and that sort of stuff and its worked so far

	Timespan	Content
6	8:57.6 - 11:59.7	AC: Okay so you mentioned there a student agreement is that something that they sign? SM: Yeah they sign before...a code of behaviour before they go we talk about consequences for misbehaving and I think fortunately I haven't had anything serious so... AC: Well that's good! SM: So yeah fingers crossed I mean you do worry about students drinking or getting drunk and what will happen but I think so far it's been fine. AC: Sweet that's good. So you mentioned there, and we'll come back to it there about disability in terms of student worries about going away and the disability aspect what do the department do then to try and reassure them? What have you got in place? SM: I think in terms of well first of all its finding out what those difficulties are it's about bringing the student in asking how can we help them and giving them the option of yes it's a core module, but if you decide not to come we can give you a comparable experience, so you give them that option. We do ask for example can you get a letter from your Doctor that you're fine to travel what is required we also let students know that it's their responsibility to take whatever medication

that they require and it's their duty to inform us and communicate with us what if they're not feeling well don't suffer in silence if they're dizzy communicate with us is essential, so that's the sort of preparation basically doing a risk assessment for the student.

AC: For that one person that's great do you find those students feel included because I know in some literature people especially in Geoscience as you say is very active physical disabilities can feel excluded. Do you think by doing that and offering alternatives that they feel more included?
SM: Yeah I think so far I've always offered them the alternative of not coming and they've all gone away thought about it and come back and said I want to go, but I think that you've given them the choice and the reassurance that if you're not able to make it there is an alternative I think that's the first step and that does help tremendously. My usual line when I go on a field trip with a student with a disability is 'look at my size! I'm the one who's going to be struggling at the back anyway! So you won't be holding up the group you'll be with me' [Laughs] So that's fine I think that reassures them we do take extra members of staff if they do need a bit of help we've got students for an hour or two hours who can't move but you know we've got a member of staff to stay with them and you know gently walk with them or back to the bus that sort of things so so far that has worked but it takes a lot of planning and reassurance and resources

	Timespan	Content
7	11:59.7 - 14:31.7	AC: Brilliant thank you, so we'll move onto mobile technologies in fieldwork so can you tell me about any mobile technologies that you use in your fieldwork? SM: Well it takes different forms from like I said, for example, the activity days you know it might be GPS mobile mapping drones that works to things more like wearable devices so collecting information using your spyglass that works to the iPads, so it does take a range of different things to 3D camera we're trying that a bit more and that sort of stuff AC: So quite a lot of new technologies in there I see SM: Yeah I like to try new things, and they don't necessarily work, but you try these things [laughs] AC: [Laughs] No that sounds really good what are the benefits to you then for trying these new technologies in your fieldwork? SM: I think there are a number of benefits I think one is engagement I think sometimes students just having a laugh trying new things I think my colleague Derek talks about Digital Natives and I don't know if that term is still applicable, but youngsters like their gadgets like I say their phone is an extension to their hands so if it is like that why not use it? So I think they engage well with it it can be a distraction of that there is no doubt it can be a distraction and again that takes careful planning if it's a 10 minute task it's a 10 minute task and it's not just using it you're going to want some feedback at the end you know how did you find using it was it useful what's the limitations so so far that has worked but also the fact that you know especially final year students when you say to them you're going out into the workplace, and people expect you to be innovative and people expect you to be coming in with new knowledge so I'm not saying this is going to answer the question you've got there but you try it, and you can suggest something that when you get to the workplace it might be so advanced now that you can say well actually I did try that, but it didn't work that way but now that its improved you could use it this way

AC: So it's an employability aspect then too?
SM: yeah it's employability it's a new skill its engagement it's also seeing things from a different perspective so you put a drone up as an example of a cliff and most times you see a cliff from you know straight on but if you see it from a different angle it makes a big difference

	Timespan	Content
8	14:36.0 - 16:29.5	AC: Brilliant In terms of challenges then you mentioned distraction as one can you think of any other challenges that you have with mobile tech in fieldwork? SM: Yeah well for those that work with Wi-Fi there is always a challenge there AC: Of course SM: Especially as we're often in areas without a WiFi connection I think there is challenges in terms of taking the equipment itself there are certain types of equipment you can't take overseas, or they're bulky so again that takes a bit...if you're flying on a budget airline overseas taking a thermal imaging camera does bring challenges there, there is worry about losing equipment there is that and limited resources in the department not enough when you go on , so you have to break them down in groups you got one drone or two drone or one thermal inferred camera so they are challenges there and I as I mentioned to you there is distraction and they can be over dependant on the technology AC: Oh okay SM: So you know yeah typed your results in a spreadsheet which works really well and students sometimes they need to take a bit of note as well they just think the technology is going to do everything without using your head to say actually what's the accuracy of the reading I'm putting in here so yeah it's a bit of a silo thinking AC: Yeah SM: Technology does everything, so I don't need to think AC: So it almost reduces the skill or the hands-on skill SM: Yeah but...it's more of a Critical thinking from time to time with the over-dependence on the technology to answer all their questions

	Timespan	Content
9	16:29.4 - 17:50.8	AC: Brilliant in terms of students using their own devices is that something that you encourage them to use is that something you see them using or is it mostly departmental owned stuff? SM: I think when we started I encouraged them to use it, but now I don't think they need any encouragement [laughs] AC: [Laughs] They just use it now yeah? SM: Like I say it's an extension of their arm and I do try to use it in different ways so in terms of one it's just simple taking pictures its using social media to tweet stuff its taking notes its interviewing to record so yeah I encourage them to use it the apps they've got in it even if it's just something like the compass app that sort of thing so I do encourage them to use it as much as possible and again distraction you have to manage these things, and at times I've had to say look guys just put it away now let's concentrate on what this person is saying, and it's just common etiquette and if you say that in a gentle way most will but there will be an odd one who still texts and stuff but yes AC: Do you find there is any resistance from students using their devices for

educational purposes at all?
SM: No...No.

	Timespan	Content
10	17:50.7 - 19:06.4	AC: Brilliant that's good to know so we'll move onto UAVs now then so do you have any experience with UAVs I believe you have some? SM: Yeah I've got a little [laughs] AC: Can you tell me a bit about that? SM: Well its probably now what we call a UAV I've probably been using for the past twenty years if you call a little helicopter with a camera attached to it AC: it is yeah! SM: Then yes it's a UAV but in terms of out of the box UAV probably three years now both in terms of teaching and of research AC: Ah okay so we'll talk about the research part first then, and then we'll move onto the teaching can you tell me about how you use it for research? SM: Well it's a range of things mostly monitoring coastal erosion and landslides that sort of thing but also looking at things like illegal quarry mining and a little on floodplain mapping land use change so mostly around that sort of area

	Timespan	Content
11	19:06.3 - 20:32.7	AC: And in your teaching? SM: Again it's giving students skills in terms of its use its applications so beyond the university its training practitioners for example in the Caribbean on how to use it how to process the data that sort of thing AC: Nice so do you use it for your students here? SM: Yeah AC: Do you get to fly it at all? SM: Yeah they all get to fly it for a minute AC: I bet that's scary! [laughs] SM: No it's not actually that scary! So the final year students go on the hockey pitch, and we fly that in that confined area and first-year students actually, the hazard students had a chance to use it in the field and fly it in the field AC: Oh wow okay SM: In Thurstaston so they have some flying skill in terms of that AC: Did they enjoy that then? SM: Absolutely loved it well there were some students a bit scared we don't want to break it or for it to fly off AC: of course yeah SM: But if you stand beside those who are willing and say do that then it's fine AC: So when they were at Thurstaston was that just a general flight or were you there to collect data with the drone as well? SM: Well no its just for them to visualise stuff and to understand what types of data they can get from it

	Timespan	Content
12	20:32.7 - 24:23.1	AC: So you mentioned before about UAVs on fieldwork giving a different perspective can you think of any other benefits for using UAVs on fieldwork for you and for students? SM: Well for students again its interactive it's another toy so to speak it is probably it's for me about improving accuracy in the data it's about the temporal resolution you can visit a place over and over its about accessibility there are

areas that you can't access so that gives you added value and the 3D visualisation that you can get out of that if you go back to teaching so research links to my teaching so the imagery that you get you can use that back in your teaching but also its stuff like open day trying to attract students
AC: Ah okay so like recruitment?
SM: Yeah
AC: So you think it's a quite positive thing then yeah?
SM: I think it's a positive thing yeah you know there are limitations and there are numerous limitations with UAVs from the physical one taking them out into the field in terms of limitation in terms of weather so if you plan an activity that's around UAVs and half of your activity is around that and it's raining or its cold then
AC: it's certainly a challenge
SM: Yeah it's a challenge there then there is the ethics and I find that even more challenging than anything else ethics in terms of monitoring yourself in terms of so okay you didn't need permission to go somewhere but are you intruding in somebodies privacy there is challenges in getting peoples permission to fly the drone there are lots of places which will not allow you to do it an example the former Duke before he died we wanted to monitor collapsed mining structure out in {???} mountain and I could have gone up there and flown it as it's in the middle of nowhere but trying to get permission they wouldn't have it
AC: What was their reasoning for that?
SM: They just said we don't think at this time we should be using drones to monitor collapse, so there are challenges of permission, and in Thurstaston I don't know if you tried to get permission there? [Laughs]
AC: It's an SSI I believe
SM: It is and I got permission and I flew there but it was a very drawn out process to get permission lots of paperwork with Natural England and we got permission but in the end that limits our flying time because the ideal time as to not intrude on the public would be early morning so in the summer 4 o'clock it's beautiful time however they came back and said no that's when the birds are feeding and taking off, so you have a chance of hitting them so can you fly in the middle of the day when the birds aren't flying about
AC: but then you've got people about
SM: Yeah you've got people so some of that can be quite challenging and then there are people who are not comfortable even when you do have permission, and they think this is a public space they will call the police so...
AC: it's a challenge all around isn't it really.

	Timespan	Content
13	24:23.0 - 24:54.8	AC: Do you have any concerns around the regulations at all? SM: No I think the regulations are there to protect people and to protect yourself so in a way I don't see regulation as a challenge I see it as you just have to work within the regulations there are limitations and there could be modifications to the regulations but I think like any other thing if you're driving your car down the street AC: You stick to the rule SM: Exactly you stick to the rules, and I think yeah it's as simple as that

	Timespan	Content
14	24:54.7 - 26:59.7	AC: Excellent. So we'll move onto the 3D model I will pull it up to jog your memory so from what you can remember before I load it up SM: Yeah I used it a couple of weeks back AC: What do you think of it? Good? Bad? SM: Yeah I think it's a good thing I think some of it it can be a bit difficult for some people to rotate and to navigate it AC: yeah it's not the easiest to navigate SM: Yeah it's not the easiest to navigate but I think beyond that it's a step in the right direction I think we do need a bit more of that I mentioned in terms of students disability in fieldwork I think something like this has the potential I've done a few 3D models and for consultants for engineers I think its brilliant in the old days I had a guy from network rail and I don't know if you heard about the landslide in Scotland a couple of weeks ago? AC: Yeah I saw some drone pictures of that going under the train SM: Yeah and yeah he had some drone imagery from there but he saw this he wasn't able to go up there but he had to stay in the office to look at the imagery and make that first assessment but having something like the 3D imagery would take it to another level in terms of risk communication in terms of for non-technical people to understand what is happening I think a 3D model makes a significant difference so yeah I think it has a lot of potential I think the other stuff to improve it is a little bit ambitious to do with it, but I think as it is it's a massive start for a teaching tool

	Timespan	Content
15	26:59.6 - 28:44.6	AC: In terms of teaching then as this is of Thurstaston cliffs so say when you take students out there would you use this before after or both? SM: I think it's a combi-you're probably talking both you probably wouldn't use it in the field or well it would be hard but then again you could get them to put it on their phones now that I think about it and that's an option but this is an instance where you don't want the technology to overrule being there I'd rather my student look at it and if they wanted to do a printout then when they go in the field they do all their measurements and when they come back they try to verify all their measurements in the model but yeah I think it has potential for all three during I would probably limit it during. On the flip side of that for practitioners having it in the field is critical because yes you might see a feature but zooming in and having a look around comparing it etc. AC: So you could use it as a discussion tool then? Having spoken to AM as it's a coastal environment, this was taken 6 months ago, and he was like I guarantee that would have changed if you went tomorrow so would you use that as a discussion tool to say that's the same or that's different? SM: Yeah I think if you're looking at change then yes if that's the focus of it

	Timespan	Content
16	28:44.5 - 29:22.7	AC: In terms of before then some students that I've interviewed said they'd like it before as it kind of familiarises themselves with the area so for you as a practitioner so if you were to do some studies on these cliffs would you use this as a tool to say this is where we're studying? SM: Yeah I think before you go out into the field trying to explain to students that's a gully that's avail that's an undercutting and you see imagery and allowing

them to almost touch it I think that makes a difference so yes pre-fieldwork I think it’s an invaluable tool

	Timespan	Content
17	29:22.7 - 29:44.2	AC: Post fieldwork, so you mentioned there about validating measurements and checking SM: yeah you can come back, and you can validate like any other thing you can come back in and check your measurements that you've got in the field and as a reminder, I think that’s useful

	Timespan	Content
18	29:44.1 - 32:09.2	AC: So having looked at this what would you want to be improved as a teaching tool? SM: Well the manipulation its self I think you've put some web links on there but I think if it’s possible if you let’s say your focus is on here and I know you can zoom in there it would be useful to have pop-ups so this is that area and if you click on that pop up it brings you only there, so you don't have to try to manage the other sections AC: Ah okay I see what you mean yeah SM: So that’s an area if you wanted to concentrate on and if you actually had something to annotate on as well so students can annotate things AC: So the students annotate yeah? SM: Yeah then they can actually print that out and take it into the field you know these are the stuff that I really want to look at out in the field and check I think that would be quite useful you can add pictures I am certain to this so you can click a certain picture of water coming out of a spring there that you saw one day if that pops out that would be useful, so it's good interacting in terms of moving around and some of the points there, but yeah I could do with some more interactivity AC: Yeah there is a way with the annotations with code that I’m trying to learn that you can add pictures and videos to that, so that’s certainly for a later model something we're going to try and revise and work on so when you do click on one of those points that it gives you that picture SM: But also the idea of playing around with as a tutor if you want to talk about something here you can actually put that video there and talk and point those things out so for the students who aren't coming on the field trip they're not missing out because it’s also there for them to see me talking about that part of the feature that’s just pushing it too far it’s just something I’m thinking about that I could use it for

	Timespan	Content
19	32:09.1 - 35:25.2	AC: Brilliant that's good to know so one more question that I forgot to ask before that was fieldwork skills so what are some of the fundamental fieldwork skills that you think students get when they're on fieldwork? SM: Well the big umbrella is the practical skills so from different equipment using different equipment understanding about scale understanding about different environments there is the communication side there is the social skills in our case there is presentation skills using the fieldwork as their canvas so to speak so yeah a range of practical communication and social presentational skills that they develop

AC: So one final question and that's around the use of UAVs and the output models and stuff to create this I had to collect still images and to create them you get 2D aerial surveys and your digital elevation models and stuff so in your teaching is that something that you'd bring in with the 3D model some supporting data, so you've got your photographs your elevation models all created from the drone?
SM: yeah one of the exercise the final year students in the past we didn't do it this year but the imagery we take of the campus we georeferenced it first and then they start to stitch the imagery together to create something that's 3D so the limitation is that with that is the software so we have Pix4D so there is a lot of challenges with Pix4D but trying to get enough seats for students cost wise is challenging for a small department like us that I can say take a trial version but our system won't allow us to download that trial version onto that machine well next year what I'll probably do is sign up for a trial version but just use the cloud to process the imagery just to see what it looks like again processing it in the cloud you can put GCP's in if you have them and yeah probably a year or two I'll develop a whole block just for that
AC: Yeah that would be useful
SM: I'm stepping away from GIS and remote sensing now with the new tutor will take over that's the hope so whether she would want me to do a block
AC: You never know!
SM: But beyond that with that new curriculum I'm developing there will be some of that
AC: Excellent that is me done thank you very much!

LECTURER D: TRANSCRIPT 1

	Timespan	Content
1	0:00.0 - 8:35.1	AC: Okie Dokie okay so a little icebreaker can you tell me how long you've been in education and how you got to the point you're at today? TS: Well yeah I suppose in education since I went to school I guess at 4! Because I haven't really left it I went to A levels and straight to a degree in environmental science at Aberwitth University I then, after three months in America I took up work in a college of FE on a manned power services commission scheme as an interpretative advisor, so there was a team of guys who were manual workers, and I was like an assistant to the boss if you like and myself and another college e similar like a graduate like myself and we developed trails and interpretive leaflets for people... AC: ...Oh okay… TS: …So they were putting up signs around this college farm in mid, and we were sort of taking photographs of plants and writing leaflets about the farm year, and the different sort of plants you can find and the sorts of trees probably produced about 20 leaflets over the year and erm it was always just going to be like a yearlong position... AC:...Okay… TS:...a 12-month post and that was interesting. During that time the chance to apply for a PhD came up in Scotland I applied and got that and went up there a PhD in fluvial Geomorphology forestry effects on sediment yields and dynamics in mountain streams was the title in the trosact/balquidda catchments. I finished that in three years and then I went to teach for the field studies council in as a geography tutor in [????] Pembroke and I there I was leading about 8 or 9 different field days... AC:...ah Okay… TS:...which largely was were okay a hydrology day, a well technology starts to come into this a bit as well... AC:...Mmmm… TS:...but hydrology day a rivers day river hydraulics sorts of day a coastal erosion day a cliff walk a coastal deposition day longshore drift sort of stuff a sand dunes day a soils day and then a village study and an urban land use study... AC...Okay, so plenty of different field trips within there...TS:...Yeah, we certainly did have a couple of computers in the field centre at the time Apple 2 E's you know the kind? AC: *Laughs* I do TS: So what we would do is we would collect the data that the students had used and one maybe I would type it onto this computer, and we would have some sort of analysis that we would give back to the students in the evening... AC...Right, I see... TS:...To do some, a bit more work on plot a graph that sort of thing. Yeah but that's probably as far there was no mobile technology really other than just taking photographs with normal probably not even digital cameras in those days well yeah wouldn't have been digital cameras because this was the early 90's y'know?... AC...Ha yeah? TS: Late 80's, sorry! I went to Bangor University PGCE in science and outdoor activities and taught in a secondary school in North Wales for about 10 weeks taught science and a bit of Geography. Then I did placements in outdoor centres in North Wales in an LEA centre and in Scotland and outward bounds in Lock

Eel. Then I got my first *proper job!*...
AC:...*Laughs*...
TS: teacher of geography in Barnett castle school, independent school...
AC: ...Ah okay...
TS: sites about 600 it was boys up to year 11 and then a mixed 6th form when I arrived but by time I left the whole school became more mixed but half were boarders, and I taught 11 classes Geography, and I ran the canoe club, the Duke of Edinburgh's gold award, the helped with the hockey club and I also ran towards the end the badminton club so I was like busy all the time...
AC:...Absolutely!...
TS: Yeah! Then in third year of there this position came up that I'm currently in now so 1993 I applied to this position which I'd never even heard of Liverpool John Moores University, I knew about Liverpool Polytechnic it had only been made a University in 1992 and my mother saw this job in physical geography and outdoor education she thought 'Oh that looks like the one' and I initially I didn't really fancy living in Liverpool but when I came here for the interview, and I saw y'know the...
AC:...The nice views...
TS:...the hills of mau vami and the river and I thought ah, and it's not in the city centre...
AC:...that's true...
TS...That was the other thing I think ah yeah I'll give this a go. So yeah that's 23 years ago! But within that time I've my job has changed a bit but not a lot really to start with it was teaching on a QTS qualified Teacher status programme a BSc with qualified teacher status with blocks of teacher practice all together they did 32 weeks of teaching practice 20 weeks or so in schools doing science and another 12 in outdoor centres. That went on for about 8 years, and I was a teaching practice, and I had to go and arrange placements and teach some educational stuff and as well as a not a great amount of some geography but yeah yeah there was some geography about half of it was geography but gradually as the programme more or less died out because we also had a PGCE in science a two-year B-ed in science we just couldn't get the placements that was the trouble.
AC...Yeah...
TS:...Eventually and thank goodness the school agreed to let us validate an ordinary BSc in Outdoor environmental education in 1998 and the and that came in as the old programme phased out so by 2001 we were just running a normal HEFCE funded undergraduate degree and that's been the case ever since...
AC...Uhumm Yeah...
TS: So yeah it was so and in that validation, I was able to teach more of my specialist subjects, so we had a module in glacial, fluvial and evolution of glacial and karst landscapes which had five lectures of my...
AC...That's your field yeah?
TS: ... Yeah and other modules in natural hazards and geomorphology and I used to run all the first year geography which used to be earth science weather atmospheres and yeah it has changed, and it started to be a module on earth since a module on atmospheric processes then it merged together dah dah dah and it's moved on but yeah so basically I'd say then most of my indoor teaching was physical geography related with a little bit of other stuff like recreational, ecological ecology, and then I would also have quite probably half of my teaching would be outdoors kayaking mountain leadership skiing winter mountaineering caving.

	Timespan	Content
2	8:35.1 - 15:57.4	AC: Would you class that as fieldwork or is that just because it's part of the course that it has to be outdoors? TS: Yeah well it's an interesting one yes yes of course as well as those there would be geographical field days which I think probably numbered about well 8 or 9 a year initially it's trimmed back a bit so we would have done a sand dunes day at Formby a well I bought in the date for Mau faumu but what did we do before that? Then we used to do trough of Bowland, five days in the Yorkshire Dales which was sorta' because we had such large groups... AC:...Was that a residential? TS: yeah 5 day residential and the students would do three days of caving and 2 days of fieldwork but because we had 40 odd students we ran 20 students on fieldwork while the other 20 went caving and we'd swap over, and we'd do the fieldwork again with the other half while they went caving, so it kept the number of the cavers down. So we would do the day that you joined us on something like that working on limestone pavements but also quite a range of things we'd go to Malham quarries we did Ordale escar, a number at one stage we had quite a few we split the students into about 8 groups each which would have a little project to do maybe it was impact of quarries maybe it was impacts of tourism in Malham maybe it was looking at ancient settlements in Grassington something to do with liken metric dating a project on that a variety of different thing that were available in that sorta' Yorkshire Dales area. Yeah I guess then round about mid 90's I started getting into the University were offering a course Open Learning and when I arrived I was under the illusion that and its and I don't know how I got it but I had to do lectures and in the first year I was up till 2 in the morning writing loads of information on acetate sheets and I'd turn up with reams of these acetate sheets all written and basically I'd be like you know gotta get all of this information in and look listen to all of this and here it is, and I would combine that with slides and the students were like pretty impressed when they saw slides it was quite a novelty! *Laughs...* AC...*Laughs* Right! TS: and erm I'd find I'd prepared all this stuff, and I'd find I'd get through about half of the stuff or maybe two thirds and I'd be rushing through all of it, and of course now I realise that 90 per cent of the stuff was probably going over the student's head. So this open learning course came up and it was basically just before electronics really why don't you just have a pack like the open university prepare a pack of information there is all the information the students need give that to them on the first day or every week whatever you want and take the pressure off yourself you don't have to teach them all that that's their job you can do activities and make it interesting and this started with me in the mid 90's probably more like to be honest 97/98 I think 97 would have been the key year because I remember 98 was the year my first PhD student came in and went 'Have you seen this thing the internet? I can check look at this' he said ' I can, I'm going to make a fridge I'm going to make a smoker for smoked salmon' and he said ' look type it in here and it comes up and shows it here, and Whoa that's amazing! Email had been around a bit before the internet came here anyway 98 internet, and then I started doing, and I must have been to a couple of seminars, and there was a guy in the law school, and another guy who still works here called BM were pushing ahead with putting files on the internet... AC...Ah, I see...

TS: and we were using PowerPoint and using word, so I started building some websites literally with here's all the files y'know? Nothing much else just some information and because the university hadn't embraced this until 2001 because I was in this group with JL, BM, myself and a couple of others who were like the group who were pushing e-learning it was called back then and they asked us to sit on a university E-learning group and they spent a few months with a guy called PM chairing it evaluating three VLE's Web CT, Blackboard and a home developed one that the computer science a lady in computer science department had built and reckoned would do the job, and they evaluated these three and eventually decided to go with blackboard 2001 and they've been with that until this year
AC: Yeah it's canvas now isn't it?
TS: Yeah it's canvas now so then oh what else was I doing then I was using blackboard I did quite a lot of work on revision quizzes and before blackboard it was called perception question mark I think it was probably developed something on that and wrote a bit about that but then realised that this has happened so many times that you're spearheading the technology and all of a sudden it was pretty tricky building a quiz in perception question mark it took a lot of work and then all of a sudden ahhh I can do all of this in blackboard for half the time!
AC: Yeah it's always the way isn't it?
TS: So a lot of it got transferred over into blackboard, and so I built some quite good things like navigation quizzes that all students could do before they went on a mountain leadership course which they would assess themselves basic stuff y'know and they had to you know you can try as many times as you like, but you have to get 80% before you can go to Wales next week because you're going to need to know how to use your map and bearings and grid references and stuff like that so I think it was useful. Then we had a couple of little projects using GPS's to assess student's navigation skills and colleagues AD and DH, and we wrote these up in the Universities learning and teaching's press it was called then I haven't seen it for years I'm looking at my shelf as there is probably a few copies somewhere around so developing student's navigation skills using GPS and erm it was quite exciting times really we were doing all sorts of stuff. Then PDA's came...

	Timespan	Content
3	15:57.4 - 20:48.0	AC: ...Oh yeah... TS: We got some funds and bought these well they're not very different from this mobile phone [Held up iPhone to demonstrate] and each one had to have a waterproof Otterbox case which was something like £40 per and we had eight sets of these we used them for about 2 years next thing iPads come along phones come along and if I gave that to student's now they'd laugh because they're cumbersome, and you can do it all on your phone AC: So you mention there that PDA's were replaced by the mobile phone etc. so did the University have any provisions to go and buy them or was it a case of well if students have got them? TS: Yeah that's exactly what's happened so these these PDA's are still in a draw and I know exactly where they are over in the science block there along with the GPS's occasionally get used, but again phone does that now AC...The phone does it now yeah... TS: and we bought a, 10 Olympus waterproof cameras...

AC...Uhumm...
TS: they were marketed on a TV advert, and there was a little baby, and it was washing it under a tap...
AC:...Aha right...
TS: RIGHT! WE NEED THAT! Because when our students go kayaking or up in the mountains...
AC...Of course yeah!...
TS: used them for a couple of years and we had a photograph competition one year, and I said to the student's here is a camera you've got three days, and when we get back we're going to vote for the best photograph and there would be wine for the winner and all that kinda' stuff and then of course the year after or well two years later...
AC:...It was replaced by the phone?
TS: Yeah yeah and of course the problem with these loaning out these cameras, of course, was getting them back again and of course at what stage are you going to get all the photographs off and how are you going to give them back to the students because they took the photographs. So that became a bit of a time-consuming thing really you know it would be really to be sure of getting the cameras back I would have to collect them in at the end of the field trip because if I didn't 'Oh I'll see you on Monday' or 'Oh I forgot to bring it in' or ' I'll bring it in next week' and you never see it again I've had that many a time, so it was literally gotta be back in but I've now got all of your photographs so then I would go home with 8 SD cards copy them all on there then what would we I think we could put them as a zipped folder into blackboard or something like that there was a way and there was at some stage doing that Oh no we had a special drive a photo's drive and then we could ah I know we had a guy over in library who used to do it for us. So I would have to get them all off the cameras onto a CD to this guy and he would upload them onto this OE drive and the students could access that then that's right. Oh you know it's the same old thing, but it's...

AC: Yeah Yeah so you think then in your opinion has the invention of the smartphone in terms of in fieldwork has been a benefit or a hindrance?
TS: Well it's a I think it's it's made my life easier because what I found was that I would have these cameras with me take them on a field trip and I'd sorta be almost hoping that a student wouldn't say they wanted one because I knew if they did take it then I would have the job of downloading them all [laughs] whereas if they had their own phone and used it and usually by this stage that at least one in each group they work in groups of four or five would have a phone so I would say if you've got a phone and you're happy with that use that...
AC...use that...
TS: but obviously if you haven't I've got...and gradually there would be all ten cameras would be left in the boxes, and nobody would use them so naturally it just...
AC...????
TS: Then we had the faculty without my input at all probably five years ago bought 60 iPad Mini's. I argued for a couple of years and eventually got waterproof cases…
AC...Yep...
TS: …and used them a couple of times for and this was at the point that I went on a one of erm D’s and BW and probably KW had a project day at Preston Monford centre...

AC...Okay...
TS:...on a weekend and I went down there and got very enthused, and that was just before we got the waterproof cases with using iPads, and we did I did use them perhaps two or three times, and then I don't know what's happened really? My enthusiasm seems to have just lost a little bit...

	Timespan	Content
4	20:48.8 - 25:46.2	TS: Yeah and perhaps it's just it's just an age thing as you know as you're...what I have found by being what someone described me as being a 'technological risk-taker.' AC: Ah right TS: One of these people whose prepared to try things out is I've been I think for a while I don't think as much now but I was relatively at the forefront of these technologies, and you know right you know yeah I've got to have a zip drives you know zip drives? AC: Yeah I know TS: Yeah? So I bought one of those and next year well that's done now let's get a CD reader and drives buy one of those, and of course, you find you've got such a lot of redundant kit AC: [Laughs] Yeah because it changes so quickly yeah? TS: So I question it and think hang on a minute let's just perhaps slow down a little bit and think it through a little bit [Laughs].

	Timespan	Content
6	25:46.2 - 35:40.4	AC: Brilliant right so moving on a little bit now towards its still part of fieldwork but more towards teaching aspect now... TS: ...Yeah... AC: So in your discipline that you teach currently which is once again what's the discipline that you would class that you teach most regularly to your students? TS: Well physical Geography would be the broad...geomorphology specifically but physical geography includes for me things that aren't geomorphology like I teach weather and I teach geology I guess yeah geology I taught that yesterday and I also teach yesterday, for example, I was teaching about population and resources and natural resource management... AC: So the human side of it yeah? TS: Which isn't yeah a bit more yeah, yeah the human side of it. AC: Is that years 1 2 and 3 or do you have a focus on different years? TS: Yeah so year one would be basically I go through lithosphere, atmosphere, hydrosphere, biosphere, basic stuff. Second-year then it's geomorphic processes and hazards which is and I have up until this year been doing climatic hazards fluvial hazards flood hazards and coastal hazards and then my colleague had been doing soils, and hill slopes system approach glacial hazards the odd collapse stuff like that so together that was earthquakes and volcanoes as well. So that was that module, and third year my colleague before B was DH did the glacial part of it, and I do the fluvial part of it, and then we jointly taught karst and stuff. AC: yeah TS: Then there is recreational ecology well I would teach stuff about expeditions which is another interest of mine... AC: Ah right okay...

TS: Expeditions and impacts of expeditions that involves some physical impacts but I'm also interested in carbon footprints and your guy? The reader at [university name]?
AC: RA?
TS: Yes! Yes! RA his kind of area that sort of stuff.
AC: Ah yeah
TS: I'm quite interested in that! I was in Pennsylvania a couple of weeks ago, and I was talking a little bit about expeditions and what you do on expeditions but also the cost of it all flights looking at, and now I've done analysis on every flight I've ever taken in my life and this graph goes 'whoosh' [Indicating a sharp incline] for the past four years. Since I've been a part of this climate change project, it's gone up! But costing that and just sort of saying there is no answer to it of course but what would it take to neutralise that impact you know and all those questions about if you didn't go on that flight would the flight still go anyway someone else would be going and then I've done the calculation where I've bought this piece of woodland and if that woodland was not woodland and I planted a woodland there it would within well a mature oak woodland would absorb all the carbon I've produced on all my like 70 or 80 flights or something in about a year.
AC: Ah okay.
TS: But the point is the woodland I've got was already there!
AC: [Laughs]
TS: In the same way the flights already going whether I'm on it or not but of course it's not like this is it because if enough people don't book that flight then it eventually won't go and so its yeah and then and then and then I gave it some thought to that sort of stuff.

AC: So you've done quite a lot then?
TS: Yeah I'm quite interested in that side of it, but of course when you start talking about right yesterday there is a population clock on the internet that gives you a live count 7.5 billion at the moment! I remember teaching the same module in 1999 sorry October 2000 the world's population just topped on the clock the same clock 6 billion.
AC: Wow.
TS: So in 15 years it's gone up 1.5 billion, and then you start thinking well climate change carbon footprints are almost irrelevant really.
AC: Yeah
TS: But we don't talk about it much do we?
AC: Yeah, True.
TS: It's quite scary yeah it's so interesting.

AC: Okay so one of my okay you've got quite a lot of disciplines there so if we just focus on one for this one. So you mentioned there about your first years there about the basics, and you used the term basics, and so one of my questions was in that discipline there are there key fundamental concepts and processes or knowledge that a student has to know...
TS: ...Yeah...
AC: in order to then build upon that to understand a phenomenon or the weather for example? So maybe if we use that as an example potentially as you said you teach weather. So those key fundamental processes and concepts do you have many that the students would have to know and how would you get those fundamental concepts across to the students?

TS: Yeah yeah there are right this is really interesting because what has happened over my 20 odd years I have I am sure it's real, but it also feels that there has been less and less time to teach contact time with the students. So what I've had to is to slowly select the really impor...so what I did about five years ago I instead of I say for example in that module I had 20 topics in that module that I would cover throughout that module I would group three or four into a keynote lecture. So instead of doing 20 lectures, I used to do like a lecture a week for two hours probably...
AC:...Yeah...
TS: …over the year. Yeah! 40 hours of lecturing.
AC: Ummm
TS: That module now is down to about 12 hours of lecturing if that!
AC: Is that per module? Per week?
TS: 12 hours over the let's have a look 12 hours in a semester so 24 It's gone from about 40 down to 24.
AC: 24
TS: something like that it's nearly half, I think.
AC: Per semester yeah?
TS: 12 per semester 24 for the whole year.
AC: 24 for the whole year brill.
TS: Whereas it would have been 20 per semester and 40 for the whole year same module. Reality is the actual module has been split into two 10 credit modules one each semester, but it's essentially the same stuff. So yeah I would be making these keynote lectures, and in these keynote, I'd still allow the students to see all of the material, but I would also stand up with the keynote lecture which chopped out a lot of the what I didn't think was important...
AC:...So it's you picking the fundamentals out yeah?
TS: Yeah it's really hard but you're trying to pick on and I do that more and more now so what I tend to teach now in this last couple of years I'll have the PowerPoint file there open but I won't open up the slide and say 'right this is topic one here we go! This is what we're going to be covering number two! Number three the first point is this and go right through like that which I did I used to do that. What I do now is I sort of have a plan in my head and I'll just the PowerPoint is up so they can see actually 50 slides up there, but I'm only going to look at three of them. Right, this is the key right let's have a chat about this then far more I'll develop an activity.
AC: Okay
TS: So, for example, yesterday I got I was doing something about historical you know developments from the Neolithic time and we done a bit of chatting about it so right there is 18 and I'd cut all these labels up now you as a group of three you have to put them into the correct order by doing that we're discussing each of these events that have happened stone henge whatever development of national parks and all these things that have affected our landscape and that's far better. The students I was teaching that lot three till six last night, and by 5 o'clock I put a short video on for 15 minutes, and at least one of them was fast asleep [Laughs]
AC: [Laughs]
TS: And I knew they were never going to go far past 5 o'clock and by doing that and working like that it definitely engages a student far more.

	Timespan	Content
7	35:40.4 -	AC: So you mention there about activities do you ever use fieldwork to get those

44:14.0 key fundamental process across or is it something they have to know before they go on fieldwork or is it a combination of both?

TS: It's a combination of both so what a lot of it is assessment lead so just before you arrived with us that level four group yesterday what I produced was a combined field guide assessment remit. Basically it had all of the logistics meet on the 30th of November by the cathedral we're going to be doing okay you're going to be doing a five minute presentation at a particular location around Liverpool it's an urban fieldwork day here is the rocks around Liverpool Geological guide that you and here is a copy of that so you can access that and so yeah you've got to do a five minute talk at a particular location but I'm not assessing you I'll give you some feedback but I'm not assessing you but the assessment is oh turn over the page you now got to produce a 1500 word plan of how you would organise a similar day for a group of 20 6th form geology students who are coming into Liverpool who are doing a three day experience they're going kayaking on day one going biking on day two and on day three they're going to be doing this geological day, so it's kinda' real exercise so what I hope is the whole lot will go away and do some research on rocks and minerals which I haven't yet taught them but the stuff is all up on canvas if they want to go and look at it and I refer them to it. They're going to visit the museum, and they're going to get some ideas from there they're going to visit each of these sites, and each give a little presentation at these sites all of that information will help them to do that information task, and that is the way I think it's gotta go. I've got a colleague in UCLAN who inspires me an ex-student from this course, and maybe you haven't met him yet? CP?

AC: No, No...

TS: Anyway he's a bit radical in a way he does lessons with sex with oranges and stuff, and I'll tell you a little bit about that if you like...

AC: That's a story for another day [Laughs]

TS: [Laughs] Yeah it is another story for another day! But it is quite good. Basically, he says tell them what the assessment task is and help them with it! That's what the students want! But of course, you've got to be clever with the assessment task that makes them find out all of the information that you want them to find out. I can't say I've got to that point yet but I am moving that way, and I'm thinking assessment tasks lets right it, so it's as real and as useful as possible, and one of the students right away said 'oh does it have to be in Liverpool?' and I thought for a second well where do you want to do it? 'Well I want to do it in my hometown down on the South Downs, I've got a good' I said well I don't see any reason why not...

AC: ... as long as they learn the principles...

TS:...Exactly! It's a bit hard for me to check up on it...

AC:...To qualify it…

TS: but I don't really care as long as it contains good information it's got to have a map presumably of where he's going to go and all of that it's got to have as part of the assessment criteria an annotated map of where the route is and what they're going to do and so on so yeah. In the second year module I've now given them an assessment where they've got either a 3000 word assignment which is pretty open-ended which evaluates how past societies can influence sustainable living today, and they're coming down to my woods and doing some bushcraft and some forest management and they're going to live in a simple way and all of that will influence it but they can either do the 3000 words which is the traditional thing, or they can do 1500 words and a half hour video, or they could do 1500 words and make something a costume or a product or a shelter or a craft, but it has to have this

academic underpinning. Now I haven't quite got the sort of confidence to get rid of the written stuff all together I'm afraid when the external examiner looks at it and they'll be saying where is all the academic references that's all to do with this so I'm sticking to it but I'm saying to the students you can do it on any you like this is open you tailor it come and have a chat about it don't just go off and do it but I said if you're making a physical model and its over in a woodland you know 50 miles away and I can't get there then you've got to take videos and photographs and show it me but if its small enough to bring here or its local I'll come see it. So if it's at your house but it's too big to move or whatever but I'm quite excited to see what comes out of that, but yeah there is no question that I've realised that there is this term that students are assessment driven and it's true really you have to embrace that.
AC: So would you do you use the assessments then as a way to qualify if they understand the fundamental concepts and processes then?
TS: Sure definitely yes that's why it's in there. Of course all you really got to do is meet these learning outcomes which there is only two in a module, to be honest, but you know there is actually lots of stuff within that you know so it might say 'to understand the geological processes that influence you know the shape of the earth's surface' so there is a lot of information in there that you've gotta know a bit about the Universe the solar system the internal structure of the earth plate tectonics continental drift before you can you know even start to look at geomorphology I think anyway. There is no point me saying look we're going to do hill processes today if you don't understand that the bloody plates are moving around you know?
AC: Yeah yeah I understand
TS: These are the really key things. So its yeah yeah, of course, the big challenge of all of this is, and it's not too bad but I've maintained attendance records, and quite a bit of research on attendance and the use of the VLE and performance and 77 to 80 percent attendance is not bidding it's as good as the University average if not better I think on my modules but still 20 percent still not turning up! Now it's not always the same ones but a lot of them are and this was the big debate about putting all of your materials on blackboard which I freely do and a lot of staff used to say 'oooh I'm not going to release it until after the lecture cos' if I do they won't come' It doesn't make any difference because the ones who won't come don't look at the stuff on blackboard anyway! Forget it! Get it up there! Just make it as easy for the students as you possibly can give it on a written form say it's on there it's on a PowerPoint it's here you can have a disc if you want it, whatever you want! Don't make barriers for them just make it easy, so that's come to me as I used to think Oh yeah, maybe they're right...
AC: ... but having done the research...
TS: but yeah having done the research there this you know the only thing we've found which collated in any significant way with the performance at the end of the module was the attendance it didn't help at all. So the ones who don't come don't use blackboard either the ones who do come are the ones all over blackboard.
AC: Yeah of course
TS: So that's how you've got to do it. Yeah, strange isn't it? [Laughs]
AC:[Laughs] Yeah I know...
TS:...What time is it?...
AC...Yeah, I am conscious of time because it's one minute to 12 and I know you had to...so what we'll do is we have a lot more to go through so we'll have another

interview in the near future...
TS: ...Yeah yeah!...
AC: but what we have discussed today any final thoughts about fieldwork and key concepts or thoughts you wanna?

	Timespan	Content
8	44:14.0 - 46:27.9	TS: Oh well yeah fieldwork I don't know whether you realise that I got involved in a big fieldwork project which sort of with Geography and Earth environmental Science subject group from the Higher Education Academy before they got disbanded five or six years ago and it saw me doing exactly what you're doing I got given could I go interview four academics for not this long but for 20 minutes and I interviewed CR and DF, and I interviewed a couple of people up in UCLAN as well as they were geographically not far for me to get to and I think two or three others JA WS, and we wrote an article titled something like constructing alignment of fieldwork in Planet in 2003. Was it MS? Perhaps it was MS was the other in that group? So we did about 20 interviews all together... AC...yeah... TS: and what was the value of fieldwork and various things came out one was marketing definitely that was very important. Issues about staffing fieldwork and I found this and I've done trips to Switzerland and I like doing it but I don't want to commit to having to do it every single year at the same time is quite a big ask because there is a lot of organising of a field trip abroad, but I also know the value of it is huge, and it would improve marketing and so on. So I've done two or three standard field courses to Switzerland but also taken students to Canada and the alps but more on an informal way I'm going anyway for research, oh let's take two or three students along with us or up to five or six for the Alps as its expensive getting them all to Canada but we took two to Canada and the following year three so we've had five but down in the Alps perhaps five or six each time you know. Then what we later did with the Swiss field trip we said to the students 'See you there!'... AC...Yeah, I've seen that... TS:...we'll take the van, and we'll meet you there' so that made it easier and then but then of course it's... AC:...Those who can and those who can't... TS: exactly! And an offer to those who can't afford it or can't for various reasons usually they have work or literally can't afford it, yeah So they're some of the issues I guess we'll talk about... AC:...We'll definitely discuss that next time yeah, absolutely. So next time we'll talk about the pressures of fieldwork for you and students... TS: ...yeah... AC: and we'll talk about UAVs and how they can potentially answer those key concepts you're trying to get your students to understand... TS:...yes yes absolutely... AC:...so brill thank you! TS: Good Good!

LECTURER D: TRANSCRIPT 2

Timespan Content

1 0:00.0 - 0:17.5

AC: Okie Dokie right
TS: Okay we're on the 15th of November Wednesday 10.20 Prof TS in the hot seat!
AC: Yeah round two
TS: Round two yeah!

Timespan Content

2 0:17.4 - 2:13.5

AC: Okay so last time we touched on some of the key principles or concepts that the students have to learn...
TS:...Ah yes and I was talking about aligning the teaching with the assessment...
AC: Yes yes
TS: that was my main well what I've learnt over the years, and that's very important to me now to try and make the teaching the assessment as relevant to the teaching as possible that's really important.
AC: Yeah...and we talked a little bit about your background and some of the fieldwork. So we're going to start off with the fieldwork again so can you give me some of the good points of fieldwork in general and then for your discipline?
TS: Oh wow....well fieldwork is why I'm here it's what got me into this subject no question at all I remember my first two field trips as a 6th former when we had two days one was to look at some river terraces on the river seven at near a place called Red House farm and we looked at some Oxbow you know meanders and things like that...
AC:...Yeah...
TS: ...and then the second one was to go up into have ran forest where I've currently got a field site still and walked up to the source of the seven which I did again a week last Friday.
AC: Oh so it's nice to relive it again?
TS: Yeah it was weird thinking it's been 37 years or something since I've been there with my 6th form geography teacher but that was obviously well he must have thinking back he must have been interesting in hydrology and rivers to take us on those two trips I guess and yeah that's how I got into it. Simple.
AC: Ah okay
TS: That was supplemented by a guy called MN

Timespan Content

3 2:13.4 - 7:30.6

Who eventually became my PhD supervisor he worked for the Institute of hydrology and the natural environment research council and somebody in the school my school got him in to do a lecture and again wow I like that and then when I did my dissertation in my degree my supervisor JL knew MN and organised my dissertation to go work with M to look at river bank erosion in mid-wales and that lead onto the PhD so yeah fieldwork is for me and then I worked for the field studies council...
AC: ...of course...
TS: ...which was fieldwork every day and it was hard work but it's what I really enjoyed and a lot of the time when I have a bad day here that I've had many times not so much lately, but I have many times thought I'd go back and work for them again you know...

AC: ...Yeah?
TS: Trouble is the pay is about a quarter of what I get here! [Laughs] and it's much harder work, and there is very little career progression and all those things, but the actual being in the field is really what presses my buttons anyway.
AC: So what is it about that then is it the fact that you're outdoors and applying your skills? What is it about fieldwork that you enjoy?
TS: Being outdoors is definitely part of it but its real and I think that's the heart of it it it's not looking at something it's not on a piece of paper its not talking about it or looking at a video it's doing it feeling it touching it and I've had students who say this when I've evaluated a virtual field guide we did for the Ingleton waterfalls trip and they said it just isn't the same it's that touch the rocks that they remember however of course perhaps you know perhaps you wouldn't want that all the time and I'm sure you wouldn't you get fed up with everything
AC: Too much of a good thing?
TS: Yeah so in the end you do want variety and it think that's what drew me eventually to the virtual world for the field guides I mean I've always been interesting in technology then this notion ok so well I started going to these foreign places glaciers in other countries and I'm thinking wow you know I could bring this to my students I can't bring them all with me well some of them could come with me but they all can't come with me so what can we do to try and enthuse the students because that's what this game is about really it's about motivating students and so I got interested probably around 2001/2 and I met a colleague who still works in the university called CM who's not a director but at that time she was a lecturer is Earth Science, and her specialism was in fossils but she was interested in Geology and we got together a virtual field guide well the earlier versions of them what could we do that was useful to all of our students but we eventually realised that we both took students to this Ingleton waterfalls trail she took her foundation degree and one of her other modules, and we took our students there so we decided that's what we will do, and we made some panoramic movies we make an interactive well yeah one of the earlier versions probably about 2004/5, and I remember well must have made 8 or 10 visits up to Ingleton and probably a lot of those days were we'd arranged to go but oh the weather wasn't good call it off because we're trying to take photographs and panorama but yeah 8 or 10 visits got the stuff but yeah any chance to get outside it motivates me and but I do accept there are limits that you can't do anything...
AC: Mmmhmmm
TS: you can't do everything in the field so the follow up the working analysing the data afterwards I really enjoy that too yes and I think it's relating it back to reality so here is a worksheet and here is some data from someplace in America and yeah you can do some analysis on that but it's so much more meaningful if it's based on somewhere you've been and seen okay that river we stood in we did our own measurements now here is our data and better still some secondary data from that very same river just brings it to life.

	Timespan	Content
4	7:30.5 - 8:40.6	AC: Do you think that's the same for the students then that they feel the same? TS: Sure I'm sure and I also do know that or I agree with research I've heard about what are the qualities that make a good teacher and top of the list is always enthusiasm and so if I'm enthusiastic about something I can see it rubs off on the students and they become enthusiastic, and that's what I see my job as really.

AC: Yeah?
TS: I've realised that I can't teach them everything I can teach them maybe 1% of what they need probably but if I can do that 1% really well and motivate them to open that book that Earth Environments book which isn't on the shelf there but any book it doesn't matter which book it is to read a bit more and then that's my job done that's it, and of course it comes to life ultimately in the final year dissertations. I have 10 to supervise, and they usually have some form of fieldwork involved which is great, and I get a lot of satisfaction from seeing students go off and collect some data in the real world.

	Timespan	Content
5	8:40.6 - 10:18.2	AC: On that then from them going out and doing stuff what skills do you think they get out of fieldwork? TS: Probably top of the list is being organised. AC: Ah right okay. TS: Organisational skills and time management skills. Organisational skills meaning they've got to work independently almost always and they've got to decide what they need to take in terms of equipment they've got to get that they've got to decide where to take the measurements how many to take lots and lots of decisions. Frequently you'll get some of them wrong for example you forget some of the kit you need that's ruined, or you end up not taking enough measurements or too many in one place you don't know that until but that's part of the learning. AC: Of course yeah TS: And that doesn't really matter at that level I think the important thing is getting out there and seeing something for example I have a guy at the moment who is going to be or has been working on a stream in Cwm Idwyl from devils kitchen down to Cwm idwyl he's been taking a load of measurements on there he's brilliant he went off and did a lot of it in the summer himself came back with the data we started doing a bit of analysis on the data couple of weeks ago and it sort of really he has a lot of measurements in places, but it would have been better if he had done fewer measurements at more places. AC: Ah okay I see

	Timespan	Content
6	10:18.1 - 12:23.6	TS: but he's learnt from it, and he's got time, and I bet he's been and done another load of measurements by now and but until you go and look in the field and see it's not as easy as you think. 'Where do I take the measurements?' well if I take the measurements here it will be right on top of that rock that will affect the results, but if I do it there it won't hit the rock but should I include the rock? AC: yeah yeah TS: So it's that sort of sampling thing isn't it? AC: Yeah the problem-solving aspect TS: Yeah and of course you read scientific papers they gloss over those issues because there isn't the space to go into those details in great depth methods okay five sites were sampled there was 50 clasts randomly collected it doesn't go into well I don't know where I took the samples from and those questions are really the only way to get a feel for it is to do it and be faced with those decisions yourself and it doesn't matter how many people tell you this is what you do whether it's a random sampling count, and you take yourself off into the river, and

you put your finger down to the toe of your right boot eyes adverted and the first clast you pick and it's all very well but you've got to go and do it, and when you've done it you think well ah I am biased towards the bigger rocks because my fingers that big and I can't pick the tiny grains of sand, ah right so I'm not really sampling everything am I? It's those sort of things...
AC: ...those questions...
TS:...that come out of fieldwork which I don't think you can really do. You can try with a PowerPoint and a slide and a video and a virtual field guide but it ain't quite the same it's not that really touching it feeling it smelling it you know yeah yeah that's it...
AC:...Brilliant...
TS:...Long answer to a short one question wasn't it![Laughs]
AC: [Laughs] it was a good one though!

	Timespan	Content
7	12:23.5 - 12:37.1	AC: We touched on this very briefly at the end of the last interview in terms of the barriers and pressures on fieldwork in terms of staff and students and you mentioned one of them was time and the organisation of it all can you explain a little bit more about that.

TS: Sure yeah yeah yeah yeah well time is the big one yeah because right I'll talk about organising students to take them on fieldwork okay?
AC: yeah yeah
TS: Okay so you've been with me to Yorkshire so the clock starts ticking at 8.30 and I've arrived at 8.15 and I've got the minibus keys and you know that unless you're very very lucky 80% of the students will be there by 8.30 they won't necessary be ready but they'll be there and there is always two or three 'Oh they're just coming now there is a taxi' [Laughs]
AC: [Laughs]
TS: So there is always the clock is ticking all the time and you've got to get there get kitted out parked travel problems if there is a hold up on the journey and all that so I'm highly aware that the time in the field is very valuable...
AC: ...Yeah...
TS: It takes a lot of effort to get that so then the key is to make use of it I suppose but at the same time what you don't want to be doing what used to happen on the old you've wrote about this...the Cook's tour *'Come let me show you look at this isn't that nice and look over here we've got and oh over there'* and quickly the students get switched off its nice for a couple but it's so it's what you're trying to do is set them a problem or a task and series of tasks, so they have a little bit of guidance but you want them to go off and quickly to become independent and face these problems that you know are there, but they don't. So you're going to measure the discharge of that stream over there, there is the flow meter here is a tape or whatever it is then the learning starts because I can show them this is how they do it but that means nothing they could sit, and I do I could stand there and go this is what we're going to do and go through all of the techniques right now okay
AC: Yeah
TS: then they start because 'Oh my stream is a bit different to the one he was in.'
AC: What do we do now yeah?
TS: '*Oh this one isn't flowing as much as that one and oh half the flow meter is sticking out'* and how and that's when for me it all starts and it's about creating time for that but of course some students will work quicker some will work slower others will be more interested and others less interested so yeah and of course you've got to

get home at some point!
AC: [Laughs] Yeah!
TS: It's going to get dark, so you've got to draw the line somewhere but it's trying to create that space for them to go and make the mistakes that's what it's about making mistakes all learning is that that's how you learn by getting it a bit wrong hopefully not disasterly wrong that you kill yourself or someone else, but a bit wrong and *ah right that didn't work* and you remember that. You won't remember getting a calculation wrong in a lecture really, but you might remember something you've actually done and experienced.
AC: It's like experiential learning situated learning isn't it?
TS: Exactly yeah so that's the time thing in terms of working independently I do some fieldwork with just one other person or on my own, and it's more relaxed then I guess...
AC: Yeah
TS: yeah yeah yeah so for example the project I'm doing at the moment I know I'll be going back again and back again so you know if it doesn't quite work this time then I'm going back in a months' time anyway and I'll get it right then its constantly I mean I suppose you're always aware you've made a long journey to the field site sometimes, and you want to make the most of it to get the most out of it, so you're taking photographs and videos and that sort of stuff its different every time you go which is part of the interest too I suppose.

	Timespan	Content
8	16:45.9 - 20:57.4	AC: Brilliant thanks very much okay so we're going to move onto UAVs now so I believe you have some experience with UAVs can you tell me what experiences you've had? TS: Yeah right when did I first...I have never flown one myself I came across it I guess first through this project I'm involved with the IAE the International Atomic Energy Agency in Vienna where I was last week, and they have 7 benchmark sites around the world, and the idea was to sample these are all in sort of mountain glacial areas the idea was to do what they call expert visits to each of these 7 sites just over two weeks each. The first one was to Patagonia which I wasn't involved with but the second was to King George Island in Antarctica which by pure chance the people on that mission happened to be sharing accommodation with a German group who were using drones... AC: Ah right okay TS: For counting penguins initially for the main aim of the project then they started to research on how the drones were affecting the penguins looking at stress in the penguins and so on because the drone looks a little bit like a Skewer which is one of their main predators... AC: Ah right okay TS: and they were putting eggs underneath the penguins to measure their heart rate and flying these drones at different levels to see how it affected their heartrates there is no sign of stress from a penguin they sit there looking up from their nest anyway whether the drone is there or not then so anyway got talking to this guy who led this group in a little place called [????] in Germany and commissioned him to then visit so on the five sites I've visited Stalvard he came China he came Peru he came Bolivia he came and Elbriskim so we've had five surveys of pro glaciation areas with a variety of drones the first was an Octocopter i might have sent you a picture way back that had issues then they used a fixed wing in Bolvia that crashed as wasn't great this is like five and half thousand

meters of course as there was issues with the air being thinner and then the Phantom 4 has been the most successful and that's been used in ah no there was issues with China as they couldn't get or wouldn't allow drones to be imported but they had to use there was a Chinese group who had a fixed wing and they did the survey there in the end then the Phantom 4 was used very successfully in Bolivia at five thousand 100 meters on the glacier and in Elbress in August at Three and Half thousand maybe somewhere in that area no problem worked great so then you came along so that's all so I’ve been with people flying them but I’ve not flown them certainly not been involved in any of the data processing which I know is a big part of it but I’ve certainly had a long interest in GIS going back probably to my second PhD student NM who by chance his chance his study was looking at the effect forestry on bed load movement through river systems because I’d done some work on my own PhD to say disturbing the forestry and cutting it down and all that released a lot of sediment including bed load which can form sort of slugs or waves and works its way down river systems and the idea was that if this slug of sediment comes down a river and when it floods that’s blocking the channel effectively...
AC: right I see it goes around?
TS: So it erodes the banks, and we have places in mid-wales we've got huge 11 meters of bank erosion in two years, so five meter a year and we were thinking is that due to this forestry so his task was to do that then he met sorry I went to a conference in Hull, and I met a guy called RC who I did my PhD with up in Scotland in Sterling and he was running a GIS lab by then in Hertfordshire Hadfield Polytechnic University of Hertfordshire N arranged to go down to meet with him for a week taught himself GIS stuff basically ARC GIS?
AC: Ah yes!
TS: Yeah Arc GIS then subsequently published some papers with RC and I've been on a couple of them but I've not done the hands-on stuff but I can see the value the potential of it, and I've been on one or two courses on it actually but I've never quite got to the stage of using it quickly enough you know what I mean? I come back, and I'm like this is great and then I've not actually gone and used it for real at any point so this is the truth of it just about every physical geographer position which is definitely the case in [university name], you know its desirable or essential it's either essential GIS or desirable GIS it really is there aren't many who don't have that these days and it's been like that the last few years so I've had that in my mind but I haven't quite grasped that so it's been therefore my interest in the virtual field guide and if I can use them in that then that's great it's not the real using it for proper surveys when you're talking about a lot of your time is spent about error warp and weft you know all of these sorts of issues with lenses and
AC: ...Distortion...
TS: And those special marks Vidicioual marks or something?
AC: Yeah the ground control points
TS: Yes exactly and I'm aware of all that, but I don't really know how to set it up. So the guy who did the work in Peru yes he showed us a map last week with all these ground control points he spent the whole day just setting it up and GPS-in them all before he runs a flight, so it's a big part of it...
AC: Absolutely it’s a...
TS: So you know it’s not just a picture but an actual survey there is a difference between a nice picture and an accurate survey that's right.

	Timespan	Content
9	24:00.5 - 27:42.4	AC: So you mentioned there that they use it for research purposes and that's what you've known... TS: ...That's it... AC: ...UAVs from thinking about why they used it for research and their potential benefits how do you think that can be applied to fieldwork and teaching in your discipline for example? TS: Yeah yeah okay well the sort of like I said this project with all these different benchmark sites it was probably not thought through correctly they thought oh this is a good idea we'll get this guy to do all these surveys what now needs to happen really is he needs to go back and survey exactly the same area again two or three years later use to DEM and subtract to see where the changes have occurred however that's the problem seem to crop in because some have good ground control and accurate and others... AC:...Not so much? TS: So not much so will we be able to detect that change and they are, and he is actually going back to the Antarctic again he's already done two flights of that area in Antarctic, so he's got a 2015 2017, and he will get another 2018 one this winter in January but its new I suppose and its different in different environments so it's that side of it but in terms of my students learning I just thought it's a new way to perhaps capture views of a landscape that they won't be so familiar with, and probably I must admit I was naive, and I did think in the inception of this idea that we could have a drone and they could have a go at flying it, and I realise now that that is not going to happen now [Laughs] AC: [Laughs] That's true TS: For good reason too! I can see that I was naive and that's probably the right thing here would you really want a couple of students buzzing around with these things? However that doesn't mean to say that they can't be involved like I have being an observer for other people using them learning from the process and of course gaining these unique views that you won't get well you can get but you won't get the level of accuracy for sure you've got your Landsat you've got your google earth images which are a mixture of things aren't they? AC: Yeah TS: Sentinel all these that's what this guy is doing now we can go back to 1953 or even earlier we've got some maps historical maps more moderns maps then we've got the first Landsat photographs from the 50's and 60's then he basically in some of the sites getting 12 to 15 images so they've got a research fellow a young guy somebody like yourself somebody to come along and assemble these so at least at each site they can plot the glacier location over time and therefore have hopefully a curve on a graph a recession rate, and I imagine it will speed up from the last 15 years perhaps. So for all the different locations, it would be really useful to have it all plotted on one graph and see, but there is a huge amount of work to get to that stage you know? AC: Absolutely yeah!

	Timespan	Content
10	27:43.8 - 30:30.8	AC: So you mention there about different perspectives on a landscape that the student couldn't get or you as a practitioner so in terms of that different perspective would you want to get that different perspective from pictures videos both?

TS: Yeah yeah
AC: Like what would you prefer your students to have?
TS: Well the 3D model that you can move around and look at it from different angles that excites me and I first saw that somebody in Natural Sciences made a virtual field guide and they got some rock samples and you could click and drag and turn the rock around and see the other side of it and I thought wow that is sexy that is getting closer to reality, and I think there was something very good from Southampton but anyway yeah that idea of a video well you can play it and you can stop it and start it but that's all you can do really whereas these models you can do a lot more with it you can interact and that's basically what I'm after really is this interaction.
AC: The interaction of the student and that resource?
TS: Yes and I think that's what you get from fieldwork you're interacting with that environment a bit more you're going and touching that pebble and you're measuring it and you're doing something with it whereas I could show you a video of someone doing that of Thurstaston and here is a pebble and this is what you do and its passive it's a bit more I try to say to students there are two ways of watching a video there is active and passive. So when I go home on a Friday night, I put my feet up like that, and I might open a tin of beer, and I'm watching passively and guarantee in half an hour I'm like snore I'm fast asleep [Laughs]
AC: [Laughs]
TS: But what I say to students is you're active viewing you're sitting in your chair you've got your earphones in like this you're watching the video you're stopping it making some notes you're starting it again you're stopping it the video is on BOB National they have the transcript so they can see everything that's being said and that is what I'm trying to say is active learning now if that could be moved on a bit further so instead of stopping and starting the button I'm actually having to turn this model around and click like you do in google earth here is a measuring tool measure that right that's what I want out of it to make it as close to fieldwork as possible that's what I want.

	Timespan	Content
11	30:30.8 - 33:44.0	AC: That was going to be my next question in terms of you've seen the first test model that was on sketchfab where it had the annotations as you moved around... TS:...Yeah... AC:...so my question was if you were to design for your students the perfect 3D model what would you want from it? You kind of touched upon there you want the interaction and the tool measurement... TS:...Yeah but I mean what would be fantastic would be if you could hover over parts of the image or the model and a pop up says this rock is 350 million years old its origin is in Borrowdale in the Lake District maybe those sort of things you could learn from in an active way or you click on something and it speaks to you and says that sort of thing so rather than a video where David Attenborough narrating in his you know casual way he does it you know maybe that instead of that you click on this part of the model and Tony Cliffe says Oh right this rock came from here and then TS says well this rock came from here and that would be really good! AC: It's almost like one of those museum audio tours isn't it? TS: Yeah it is, and what a fantastic place to get ideas for that sort of thing is

from there.
AC: So touching on what you've just said there then the interaction and having those extra resources then within that model the audio or the video or extra pictures from within that model do you think that's quite a useful thing for the students then?
TS: Mmmm definitely and I think I suppose there has to be a limit but I don't think you can have too many different ways of stimulating I can think of one of the things I use with the students and still works is amazing it's an American based thing called Virtual River I can show you it afterwards, and basically they've got about 20 pages of questions but answers to do so they can't go onto the next page until they've got the answer right on that page, so the first couple of pages is like a there is like an animation there is a block a column of a river 3D. There is a fish that is floating from point A to point B, and basically they have to as it passes point A they have to click a timer and then when it goes past point B they stop the timer but then they have a figure, and there is a little box where they have to calculate the discharge and unless they get that right they can't go onto the next phase so eventually at the end of 18 pages, and it will take them an hour they get a certificate, and I give them credit for that.

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12	33:44.0 - 34:42.4	REDACTED ON REQUEST OF THE INTERVIEWEE

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13	34:42.4 - 43:30.1	TS: That's the kind of thing I really like where they've got to actually be doing stuff

AC: potentially a little testing element in there?
TS: A little reward at the end is great.
AC: Brilliant in terms of that then and having the 3D model would you prefer them to have it before during or after their fieldwork process?
TS: Oh yeah well I think in the past we would have said all of them but perhaps what would be nice would be if that it had three stages. So you're into this section of it which is the pre-fieldwork bit no two would do it a pre-field trip and a post-field trip yeah so you'd look at all this stuff, and I did something like this with first of all question mark perception and then blackboard and right we're going on a mountain leader training course and it's going to be before you go you need to do this thing and I designed a whole series of questions where they had to do right read this grid reference what's the height of this mountain get the map read the contours and measure the distance from here to there how long would it take to walk and all that basic navigation stuff. Twenty-odd questions usually with an image or a map or something you know a compass bearing, and they can take it as many times as they like they just had to get 80% before they went out onto the real ML training, so I think it was good because it got them familiar...
AC:...and up to standard...
TS:...with the stuff so rather than standing out on the top of Snowdon and *'oh right this is the first time I've used a compass'* you've actually had a go on there and seen how it works. These students should have done that before, but you'll be surprised how many haven't! [Laughs]
AC: [Laughs] Yeah?
TS: It's amazing they come on an Outdoor leadership course, and they haven't

got a clue! Honest to god I would say 70% of them can't even do a grid reference
AC: Wow
TS: that's not when they start that's in January when they go on the ML training course, so that's why I developed this you see.

AC: So you would use the model then to develop their skills before they go on the field to make it more efficient?
TS: Exactly make it more efficient save more time in the field as that time costs more money and is valuable
AC: Well you mentioned that as one of your issues with fieldwork is the time
TS: Yeah that's the thing and the university manager see that as costing money so that's why we largely build our assessments around field trips because they cost money we want to make the most out of them and yeah we feel beholden and we've got to but that does raise the issue of the student who has already emailed me I'm taking them down to Wales for next week for three days he's emailed me fair do's he's organised enough he has a hospital appointment at 5.30 on the Wednesday we leave 8.30 Wednesday morning...
AC:...Right...
TS: and he can't move the hospital appointment so he's basically going to miss the whole of the three days as he can't get down there or at least I predict that's what's going to happen what do I do for him? So I set them a series of tasks I give them a learning log where they're going to go into this forest, and they have to build a shelter they have to stay overnight in it they have to build a fire they have to build a raft thing they have about five different tasks which he won't be able to do that, but I'll have to develop something where he can do it independently but it's not going to be the same is it? So that's always a problem building an assessment onto fieldwork and fortunately, in this case, its only 40% of the assessment the other 60 is on something else, so you don't want to put all of your eggs into one basket but sure the Yorkshire thing that's 25% of the module the Thurstaston one is 30% it's not going to kill you dead if you don't go, but it makes it difficult you know so something like a virtual thing could or an assessment in a virtual model
AC:...Could potentially alleviate...
TS:...and this is what I go back to the thing I talked about last time making the assessment as relevant to the learner as possible if we could say that the field trip is only its really going to help you, but it's not...
AC:...The be all and end all?
TS: yeah the be all and end all this geology one I'm doing with the first years next week is saying right you've got to design a geological trail around Liverpool
AC: I remember you saying yeah
TS: we're doing that but even if you don't do it but if I set you that task, but you could still go and do it you'd just go down there and do it yourself, and you'd get this guidebook and you'd say well I can build that in or take a picture of that I mean you'd still get there but if you came there with me and I took you around those sites, and we all had a chat about them then it's going to make it a bit easier doing it. So that would be nice if the virtual field guide could be the ultimate task but having been on the field trip makes it easier or better somehow dovetail, so we're not doing totally different things we're...
AC: Complimentary?
TS: Complimentary that's the word yeah that's the now how we do that now

that's the difficult thing I suppose is where to have overlap and where to have to extend stuff so maybe things we can't do in the field one of which classically is there is no point right here is Glassers research paper this is the classic *'Right here we are everybody we're in the field go read that'* no one is going to read that in the field or even on the minibus or anything! So there is a time and a place and maybe afterwards because if I give it to them beforehand and they've seen the field site and seen the *'ah right I can see all the layers' or ' Ah now I see what's going on here now I want to read glassers work because he's interoperated it one way, but I've interoperated it so what does he say?'* Then it's just a bit more in context, and that could be on the virtual field guide that could link to the key readings just to make it easier really.AC: So it would make sense to do that post-fieldwork?
TS: Yeah and what I've done before with virtual alps two I've provided reading and then in the assessment criteria I've said you know it's easy to just click click click there's the PDF file or the link to it so I've said in the final report you can only get credit if only half of your citations can be the ones in the resource you have to go and find the other half elsewhere otherwise those skills which they've been learning throughout their career as a student can get lost can't they?
AC: Yeah
TS: because you want those independent go look for yourself but it's like it's when I used to do this with my kids when they were very young when you'd go on a walk you know they would get left behind because they're too little and you'd hide a little chocolate on the side of the path, and then you'd say *'There is a chocolate! Look out for it!'* and they'd be like *'Where is the chocolate!'* and they'd speed up and then you'd do the same later on its like that with students it's no different it's saying here is one to start you off here is a nice little chocolate have this paper but now you need to go find your own one now it's that sort of notion of keeping them motivated.
AC: Yeah keeping them engaged but not give them too much that they're passive...
TS:...and a little bit of mystery as well you can't well the old saying 'don't sell the whole farm' give them enough to be keen but there is always a bit more to do, and that's true isn't it there is never going to have all the answers I know that for a long time. The students know a lot more and find out a lot more of things than I would ever hope to find out because that's not my role of a teacher well it used to be before the internet the teacher was the fountain of knowledge, and all you had to do was as a student find out what was in that guy's head really and read his books, but that's way been flipped around now.
AC: Brilliant right any other comments?
TS: Ah we're there? Oh, excellent well I think we've done well there we've thrashed it through! [Laughs]
AC: [Laughs] We have thank you very much!

LECTURER E: Transcript

	Timespan	Content
1	0:00.0 - 1:55.6	AC: Brill right then KW what's your position in [university name] at the moment? KW: I am a senior lecturer, and I've also got a leading researcher fellow post there you go a bit of information AC: Very nice KW: So yeah I've been here for the last seven years in a variety of roles, but I'm currently a senior lecturer. AC: Brill and what's your current discipline? KW: Physical geography so an array of different subjects I teach hazards people hazards and resources we look at resources so peak oil fracking I teach on the hazard programme, so I look at flooding tsunamis earthquakes community resilience what else do I teach let's think? I teach on the third year module Anthropocene which is looking at , and in the past, I've taught on the processes and that kind of thing. AC: Is that your original discipline or have you changed...the geomorphology bit is that like your main one? KW: Mainly yeah but I teach more hazards than geomorphology these days but yeah actually some of the questions coming up are more relevant to the geomorphology really but I'm sure we'll come onto that I'm sure! So my background is obviously flooding numerical modelling catchment processes sediment makes the world go around [Laughs] that kinda thing, so that's my background. AC: [Laughs] Brilliant okay so you mentioned there probably that the geomorphology questions are most relevant to the fieldwork questions so if we used that as a basic first and if the other disciplines feed in... KW:...That's fine.

	Timespan	Content
2	1:55.8 - 4:00.9	AC: Can you tell me a bit about your opinion about fieldwork in general so not your discipline-specific but fieldwork in general in higher education. KW: I'm probably a bit biased because obviously been involved in DF's enhancing fieldwork learning projects, so I am a bit bias towards thinking that fieldwork is good. I think it's really important to get students out on fieldwork I think it's important that students go out see things for themselves when you see it yourself you can really understand it far more than anything you can read about or listen to so you really need to get students out there looking and seeing for themselves. Also doing things for themselves out in the field doing things is much more important that seeing things so actually having that time out of the classroom and in the field, I think students learn far more during fieldwork than they actually do sitting in lecture theatres, but that's just my opinion. I think it's good I think it's time-consuming for staff and students as well they're long days usually and I do think it's expensive in our department we pay for all compulsory fieldwork... AC...Oh okay...

KW: ….Fieldwork where they're away for a week abroad if its compulsory we'll pay for it if it's optional we've got a New York field trip Spain Barcelona field trips that are optional and students pay for that themselves but everything compulsory the department pay for so its therefore quite expensive for us as a department and the only way it would become less expensive for the department would be if the costs was put onto the students who we feel already pay enough, so we don't want to load them with extra. But having done this kind of research in the past with D, we are one of the few departments in the whole country so who we interviewed, and we interviewed about 30 35 people, so 35 universities in Geography and we were one of the only few who didn't actually charge for compulsory fieldwork...

	Timespan	Content
3	4:00.8 - 8:24.7	AC:...Oh wow okay. So we'll go onto pressures then while you mentioned them, finance being definitely one... KW:...Yeah... AC: So have you found then with the non-compulsory ones where the optional ones students have to pay what issues have come out of that? KW: I think it's so they've got mainly New York and Barcelona and they're second and third year trips and I think they also go to Spain in their third year as well so there are three optional trips and the students you know they still they still go for that its basically I think a lot of it does come down to if they can afford it or not. Obviously if they can't afford it and they want to go then that's a bit difficult, but I feel within our programmes they do get enough not enough you can never have too much fieldwork but I feel like they get good opportunities to go and they're already paid for whereas in other universities compulsory fieldwork and you're having to pay a couple of hundred quid to go I think that's quite a big pressure when you might not be able to afford it when its compulsory, so I think not going to New York, Barcelona or Spain isn't going to do any of the programmes too much damage because they do have the option to go to...Single Honours go to Betwsy Coed for a week, the hazards go to Naples for a week, and the International Development students go to Geneva for a week, so they have all of that paid for... AC:...Ah okay... KW:...So there is opportunities so good opportunities and at decent length field trips to go on. AC: So these compulsory field trips sorry the optional field trips are just nice to have like extra bonuses so they're not like core? KW: Yeah I think so and I think I wouldn't say student numbers are you know they're very similar each year it's not particularly due to any financial sides of it it's just whether they want to go on it or not sometimes. AC: Brilliant, so other issues then that you mentioned there was staff time and staff commitments, so I know in literature that is quite a big challenge so is that something that you have faced? KW: Yeah definitely and I think actually running field course particularly the week-long field courses they're very time intensive for staff because you can't do anything else other than be teaching on whatever particular module so you know although it may be in a development week where we don't have any teaching that means we have you know no other time for marking or preparation that week, so you still have to do all the work that you're supposed to be doing

anyway even though you've been away for the week...
AC:...Yeah Yeah...
KW: It's not like some nice little jolly [Laughs]
AC:[Laughs]
KW: So there is that so also putting together a field trip takes a lot of time so we were on a half-day field trip well we used to run a half-day field trip out to Farndon and actually just putting that together in terms of time recceing the field sites making sure that there is enough for the students to do or health and safety all those kinds of things costing the buses getting enough drivers, so you know all that takes time or sorry costs staff time or money to put all that together, so you've got to make sure that you're getting the most out of the time you spend in the field basically.

AC: Yeah do you think that since you've been in [university name] that there has been less number of field trips or has it changed because of that pressure?
KW: No I think actually we've done really well to keep the same amount I'd actually say we probably run slightly more of the day trips and I say slightly like literally a day or maybe two days extra that we might run over the three years. I'm trying to think we've also added Barcelona in as an option, so that's a new one we've still got a few new half days, so I think we've got more overall...
AC:...Ah right okay...
KW:…Than when I started seven years ago which is encouraging so, we're going the right way rather than the wrong way which is a good thing...
AC:...Absolutely...
KW: …So yeah it hasn't really affected the amount of fieldwork that is going on, but of course, it is extra pressure on staff and extra time and extra cost to the department all the time.

	Timespan	Content
4	8:24.6 - 12:02.9	AC: Absolutely, so my final one on barriers then is, have you come across any disabilities or accessibility that students may have in a department that therefore you have to try and accommodate on fieldwork or?

KW: Yeah we've come across this not when I've been at [university name] but when I was at [university name] we had a student who was in a wheelchair and our usual field trip was you know a walk up a mountain so because we had that student with us we changed the entire field trip to accommodate that student we did that around a lake which had a boardwalk so that it went around it.
AC: Ah okay.
KW: So everybody did that it wasn't just the one student that was doing it, so we changed the whole thing for that student and then the following year we reverted back to the walk up the mountain so in some ways they were getting different things out of the field trip and because it was first-year course it wasn't such a big deal that they hadn't been up the mountain to see the processes as ultimately first year is all about getting to know each other getting out in the field you know so it wasn't particularly that they were missing out because they couldn't get up the mountain they were learning other things, but so there is that that we've had to deal with in the past by completely changing the field course...
AC:...Yep...
KW:...but overall I don't feel that disabilities or accessibilities or lack of accessibilities would hinder students overall because ultimately as long as those learning goals are met in some way then that's fine but again if we had a student

who we had wanted to go to Norway with a disability then would that be more tricky because we need to get them up into the mountains okay so we can just tick learning boxes to make sure that they can write a report and all of those kinda skills its actually getting them to see things first hand themselves that might be more tricky, but we haven't come across that yet.
AC:...Yet...So I was gonna' say do you think that Geography in general and geoscience does suffer a little bit as you mentioned the traditional field trip is to walk up a mountain so in terms of recruitment and that kinda' stuff do you think that as a whole that is an issue or like you said there are ways for accommodation?
KW: It's possible I mean it's not something I've ever actually thought about if I'm honest, but it's a good question, and it is possible that we don't recruit physical disabled students because of the nature of the discipline but yeah...I think there is a PhD in that there Tony! [Laughs]
AC: [Laughs] quite true.
KW: It is possible, but at the same time yeah I don't know I've never really come across that so good question but we would have to in some way think of a way of getting that student to the field site I mean we used to use, well one of the people who came on the enhancing fieldwork learning fieldtrip he had a student who couldn't get onto the beach for some reason to look at the cliff sections so he used a gigapan so students could see the photo they could zoom in with high level detail so he said although they hadn't been there he doesn't feel they suffered too much and I feel that there have been other instances where local networks have been set up in a place where students could get to, and they would be doing a different part of the group activity while somebody else would be further up a mountain, so there are ways of working around it but actually to give that physically disabled student the same experience well you'd have to use some sort of technology to get around that I would say.

	Timespan	Content
5	12:02.9 - 14:37.1	AC: Yeah? Brill okay so moving back to fieldwork then and the benefits...What would you say were three most important benefits for you as a practitioner for going on fieldwork? KW: I think for the student well for me actually getting the student learning and doing stuff for themselves that experiential learning is very important rather than just saying look here is a mountain isn't that very nice let's take a photo and forget about it five minutes later actually getting them working on projects out in the field and coming up against obstacles and solving problems for themselves rather than I don't know what to do next so getting them doing it themselves I think actually for me fieldwork the actual social side of it is quite important as well. AC: Ah okay KW: I think in some ways can be overlooked because the department is paying for it, so you don't want it to be a jolly... AC:[Laughs] of course... KW: …but at the same time that social and group bonding that you get on fieldwork I think is actually a really important part of geography as a discipline because you know who hasn't gone on a great field trip? AC: …very true… KW: …Everyone has been on at least one great field trip particularly residential and I think by cutting residential field trips you wouldn't get that full experience

and ultimately yes you want students to learn but more and more people are going for the student experience and it's all about what experience they have had overall have they had overall on their degree as well as learning and getting a good degree. It's not just about whether they can cite the physical laws of fluvial morphology back its much more about the whole experience nowadays, so I think ones of the very important parts for me as well.

AC: So is that something you think the department uses for marketing as well in terms of fieldwork?
KW: Definitely when I heard that [university name] did a trip to California I practically signed up on the dot I couldn't wait for that first year field trip so going from being there at the open day to actually going on that California trip time went so quickly but ultimately that was going to be the highlight of the degree, and it was...
AC:...Yeah?
KW: …and I learnt so much because I enjoyed it and I think students enjoy fieldwork so much because they're in a different environment...
AC:...Absolutely...
KW: …So when you're enjoying something you're actually learning more because you're not just listening to somebody going on and on in a lecture theatre.

Timespan Content
6 14:37.0 - 16:13.1
AC: Yeah, Yeah. So do you think that students like their of top three that they would rank as most important in fieldwork differs from yours or?
KW: I don't know really I was thinking about this as I saw the questions and I don't really know how students would feel I don't know really some students really love fieldwork because it's a different environment, and they love being outside some hate it because they don't like getting up early they don't like sitting on a bus they don't like being away from home, so it's that aspect of it as well as they're kinda' out of their comfort zone. So I don't know, I don't know what students would think about fieldwork I think as practitioners we think of it in a certain way, and there is that Alan Boyle paper fieldwork is good, but I've often wondered about writing a paper called fieldwork is bad and actually looking what students would change about fieldwork. We've got these ideas because we love fieldwork, and we are geography practitioners, so we have a biased view of fieldwork whereas not everyone feels the same way and at least one student every year on that first year residential field trip either has or gets upset before the trip as they don't want to go or they get upset during the trip because they get upset because they're , and they don't want to be there so there is although we might think in a certain way I don't know if all the students think that way too and then we have students who are super enthusiastic about it and can't wait so, there is a variety of different thoughts.

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	Timespan	Content
8	19:56.3 - 23:29.1	AC: Brilliant okay so we're going to skip now to question 7, and we'll probably come back to the mobile tech at the end, so this is the big question in your discipline what are they key fundamental core processes that the students have to know? KW: Yep so I was thinking about this in terms of what I teach with the hazards programme the fundamentally we want to teach students how to manage hazards how people and landscapes interact that’s kinda' the overarching aim of hazards. In terms of geomorphology we're looking at the fundamental principles so physical laws looking at the applications of you know really why it matters why a river meanders why do we care what’s the reason behind that so that’s the kinda' two main areas that I teach and they're the fundamentals of those subjects really. AC: So how do you try and get them across is that something that the fundamentals have to be known in like first year? Is that something they have to work on in first year? KW: No well we kind of build upon it really so you know first year is much more thinking about the applications of this kind of thing and then we move into more theory at second year and third year is a mixture of the two looking at theories but also the bigger applications or more in-depth applications. We try to do this obviously via lectures I try to use quizzes get the students to do reading computer practicals I quite like using a lot of those particularly for geomorphology and fieldwork as well that’s another tool in our arsenal. So yeah that's it really. AC: So by time they leave in final year how do you qualify that they have understood those key core principles that they should have taken away in those three years? KW: Well we do that using assessment criteria for their assignments basically so for example at second year we do a literature review well they now do a literature review of either glacial processes or fluvial processes and there is a list basically were we have to assess them on can they write can they think critically have they got sufficient reading in and have they looked at all the principles that we've discussed and that’s a really useful way in how we do it in terms of

assessing criteria and its mainly done through the assignments really oh and dissertations.

AC: Do you ever use fieldwork to try and help them understand those key principles? KW: Yeah we do use fieldwork so, but in terms of assessing or qualifying as you said exactly if those fundamental processes have come across we do use fieldwork we use field presentations as well so we're not all about the written assessments, different types of assessments. Ultimately assessments is the one way we can assess whether students understand the fundamental concepts or not.

	Timespan	Content
9	23:29.1 - 30:00.2	AC: Brilliant thank you very much. So moving on now to question 8, so that's any experience with Unmanned Aerial Vehicles which I believe you have some? KW: I do yeah only slightly though mainly through you and S and D so yeah there is a couple within the department, and I was really keen to go down this route with my own research...[Pause] AC:...Yeah? KW: and I thought wow this is going to be fantastic for teaching, but the more I know about them, the more I think hmmm I need to stay away from these and let somebody else do it [Laughs]. So really I don't have any experience, but I have flown a drone once... AC: Yep KW: And I know a little bit about them that's it really so I just think no I'll just let you ask the questions sorry [Laughs] AC:[Laughs] no no please feel free to carry on! So you mentioned there that you thought it was going to be really good and you were thinking of using it for teaching and you decided not to so what was it about it that you decided not to? KW: They just seemed far too complicated! In like the laws and the licencing that completely put me off. I see how long it took you to get your pilots licence and the rest of it... AC: [Laughs] Yeah... KW:...obviously then I thought it would be great having students out there doing that but there is no way that would happen due to all the restrictions and I think they're absolutely fabulous but I actually the amount of time I'd have to invest in trying to get to a standard where I could use it in my teaching I don't think I would get I don't think there is enough I'd get out of it for the amount time I've put into it if that makes sense? AC: Absolutely! KW: However knowing somebody who can use one of these things would be very useful... AC:...Yeah? KW: [Laughs] Mentioning no names! AC: [Laughs] KW: Because I think they'd be really good for teaching and they are but it has put me off doing the CPD course and listening to your talk as well in September that really sealed the deal for me just because the amount of work I'd have to put in and I don't feel like I'd get enough out of it at the end really in terms of putting that time in for my research that's a different kind of thing because I think actually I could get quite a bit out of it in terms of research but not enough for my teaching.

AC: Ah that's interesting so do you ever think what you would use it for your research once all that is done you may be able to filter some resources from that into your teaching because I know that's something geographers do quite a lot in terms of basing their teachings on their research?
KW: Yeah definitely and I think, and I think in terms of research you're thinking about what I may or not be able to achieve in the next three years what will I be able to achieve in the next five years but in five years' time will we still be using drones? What will we be using instead?
AC: Good question!
KW: Will it be something easier to use or will it be something more user friendly probably not because I think the restrictions are only going to get tighter and tighter and rightly so because I can't believe that there isn't a register I know that it's coming in or it is in now but the fact that it hasn't been one for so many years is just unbelievable you know literally any man and his dog can fly one so it's a bit scary if I'm honest.
AC: Absolutely [Laughs]
KW: So I think it's a great idea for teaching, but I don't feel like it's something I can put enough time into in the next couple of years to achieve anything useful.

AC: Absolutely and that's fine! So you mentioned there that other staff in the department have drones is that right?
KW: Yeah
AC: Do they use it for teaching at all or are they in the same boat as you?
KW: I think to be honest they're in the same boat as me because it I think well I can't speak for them obviously...
AC: Oh I know I of course...
KW: but I get the impression they thought it would be great for teaching but actually when they've looked into it and realised just how much time consuming it is on top of all the other teaching and research pressures you've already got maybe it's something you can pursue, but it's not something you can pursue in the short period of time. I know one of my colleagues have used it for research purposes, but I don't think either of them have used them well there is three of them actually I don't think any of them have used it for teaching.
AC: Ah okay.
KW: I might be wrong.

AC: No that's brilliant. So before you were put off by my talk...
KW: [Laughs]
AC: ... What was it about the UAV that you thought oh I can use that for my teaching? What was it about it that you thought was going to be beneficial?
KW: Well I've seen your link to the 3D model at Thurstaston and you know having something like that is just brilliant you can take the students to the field before you take the students to the field. So you know you can familiarise them with the area I mean you can look at pictures of course before you go but it's not the same as being able to interact with a model like that and to zoom in to such good levels of details to say actually this particular bit here you can actually point to it on the screen, not just a picture you know the fact they can interact with it look around it if you know there is that argument do they actually have to go into the field which I'd argue they do...
AC:...yeah...
KW:...but the other thing is of course they can revisit it once they come home so

it's that I can't quite remember that bit let me just have another look so it's that kind of thing of they can look at photos again it's the ability of being able to revisit it and that's the great thing about photos 3D models anything that the students can interact with and manipulate in that way because ultimately and quite often you're only going to get one shot at the fieldwork...
AC:...Absolutely...
KW:…So if you've forgot something or didn't take the notes if something happens and you didn't have enough time so being able to go back in that way kinda' virtually almost isn't it?
AC: Yeah it is…
KW: …You know just having that sort of resource available to us is just fantastic!

	Timespan	Content
10	30:00.2 - 32:55.2	AC: Well that's good to know! So you mentioned there in terms of well we'll come onto the 3D model in a little while you mentioned there about pictures so how would you use as a practitioner pictures captured from the UAV to help the students understand a particular field site for example? KW: I think rivers, in particular, would be so useful to have drone footage a video would be great where they could pause a video and look at certain areas. I don't know if you can zoom in on a video but you probably can can't you? AC: Yeah there is probably some software somewhere KW: So that they've got that birds eye view kind of thing of the river because you just don't get that standing next to a river so aerial photos are great but actually being able to fly literally over the river itself you know that's a completely different perspective which students just cannot get ever other than if they jump in a plane, but that's very unrealistic [Laughs] AC: [Laughs] yeah KW: So it's great looking at channel morphology and looking at how morphology changes all that is fantastic I'm thinking about particularly about the trip down the river Dee that's quite a dynamic area there is a really straight section and there is lots of meandering sections so to show the change also there is quite a lot particularly where we can't access because its farmers' fields so although we want to go show them when it meanders we can't actually get to it so getting to inaccessible areas is also a useful thing to kind of give them more than its just a bit of water here and it looks like a straight bit of river its far more it's you can get a long perspective I guess how else would I use it? I'd use the 3D models as well that would be really useful. You know you could use a cliff section or a I'm trying to think in terms of coastal geomorphology although I don't teach that it would be useful... AC:...Useful for that... KW: ...Yeah… AC: So you feel there is some traction in using or providing someone does it for you... KW:...Oh I think it would be fabulous yeah I think a lot of people would feel like that as well that as well that it's a fantastic resource to have but whether you've got the time and the skills do that yourself I don't think many people would be able to say yeah I've got that however if someone could say well we can do this bit for you what do you think oh that would be great, but people and staff are always looking for something that is quick and easy to enhance their fieldwork with rather than something that is very time intensive and costly as

well.

11 32:55.2 - 38:10.3 AC: Ah of course brilliant so you mentioned there is someone came in and did it for you so say if that was the case for example and you mentioned rivers there so we'll take that as an example what would you want out of a 3D model of a river or a meander etc. what would you want what's your perfect 3D model that you would want to incorporate to get your students to understand the key core principles that you wanted to get across on fieldwork?

KW: I'd like them to look at it in 3D that's kind of important rather than just an aerial view is great but if you can look at it in 3D that's even better so that they can get an idea of scale as well that's useful being able to zoom in at a very high level of detail that would be really useful as well as I think that's what you can't get from other than things like GigaPan you can't get that from aerial photos you can't zoom in to sufficient detail and say oh look you can see the clasts or you know you can see where the bank has fallen in there, or the banks collapsed or what have you. What else? Being able to annotate it would be useful. Having the students annotate it would be useful too. Trying to think about what else really [long pause]

AC: I've got one that part of the software can do in terms of you can create digital elevation graphs and models from it and you can do very rudimentary measurements of heights of rocks and that kind of thing so it's not as accurate as if you did it in the field but do you feel that if they had the ability to do it virtually, therefore, they would develop the skills so they would be more efficient potentially in the field?

KW: Definitely yeah and looking at cross-sections of rivers and that would be useful I don't know whether you could actually do that because it depends on I don't know if you can get through or what the 3D model would look like with the water with the drone, but definitely measurements like that would be really helpful anything like that would be great

AC: Would you do you think high resolution is highly important then for this kind of model?

KW: Definitely because I feel that is really what is lacking from aerial photographs you know that's great having aerial photographs you can zoom in but if they haven't got the detail there then particularly in coastal geomorphology well that's being able to zoom in to look at ripples and other formations would be really helpful and thinking back to the GigaPan images or cliff sections being able to zoom in on I mean the level of detail in them is phenomenal so if you can get that from an aerial photograph that would be brilliant.

AC: Super! that's good to know. So the sketchfab one you've seen the link it has a couple of annotations that draw potentially the prospective student around do you think that's important to have rather than the student who ambles around it aimlessly I mean it's good to explore, and that is an important aspect of it but do you think as a practitioner its useful for you to have those individual pointers in that Model?

KW: Yeah and I also think it's good if you could take that out in the field with the student as well you know on their phone or on a University iPad or what have you because quite often you know there is only one practitioner and there might be ten groups so trying to get around all the students making sure they're seeing everything you want them to see so actually its almost guiding them around the field in some way that would be great but you're right you don't want

to switch them off to everything else so that's the difficulty you want to guide them enough but not switch them off from everything else do that they're not looking I particularly like the rocks annotation [Laughs]
AC: [Laughs] Yeah! I thought that myself its quite good!
KW: [Laughs] very human geography!
AC: absolutely yeah! So if I did it properly, I'd do it better! [Laughs]
KW: [Laughs]
AC: So one thing on the annotations do you think it's important if this was given before or after that those links to external links or potential higher resolution for examples the rocks one you've zoomed in and the students can zoom in but do you think it's useful for the students to have a link to external drop box file or a google drive that had high res photos of that?
KW: Yeah as well possibly yeah I think so, but I also think being able to see it before they go during and after and having it available to them at all times because it gets them more and more familiar with that particular site.

Timespan	Content
1 38:10.3 - 2 40:52.7	AC: Do you think that the students would use it differently throughout those three separate areas, so you mention get more familiar do you think it would be a shift from getting more familiar to after actually doing the data and field trips that they'll then use it to qualify what they've seen? KW: Yeah definitely you know when you talk to students first of all about fieldwork and about field sites they can't really understand what it's all about until they've actually seen it for themselves so that's where I feel very much that these kinds of field guides and 3D models can't replace fieldwork because until you've actually been there and experienced the place for yourself and understood what it looks like for yourself yeah I think you have definitely got to go out but having such a good kind of resource to take or to look at before you go out I think that's really useful... AC:...Yeah... KW:...So yeah I think they would use it differently because I don't think they'd be that engaged with it to start with because they'd be like oh look it's a bit of sand or whatever or that's a nice cliff but when they get out there and they get out there and when they have to fend for themselves that's when they become very dependent on any resource they have available to them so it's like oh yeah I'm sure she said something about this so let's have a look at it and that's kind of when they engage a bit more and then afterwards it's kind of a reflective process so level of engagement increases but also level of like getting to that deeper learning reflect student reflection and getting to think about things in a different way so I think pre during and post are three very different things and they'd use 3D models in very different ways so yeah. AC: Ah excellent that's good to know. So overall then you'd say having a 3D model of that is a positive thing for your students? KW: Definitely and I think so much with geomorphology I feel like things like the hazards that I teach like when I teach human geography I'm very keen on using mobile technology on fieldwork and in the classroom so I feel like we can use social media and we can use lots of different things you know to engage students to make learning a bit more fun, but when it comes to geomorphology, and it comes to those fundamental physical principles it's very difficult to engage students because it's very science.

AC: Yeah
KW: So we try different ways like computer practical's for it but actually using 3D models in this way I think it's perfect for geomorphology and I think it's quite nice that it's another tool that we'd have you know we don't have that many tools to teach geomorphology with I don't think.

	Timespan	Content
13	40:52.6 - 41:47.3	AC: Ah okay brilliant! Do you think any student would potentially struggle with like having a 3D model or do you think because you mentioned you use mobile technologies in your teaching that they'd be kinda used to it? KW: I don't think they would struggle because they don't have to produce it as long as they don't have to produce it I think they'll be fine with it ultimately as long as you can swipe it around on a phone it's no different really to using like one of the 3D images you can use on your phone you know you can do panoramic, and they understand how to do that to tap on a phone so as long as it can be used on a touchscreen I think they'll be fine with that really I don't think they'd struggle at all. AC: So basically its useful to have the model but it's good if it was portable in the field and accessible by the student yeah? KW: Yeah definitely!

	Timespan	Content
14	41:47.3 - 45:14.0	AC: Okay super! Thanks very much for that bit we'll move back to mobile technologies now that you've mentioned it, so you said you use it in your teaching in what way do you use it in your teaching? KW: Well lots of different ways really I'm just looking for the question I've written it down...we've used iPads in the field for the last seven years so we were kind of one of the early adopters of iPad in fieldwork to use it as kind of a so we didn't have to take loads of different equipment out into the field so that students could analyse data when out in the field so that they could save time when out in the field we tried well I'd like to use social media a little bit more out in the field, but we have this issue of connectivity which is improving and has improved over the last seven years, but it's always that risk of you know is it going to connect? is it going to be okay? AC: Yeah KW: However we sometimes have that in the institution as well! AC: True KW: I remember a reviewer came back on a paper once saying surely this isn't an issue any more but you know I can confirm sometimes it is in some rooms! [Laughs] So you've always got that risk with technology you know is it going to work? Brilliant if it works but if it doesn't so I think some people are a bit...I'm always kind of willing to take a risk with technology and I always have a backup plan if it doesn't go to plan or what have you but we definitely use iPad in the field and having that ability to let students learn wherever they want to learn mobile learning has so many benefits they can learn where and when they want to learn they've got all the tools available to them they can just pull up google whenever they want to... AC:...yeah... KW: ...and it's something they're familiar with as well obviously as you know I'm

very keen on bring your own device so the students are have their own device they own their data rather than having it on a department iPad or anything like that so they actually retain that information themselves as it belongs to them they can do what they want with it...AC:...Yeah...
KW: One of the things we're trying to I've had a trail of is using Evernote as a field notebook...
AC: ...Oh okay...
KW:...Which is quite nice we're looking at doing something around campus, and the student can update their field notebook and the member of staff actually you know we would go out into the field with them, but there is an option where you can literally check up on Evernote on your desktop computer...
AC:...Ah okay...
KW:...so they send their field notebooks back to you, and they will update, and all the data goes through back to your main computer which I think is quite a nice thing...
AC: Yeah that sounds quite handy!
KW:...we haven't really developed that any further than kind of an idea at the moment but it's kind of like centralising the data so that staff haven't got to collect all of the iPad in to see what is going on its trying to share data in a useful way which is where we'd like to explore next. Other mobile technologies I get them doing quizzes on their devices in class trying to think in terms of fieldwork what else do we do? Lots of different things!...Geotagging which you're obviously quite familiar with [Laughs] just sharing photographs as well and getting them using social media for discussion and discussion boards interacting or reflection using twitter as a tool for reflection.

	Timespan	Content
15	45:13.9 - 46:25.2	AC: Do you feel that Twitter and reflection then do you feel that they actually engage with that? KW: Some of them do yeah probably not as much as I'd like them to I don't think I just generally don't think that technology is used in higher education as effectively as it could be and I don't know if its reluctance from staff or reluctance from students who think hang on this is very much my phone or my iPad and you know we're not crossing the boundary for using this for education as well but if feel once they realise that they can use mobile technologies for educational purposes and actually sometimes it's just educating them on this is what it can do you can download this app this app this app and this is what it can do and it can really enhance how you learn and ah okay that's great but it's actually just educating them and although they're like the digital natives you know the tech generation a lot of them come in and they're not actually that confident with technology not all of them but a lot of them aren't as confident as you might think that they are.

	Timespan	Content
16	46:25.2 - 49:32.4	AC: Absolutely yeah...you mention there about bring your own device... KW: ...Yeah... AC:...Has there been so when you offer them that choice to have an institutionally owned device compared to bringing their own are they quite happy to do that or? KW: Some of them are fine with it some aren't fine but the experiences we've

had and interviews with students and questionnaires they're actually you think they're not going to be concerned about institutionally owned devices, but in some ways they're almost some of them are more worried about institutionally owned devices because they're not theirs and if they break it am I going to have to pay 500 pounds to the department you know because I've broken their iPad, or I've dropped it in a river or whatever, and the other side of the coin is well it's my device, so I don't want to get it out in the rain, and what happens if it gets soaked or of course universities just don't have bring your own device policies in place it's a very grey area in terms of who's liable if anything happens to a student's device, so it's a tricky one really but more often than not most students are happy to use their own devices you know they always pull out their phones for calculations and things like that it's not different in that way, and a lot of them do say that I've got my phone out messaging my friends in the rain so why would it be any different collecting data you know?
AC: [Laughs] yeah
KW: So there is two sides to it but I don't know which one is stronger really some prefer to use their own some prefer to use the institutions so I think having both on offer is a good mixture really.
AC: You mention their which is quite interesting that some students are very averse to damaging university equipment and that's something the research so far that I've done has found that they're very concerned about dropping it or damaging it and their second one for their own device was the weather issue...
KW:...yeah...
AC: ... but do you think because having gone through a geography degree myself like GPS' aren't cheap...
KW:...Yeah this comes up all the time differential GPS you know they don't ever seemed concerned that they've got 25 grand worth of equipment in their hands that's not the same level of concern as oh my goodness I've got £500 worth of iPad in my hand but I don't know if that's because they realise how expensive that is and maybe they look at the GPS and don't think anything of it but it doesn't mean anything monetary value to them whereas to them an iPad is an expensive because maybe that's not something achievable that they can own for themselves because it's too expensive whereas they've never really thought about owning a GPS you know so it's tricky that I don't know whether they're just so much more familiar with it or what it is but yeah maybe I think it's equipment that they're familiar with and recognise the value of they're scared of damaging but not so concerned with other things.
AC: yeah it is an interesting one...
KW:...Definitely...

	Timespan	Content
17	49:32.4 - 52:03.3	AC: So just to conclude that section what would be your number one key reason for using mobile technologies in fieldwork? KW: [Long pause] well I think it's probably...I think it's that students can start to analyse data in the field themselves they've got all the data in raw as they're going along and they can see oh actually I haven't got enough data for this section or hmm the results aren't showing us what we might think so maybe we need to get a bit more data whereas if you just collect all the data go back to the field centre or go back home then you start analysing the data then you kind of go well we haven't got enough data and we can't go back out anyway so never mind let's just get on with it. So actually it's giving them a heads up on have they got the

right information have they got enough data, and I think that's good to actually save them that time but it also makes a better project for them as well I think.

AC: Brilliant on the flipside to that what is one reason for not using them?
KW: Well I can't think of one really! [Laughs]
AC: That's fine! Although I have one potentially to throw out there the research so far when I've asked students what is their number one concern about using mobile technologies I think 90% of them so far have said distraction and having those devices as a distraction be that using social media for other things while on task or having messages come through to their phone is that something you've experienced at all?
KW: I well as I've done a few interviews and questionnaires with students about this and the feeling I get from it is that they aren't as distracted in the field.
AC: That they think they're going to be yeah?
KW: Because they are engaging in active learning their mind is much more on right we need to get this done what do we need to get so they're focused more in the field than if they're just sitting passively listening to someone lecture so I actually think distraction levels are higher during a lecture when they're not as engaged rather than as they're learning actively in the field that's my feeling on it so yeah they might be distracted but how distracting are you going to be really? Like how much time can you spend on snapchat? I don't know! [Laughs]
AC: [Laughs]
KW: So actually that's my feeling that when they're actively learning, they're not as distracted as when they're passively learning.

	Timespan	Content
18	52:03.2 - 53:38.2	AC: Brilliant! Right so that is great, and that's me pretty much done! KW: Great as I have a tutorial actually in about 11 minutes! AC: Ah super that's good timing then so do you have any other questions or comments? KW: Not really other than I think the UAVs is a great idea and I do think that there is huge and so much potential out there for it, but basically we need more of you to go around and getting the footage everyone needs producing it for them and then everyone would love to use it then! AC: So on the basis of that you think it would be good to have some sort of like resource base that you could access? KW: Yeah but the flip side of that, of course, would be that would incur a cost so would the department then pay that cost and that's what it comes back to. Is it a reasonable cost so the amount of time it's going to take you to get that footage and put it together in a 3D model how much is that going to cost? Are we looking at hundreds? Thousands? How and then it becomes is it really going to be worth it... AC: ... for that amount of money yeah? It's finding that balance. KW: It's a great resource but is it really worth it and of course if someone says lets change the field trip for next year then that becomes difficult because you've invested a lot of money and a lot more time so yeah I do think there is loads of potential for it, but I don't think people have the time or the skills for it. I definitely don't! [Laughs] AC: Brilliant thank you very much KW!

OUTDOOR EDUCATION STUDENT: TRANSCRIPT

	Timespan	Content
1	0:00.0 - 1:15.4	AC: Okay right then so can you just tell me what course you're on and if you've done any fieldwork so far NS: I'm studying outdoor education, and we've done a small amount of fieldwork just doing coastal hazards and we're away in Yorkshire next week I believe doing more fieldwork for that and general day is just out in the mountain quite often we do fieldwork there so we look at the formation of the mountain while we're off hiking looking at the flora and fauna and all those sorts of exciting things AC: Oh very nice and what year are you in? NS: Second year AC: Second-year brill that's good to know...what's your opinion of fieldwork are you positive about fieldwork or negative? NS: Positive in general as long as you…you're not ripping up acres or acres of moss and calling it fieldwork... AC:...Yeah yeah... NS: I think it needs to be done in quite a conservative way you need to make sure you're protecting the environment that you're in but in general I think it's great it gets people outside it gets them understanding things its practical knowledge as opposed to book knowledge so... AC:...Ah of course absolutely...NS: There is always the possibility also of learning something new! [Laughs] AC: [Laughs] That is true! NS: [Laughs] Well that's the hope! AC: Your fieldwork that you've done so far has that sort of lived up to your expectations before you started or?

	Timespan	Content
2	1:15.4 - 2:48.5	NS: Erm its possibly been more basic than I expected I would have liked to have gone into it more but I think the nature of the course is there are so many elements that its actually quite hard and it's the sort of thing where you have to do it on your own and its actually very hard to construct your own field research! [laughs] AC: [Laughs] Yeah that is true yeahNS: So I would have liked it to have stretched me a little bit more, but research that goes into it and the background is always quite interesting AC: Do you think that that's the same across your group? NS: I think yes it is because I know with data readings and things so when we were out taking we were using different equipment to look at levels and things, and we went back into lectures and lessons it was almost sort of GCSE data work putting it onto excel creating graphs and things its stuff you do at GCSE, and obviously we need reminding of that, but sometimes you want to learn the next level AC: Yeah so you want to progress? NS: Yeah! So that was a little bit simple [Laughs] AC: [Laughs] Yeah I'd have to agree on that one NS: It would have been nice to see how that's really done even if it's been an intense sort of 10 minutes this is actually how that data is collated for real

research that would have been quite nice I suppose 'This has been done before, but we're just going to show you how it's done'

	Timespan	Content
3	2:48.5 - 4:08.9	AC: That's a shame that you don't get that that's a really interesting one. In terms of data logging, I think you said?... NS: Yeah AC: Data logging data collection do they use any specialist equipment for that? NS: We've done a few different ones were we've had specialist equipment so we did altitude and temperature so we had these little log boxes that attached to our bags and we had a climate collection thingy at the bottom of the mountain that told us the temperature and the humidity and everything else, so we got access to that and got sent all the data to that AC: Ah okay NS: So we could analyse that to compare it to our own data that we've taken, so we were using those whirlygig things! [Laughs] AC: [Laughs] Ah yes! They're funNS: So we got to play with a few different instruments, but when we're given them we're already told that they're 20 years out of date AC: Right I see NS: So we know that stuff we're using there are more advanced methods AC: Yeah? NS: So we're almost learning you know the pre-age learning [Laughs] if you can call it that AC: No that's true NS: and they're like "Well there are more advanced things available, but they cost £30000, and we just don't have that, and you're not allowed to play with them! [Laughs] AC: [Laughs] Yeah I've had that before! [Laughs] NS: [Laughs]

	Timespan	Content
4	4:08.8 - 6:04.7	AC: So in terms of mobile phones do you ever use mobile phones on fieldwork at all to collect data? NS: lots of people do, and I admit I had to buy a phone in the black Friday sales because I was so behind on being able to do certain things AC: Oh okay yeah? NS: Everyone else and especially for weather for the weather apps and GPS when we're walking and emergency things so when we're out hiking you can have access to all sort of Wi-Fi and data free contacts, and I didn't have any of that because my phone was so old! [Laughs] AC: [Laughs] I see! NS: So I was like; actually, I'm going to have to keep up, and often we're asked to take photos, and I'm never able to take photos I can't record lectures when I'm out and about, and that's quite useful, so I have had to get a phone which is my begrudging [Laughs] AC: So you didn't really want to then? Would you prefer not to have? NS: No well I worry you become too reliant on it so if I could draw and had the time I'd love to sketch a scene rather than take a photo, but actually it's not

as accurate, and my photo tells far more words than any writing I could do so you kind of had to give in, so some technologies are really helpful.
AC: Yeah...so would you agree that or would you say that mobile phone technology are useful for fieldwork in that sense?
NS: I think so I think the only thing that worries me is I'll become I'll just be looking at the phone so I'll ask a question and rather than researching it because quite often you can find out what you need to know just by looking at what's in front of you
AC: Yeah
NS: You can analyse it you don't have to ask google and I think the tendency will be "*oh I'll just look it up Wikipedia will tell me*" and you have no idea whether that's true or false whereas you can come to your own conclusions by investigating and I think it would just take that little bit away.

	Timespan	Content
5	6:04.7 - 8:07.4	AC: Do you have any concerns about the weather damaging the device when you're out on fieldwork? NS: Yes I do, but I think people need to take their own responsibility for that AC: Okay yeah NS: So you can get cases you can get waterproof carriers, and that's the other thing really I don't think people have respect for it they cost a lot of money and they just throw them around and let them break whereas I'm going to be so proud of the one I've bought [Laughs] AC: [laughs] Absolutely NS: But I've bought, and industrial one I've gone and got cases and all that sort of stuff but phones and things people see them as such a throwaway object even if they're sort of £500 which is huge amount of money I'd never spend that but they're seen as throwaway objects but if I think then people aren't as careful with something which is £50,000 because that's they're so used to that little piece of technology that you can chuck it away or maybe I can drop this piece of machinery that could cost a lot more. AC: Yeah it's one thing that's discussed in research is that students seem very happy to take their mobile phones out yet if you give them a differential GPS which is like 20k worth of kit they still treat that the same as like a £500 phone NS: Well this is it I think people are almost numb to it technology is technology they don't see it as different grades of technology and I think they're just so used to everything being safe because I'm not used to having you know the clouds and Dropbox and things like that so they're so used to having this safe place for things to go to somewhere in the ether but they kind of treat technology the same so the hard case and everything is the same whereas I'm from the generation where it was a photo and if that photo got lost burnt or a cup of tea poured onto it well... AC: You were buggered! NS: [Laughs] Yeah and that memory disappears and you are far more precious when you've had that so I do think there is definitely more I don't know what the word is...don't take the same level of responsibility for things and not careful.

	Timespan	Content
6	8:07.4 - 9:16.7	AC: Brilliant thank you. Last one on fieldwork then is what skills do you think you get out of fieldwork that you can't get out of the classroom or is enhanced from the classroom? NS: I just think it's that sense of practical learning isn't it? You can sit there and read a book or a passage a thousand times, and it won't sink in as much for certain learners some learners can probably learn that way very very effectively but for quite a few people hands on is always going to beat it. You're not going to well someone can tell you a very simple valleys are created by glaciers. Great! But they'll never understand it until they go out there and look at how those rocks are moved and then you actually not only get to understand the process but the power and magnitude of that particular situation and I think added gravitas can only enhance your want to learn as well? AC: Yeah NS: It's more exciting it's more interesting that's fieldwork for me, and I'm sure they learn an awful lot more from a base level it's more interesting and more exciting to get out and get involved.

	Timespan	Content
7	9:16.7 - 11:34.4	AC: Brilliant thank you very much! NS: You're welcome! AC: So we're going to move onto Drones now so have you ever used a drone before? NS: I have not no AC: Okay that's fine but do you know what a drone is, do you have an idea? NS: Yep yep AC: Can you tell me what you think a drone is? NS: I guess from the basics it's just a device that just flies around and can enhanced in that way can record data and I guess it started out with those funny little toys that used to play with. That's what I remember them starting out as so it's those weird little aeroplanes that used to get blown away AC: Yeah [laughs] NS: Except now they've got a lot more heavier and industrial and all sorts of different uses now but its effectively just a flying machine controlled by someone on the ground AC: yeah effectively yeah that's it pretty much in a nutshell! NS: [Laughs] AC: In terms of you mention there like they used to be these little toys is that something you've seen or you've picked up in the media? NS: I think I might have actually had one of those AC: Ah okay NS: The ones were you could literally only fly them in your living room the ones when they first came out, and I'm sure there were probably far more advanced versions around then, but my personal one was it always used to fly sideways [laughs] AC: [Laughs] Right NS: They just never followed the direction you wanted them to go! They were

just like remote controlled cars I suppose but plane wise and then all of a sudden there was this massive boom, and within a year you couldn't sit in a park without hearing one overhead they are sort of everywhere
AC: Yeah they are now
NS: And I think I don't know if cost has been involved in that whether they've just been massed produced, so people were more accessible but there was always the hobbyists who had the planes and the sort of hobby planes they were always around but the drone themselves that more stable filming platform.
AC: Yeah yeah so basically the mobile phone came along and the smartphones so they had developed these small sensors for cameras and the hobbyists basically went oh we can use that for that, and the companies got hold of it, and the cost came down, and that's why they are everywhere like you say. So you alluded there to you couldn't be in a park without seeing them, so one of my questions is how do you feel about UAVs and drones in general?
NS: I…I don't like them when they're invasive I can see you know that they can be really useful certain things you sort of think okay great they could be used in delivering certain things they can be used in remote areas they can take photographs and land scans and things like that all very useful but I don't think anyone's looked at it well I'm sure lots of people have but for me when I'm sitting in a quiet park, and I can hear that I'm like what are they filming? It puts me on edge I feel like I'm in EastEnders [Laughs]
AC: [Laughs] Yeah?
NS: So I sort of change what I do I need to start acting prim and proper not just lounging around you know being lazy looking at my book which I would be doing I just think it's quite invasive, and I think there is a lot of...I think it can be used in an incredibly wrong way and I think that is the danger. From what I've looked at there doesn't seem to be that many kind of conditions I know you have to be x amount of distance from this or that, and actually you have no idea how powerful phones are sorry not the phones the cameras you know the cameras on phones are quite good now, and I bet you can get all sort of shots and pictures flying through people's windows whatever else and you have no idea what else they can film, and I really don't like that. I think out in the wilds we don't know how that's going to affect animal life either you've got tiny animals on the ground they're just going to think its a hawk a hawk is going to think its a hawk so even in the smallest way you're changing the diversity of that landscape you're in a place completely devoid of man and there are not that many of them left you're introducing just another element, so I don't know...Pros and Cons.

AC: That's really interesting thank you. In terms of...actually we'll come back to something you mentioned just before the interview started about reading the Drone Code, so you went away and looked at that?
NS: I did yeah
AC: Was that on the basis of this, this interview or was it just something you were genuinely interested to have a look at?
NS: I think because I filled out the form and even before that they've annoyed me and I thought well what are the regulations and it's been in the news this week as well hasn't it?
AC: Yes very recently yeah yeah
NS: Yeah so I was just sort of looking into it because of that, and I was really

surprised at how loose they are, and that might be an old website, but I was just quite surprised that it's kind of oh they won't fly anywhere near an airport...well how near an airport? You can only fly up to a certain meterage and fly within a certain meterage of built-up areas and I sort of think yeah but it's just too whimsical it's too sort of...
AC: Yeah coming from an operators perspective who has the licence we as a body agree with you that while we adhere to the rules you've seen it yourself you mention about sitting in a park and see them. I go to Crosby beach every weekend, and you'll see someone flying about this high, but there is no enforcement which is a shame it does give the UAV a bad light in a way, but it's the operators but its definitely interesting that you should mention the animals. They started using them in the Antarctic to look at Penguin colonies, and they had exactly the same thought that the UAV looked like I think it's called a Skewer I think it was one of their birds of preys and they started to investigate at what height do they fly it at that the penguins don't get affected by it, so it is nice that people are starting to think about that although maybe they are a little slow in it coming about.

	Timespan	Content
8	15:28.3 - 15:28.9	NS: It's always the way with technology it goes so quickly now that it's almost just you have to go too far with it in order to rein it in they have no idea how far that technology is going to expand and it's so it's sort of exponential in the way it goes we sort of go [intake of breath] the implications are massive [Laughs] Lets rein it back in! [Laughs] AC: [Laughs] NS: [Laughs] take control again! AC: Absolutely I agree [laughs]. So you mentioned there about UAVs and how you feel that they can be used in a wrong way we kind of alluded to it in a way about the effect on animals and even their effect on remote places so how do you feel about them then being used by an operator on fieldwork?

	Timespan	Content
9	16:12.2 - 17:38.9	NS: I think it will be down to training AC: Yep NS: You know It's going to be people who are aware of what they're filming but they don't you know you can't just be aware of I want to look at the landscape to see you know this particular part of the coast is you know moving or whatever it is you also need to know that part of the coast you can't just, so you need to know what your birds of prey are you need to know who lives there as well as you're bound to have residents and things around so if you've got to look at things like that so I think it is going to be down to training. AC: So training for the operator yeah? NS: Yeah and if it really needs to be done? AC: Yeah? NS: Is it just that someone is being really lazy and its easier is it actually the best method you know sometimes they're used because they're a bit gimmicky AC: yeah yeah NS: So that has to be avoided you know oh that's cool it's a drone and I can do this and look at this cool technology and yeah that's great but could you have actually done that on foot or do you have has there already been research there

are you just kind of treading on ground that's already been tread on I don't know I think sometimes people like to just do things because they're a bit more fun [laughs]
AC: [Laughs] Yeah that's fine yeah brilliant my next one would be what would be your number one out of all of them what would be your number one concern for UAVs being used in fieldwork?

	Timespan	Content
10	17:38.8 - 20:10.2	NS: On fieldwork? Hmmm...I think it's probably just the disturbance of the general peace because they're not quiet and I think it's basically an alien within the environment isn't it you just never know what that's going to do, and I just find them so distracting. AC: Yeah? NS: If I'm there and I'm working that sort of noise in the background, and I guess if you're a solo person and you're working on your own, and you're not interrupting anyone else's day then that's an ideal situation, and it probably works quite well and obviously in very remote regions were you don't ... were you want to protect the landscape from footfall there are a lot of positives to be had for it but you just need to keep it under control. AC: So for you as a student then would you prefer it wasn't on your particular trip for example say you went to Yorkshire would you prefer that the outputs from the UAV for which we'll come onto later was already done the flying was done rather than it actually taking place while you're on fieldwork because you mentioned there it might be a distraction? NS: I don't know it depends on the context really if it was part of my course to study how a drone was being used then I would want to see how it's being used but if I'm there, and I'm collecting my own data, and there is a drone buzzing around then I'm going to want to look up or come over and see what's going on because it's a little bit more interesting than looking at me and my measuring stick or whatever so I yeah I would probably prefer that they weren't there but I just...I find them very... AC: Distracting? NS: [Laughs] Oh yeah! It's just that background noise it would be like sitting...I described it earlier to someone as a massive invasive wasp just get it out of my head you know like tinnitus [Laughs] AC: [laughs] Yeah NS: So probably not but it would depend if I could if you're in a situation sometimes it's quite useful to have a video of it its quite nice to have that video to go back and look on so from that its quite positive you've been on that day you can't take everything in and you can sort of go well someone's taking a video of this I can look at that I've been there look I'm there, and you can see me there I am [Laughs], and it could remind you of everything you were doing... AC: ...Ah okay...NS: So from a writing up point of view it's probably quite useful, but this is it I'm totally torn! I can see the positives, but I also find them, but that might just be me and my age and my kind of not used to it being there yet? [laughs]

	Timespan	Content
11	20:10.1 - 21:13.3	AC: Trust me you're not the only one to bring this stuff up which is good it's really good to explore these things. So you mentioned there in terms of you

had one of the positives was to have a video to look back on is that in terms as well as you get a different perspective of the landscape from being high up with that birds eye view?
NS: Oh yeah totally you'd get...there is only so far your vision can take in...
AC:...With your own eyes?...
NS: Yeah! So you'd have to stand there for hours and write everything down for hours whereas you know if you have something you can constantly click on and look back on okay there it is there it is you know kind of like a checkpoint?
AC: Yeah
NS: That's really useful from just a memory point of view
AC: Yeah Yeah
NS: Photos are very flat as well you can take a photo and actually that feature doesn't stand out very well whereas if you've got a 360 video and you spiral around and go ah there you go! [Laughs] there is it! that's very useful

	Timespan	Content
12	21:13.3 - 26:44.0	AC: Brilliant because that leads me on nicely to the outputs...we have one here this is usually smoother, but it is the mouse! Okay, so this is Thurstaston I think you go at the end of this year maybe March TS may have mentioned that before? NS: Hmm maybe... AC: But maybe third year but you'll visit this place it's just on the Wirral, and you do some glacial till work which goes over my head [Laughs], and basically you focus on this section of cliff, so we used the drone one day when students weren't there, and we went and flew it in such a way all within the regulations etc. and we created one of the outputs so from flying it we didn't create a video but we did stills you can create a 2D map so you can basically zoom in to quite high levels of details and one of the things I did is to make a 3D model, and that's really interesting that you mentioned having something to look back on and to click on... NS:...Yeah... AC: So I just kinda want to get your general thoughts and feelings of if this would potentially benefit you in any way as a student so I'll let you move around the model it is easier with a mouse you can zoom in you can double click you can zoom in so if you just want to play around with that and I'll try to get this mouse to work. I'll talk a little bit about the numbers and what they mean too in a bit. NS: Oooh I've just turned it upside down that's exciting [Laughs] AC: [Laughs] Yeah so when we role this out properly because this is our first draft as it were and what we will do is build it in so that you can't physically go upside down etc. NS: Ah okay I've got it back now! AC: So yeah with the tracker pad it's not as easy. NS: Do you know what is useful about this? AC: Go on... NS: You can use it as a climbing tool so quite often you'll go to a crag... AC:...Yeah?... NS: And its described it will be described in a sort of book a, and it will be like you know this is a 7 climb, and it has this amount of placement blah blah blah if you had stuff like this you could actually look for gear

placement areas...
AC: ...Ah as in before you go?...
NS: Yeah! So just as a actually looking at the landscape will give you a much better understanding of what you're getting yourself into and what sort of kit you needed
AC: Ah okayNS: need to take as well, so you're looking at this and thinking well would it be helpful if I took this climbing gear or this climbing gear how accessible is this area so you could have a more productive time while you were there.

AC: Ah okay that's a really interesting application for that! So yeah that's a really good example of using it then so do you think this is something that would be useful to say if TS said to you-you're going to be going to Thurstaston Cliffs and he gives you this model would you prefer to have that before or after you went on your field trip?
NS: Access to it both would be brilliant, but I think almost if you had it before because quite often you waste so much time when you're there assessing something whereas if you had access to this, to begin with, you'd already know certain angles to be looking for...
AC: So you think it will be more efficient?
NS: Yeah and your equipment can be set up in areas of focus all those sorts of things will be really interesting... this is cool! I didn't know you could do all of this!
AC: Yeah this is one of things...
NS: Must be a very advanced drone!
AC: No any drone can do this you wouldn't have the good quality, but it's basically how you use the images and how you fly it. So one thing we're thinking of including is the element of directing so in the literature people use virtual field guides while it's in its infancy a lot of students complain that they feel that they get lost or as you mentioned there it goes upside down, and it's like Huh? You know what's happened here. So this software here you can highlight certain aspects of the model and pull the student around it effectively so for example here the cliff cuts in due to erosion and you get a breakdown there and in the future ones we're hoping to have a little video in there and you click on the next one and you can click on further links so that could be an external video or a paper. So just on those two points what's your thoughts and feelings about that?

	Timespan	Content
13	26:44.0 - 35:16.4	AC: Do you think that would be useful for your learning? NS: I think it's very useful actually I'm surprised at how useful I think it is I didn't realise that...I prefer probably just prefer the idea of the drone being used when I'm not there! [laughs] AC: [Laughs] Yeah? NS: [Laughs] So I like the idea of accessing all the data that the drone has and again I guess that just comes down to managing it and there aren't thousands of people going around getting this sort of data but this sort of stuff is really useful just before you go because it's a good sort of intermediately you've got that classroom learning, and you've got a book and you're learning from it whereas this is somewhere between the physical and the sort of a little bit more tangible you can kind of go around you can explore it whereas if I'm

there I'm not going to feel as like oh here I am I'm dumped in the middle of a landscape.
AC: Okay so you'd feel a bit more prepared then yeah?
NS: Yeah you sort of know what you're looking for and compare like oh yeah I remember that happening or I didn't expect that to be there would be quite good!

AC: Vice and Versa then in terms of post-fieldwork is that something similar in terms of like you get a bit more time if you're like 'Oh I didn't quite get to see that area'?
NS: Yeah I think so
AC: Because one thing here that I personally quite like having visited this field site with last year's cohort to just get an idea of the site that this all up here there is no path to it so this is a small fence up there and part of it is this is all glacial till and the direction of the till and the clasts show which way it came but TS said to me this fieldwork is fine for students but they can only look up from the ground; therefore, you can't see what's in the cliff whereas with this and the drone you can then...if this mouse decides to work...you get the idea you can zoom into different viewpoints that you don't quite get the chance to see. So that's one thing we're hoping that people like yourself which is good because what you've said is matching up to our ideas about *"lets me be more familiar and more efficient"* and then you come back and use it for *'Oh I didn't see that bit'* or you can use these different resources to look at different papers in terms of this then one question is although this is all written text how would you feel if that was an audio file of say TS, for example, discussing that do you have a preferred method at all?

NS: I would probably prefer to read it but I know lots of people...TS does a lot of verbal feedback and audio feedback when we've had papers and a lot of the class really like that because it's just better for the way they learn and the way they listen from more audio base, but I think it's just nice to have the different accessibility. I think it's interesting because this makes it look...I don't know what the word is...it makes it seem less invasive so potentially when people do use drones in the future they'll use them for more productive reasons and maybe through learning with drone images and things they'll come to use them in the future and be like oh actually it isn't just for this which is probably where my ideas were which is just a load of people spying on people [Laughs] whereas actually it's got a good practical use as long as you're sensible with it.
AC: So has this surprised you then?
NS: It has surprised me yeah! Because it's far more valuable to me than I expected it to be
AC: Ah okay yeah
NS: In my learning and in my research that would be something that would be really helpful! [Laugh] So yeah!

AC: Brilliant that's good to know. I guess my final one is and this is always a contentious one could you ever see this ever physically replacing you going to a field site?
NS: No
AC: And why would that be?

NS:]Pause]....Again it's quite interesting...I want to be there, and I want to see it because that helps me learn and understand because you know you're touching and you're feeling etc. etc. but potentially it would stop 20 people descending every day and looking at that particular landscape, so actually you could be preserving quite a lot of landscape...
AC:...That's interesting...
NS:...by taking the fieldwork a bit more virtually and you could be protecting the landscape but from my point of view I just enjoy being there in the landscape and being there and I think being there gives you the inspiration you know it gives you-you know if I was just playing with this all day I wouldn't always want to play with this I would probably get bored and go onto another subject whereas if you're actually going into the field and your there and you have the wind and the rain or the sunshine whatever it might be that day it actually inspires you to stay within that field and to keep that interest there so yes I think it's very useful and I quite like the idea that it would stop everyone trampling the countryside but I just love being outside so it would just take that bit of pleasure away.

AC: Yeah that's brilliant I guess one final question would be although the technology is not there yet this is hypothetical but if you had those 3D goggles on and you could physically walk around
NS: Oh yeah! AC: Say a sports hall, but you're virtually there, but not physically there I guess it's still the same in terms of what you said...
NS: Yeah but I think from my university point of view probably it wouldn't be as helpful to me as I would just feel I was in a game.
AC: Yeah
NS: You know it's just a bit too virtual but actually if you take it down the line classes that are taught in primary school they'd get huge amounts out of that and you know if especially if you can start to add other elements into it for them and in areas where they possibly don't get as much funding and things like that it's a really good alternative to get children interested and to understand, and it's fun to them and they've obviously got a lot more of a positive relationship than I do with technology as well so they're always going to be a little bit more willing to understand it so yeah I do think it has positives I am surprised at how many positives there are, but I don't think it will ever replace it.
AC: That's fine that's good to know. So I guess my final one and I know I've said that now about fifty times
NS: [Laughs]
AC: But is there anything else as a student you would like from a model such as this that hasn't already been presented?
NS: Obviously it's not possible, but it would be quite interesting to be able to layer the history within it?
AC: Oh ok
NS: Does that make sense? So you know or predictive qualities as well so if you've filmed it for five years you can layer it up your five years and say well we know from these five years that actually this may happen in the next five years so layering capabilities would be quite interesting
AC: Brilliant
NS: I don't know [Pause]
AC: Well that's quite a good one! NS: That's probably my only one I like the

fact you can bring in audio perhaps links to similar landscapes you can sort of go here is an example of here and here is another you know down the coast in Summerset or whatever this is the same so you could almost if you're looking at a say this was coastal weathering or glacial till whichever one it is you can look at other examples around the country and compare each other with different rocks because you've got this is this is this is this, and actually this is the difference between the rocks in these different areas etc. etc. so these links to...you know make it easier
AC: So other sites or other models?
NS: Yeah
AC: Brilliant thank you very much that's me done do you have any questions or comments?
NS: No it's been enlightening thank you!
AC: No thank you!

OUTDOOR EDUCATION FOCUS GROUP

AC=Interviewer

Timespan	Content
1 0:00.0 - 2:16.3	AC: Right okay so we'll crack on with our first question then so using this graph the one with the orange and blue on okay so looking at this graph then this was I asked students how they used their mobile phone on fieldwork, so the main one that students tend to come out with was using it for mobile apps checking the university app, and their emails is that something you guys agree with is that something you do? DM: Uhumm EC: No JR: Yeah I use it for that quite a lot actually DM: Oh just in general or for educational purposes? HK: For fieldwork trips? AC: Yeah so looking at the checking the emails and apps bit first the university app is that something that you guys use quite often? HK: Yeah all of the time AC: All the time? HK: For me anyway DM: Not really on my phone though EC: Yeah not really on my phone AC: Ah okay JR: I don't think the actual app itself, but I think taking notes and things like that AC: Yeah so you mention you use it all the time there HK: What do you mean? Like canvas? AC: Yeah you access the app HK: Yeah I use it more on my phone than I would... AC: On a computer? HK: Yeah AC: And why do use that more? HK: It's just more convenient you've always got it in your pocket so you can just check it if you need to check something rather than going to get your laptop JR: Very True AC: Brilliant HK: And with emails, it's just linked up to my phone, so it goes straight through AC: Ah okay yeah HK: So just means I don't have to get the laptop out to check, so it's just convenient AC: Brilliant EC: I don't have mine linked up to my phone my emails JR: Nor mine DM: Me neither EC: I can't figure it out so HK: Get Tim to do it for you...sorry I'll just be one minute [HK Exit] DM: I'm just usually not that bothered like when I'm in University I don't bother checking my phone for stuff that's happened in University because I'll just ask someone. JR: If I had the option to link my phone up which I've tried to I've gone to the librarians, and they couldn't do it...I would do it, but I can't find a way of doing it.

EC: I don't know a part of me is always in the mindset of I've always...University is a bit like work in a kind of way my phone is for personal use rather than anything for University I do it on my laptop...
DM:...Yeah...
AC: Rather than your phone?
EC: Yeah rather than my phone

	Timespan	Content
2	2:16.3 - 2:42.8	AC: So do you see your phone then almost as your personal space? EC: My personal space yeah AC: So you don't want that invaded? EC: Yeah DM: Yeah it's a like messy space EC: Laptop is where all the work goes RK: I do think because we're first years as well like we don't need to use it as much because we're not getting all of this stuff in rather than I think second and third year you get a bit more information and stuff EC: Yeah ours is more simply laid out once you've read it you kind of know what's happening

	Timespan	Content
3	2:42.7 - 4:13.9	AC: brilliant that's great, so one or two of you mentioned using it in lectures for note taking? RK: Yeah I did AC: So you use that...is there a reason that you use that rather than your traditional pen and paper? RK: Because it's so quick and easy especially say if you're out on practical or something and you can take notes and its rainy wet windy whatever having a piece of paper flying around trying to write is very difficult plus you need something to lean on so if I have a real flimsy book it's so difficult to write on whereas my phone I can type really quickly has spell check and everything done for you EC: Yeah but in class you don't actually use it to take notes it's all good saying oh yeah it's convenient, but we don't actually do that no one actually sits in class on their phone taking notes of what the teacher says we all sit there with a laptop or a piece of paper RK: I think it's more constructive for when we're on practical's AC: Yeah EC: But on practical's, some lecturers have specifically said we're are not allowed to take notes on a phone AC: Oh okay while you're on practical is this? EC: Uhumm Some practical and out and about we're not allowed to get our phones out AC: Do they give a reason? EC: Yeah because they think it distracts DM: Yeah AC: Right EC: It distracts from the actual learning so if we physically write down and draw diagrams of what we're seeing and learning on a piece of paper it's better than having your phone or if something pops up on your phone you get distracted by that and next thing you know you're not paying attention

AC: Do you think that happens quite often or?
EC: Probably
RK: It can do it can do for many others too not just ourselves
AC: Yeah
DM: Because it's easy to just for me to go onto notes on my phone I can just then pop onto snap chat
HK: [Enters back into the room] Yeah
DM: Check messenger...I'm bad at that

	Timespan	Content
4	4:27.2 - 6:15.9	AC: So when you're on fieldwork then and you feel you may be distracted by your phone and stuff is that because it's not engaging in terms of what's happening with the landscape and the actual teaching that you feel you have to? EC: No I wouldn't say…Well you get your phone out, and you look at the screen and you instantly get diverted from all of the surroundings you're focusing on this one screen, so of course, people do get distracted RK: Yeah DM: Sometimes lecturers can put you to sleep a little bit, but I'm not usually so rude to get your phone out... HK:...Get your phone out... DM:...because I'm bored, or there is nothing to do you just go I'll check my phone AC: You mention there in terms of note taking when you're on fieldwork if you're allowed to do it how do you see the benefit of using the phone regardless of the distraction element how do you see that benefit over the traditional pen and paper you mentioned about weather may affected it EC: I personally don't think there is a benefit in using your phone HK: I do EC: I don't like using my phone for notes I don't like getting it out I'd rather write it down AC: Okay HK: Erm one thing I will say is like for instance setting up a certain so when we went climbing because I didn't know every knot and stuff I found it quite useful to take photos, and you can go back and like you'll know what type of knot and things is AC: Yeah HK: Maybe that's for me because I don't know a lot about it I found it very useful and especially when they say you draw a diagram and stuff you can just forget whereas if you take a quick photo, you can just go back to it AC: You've always got it kind of thing? HK: Yeah I find it helpful for that way

	Timespan	Content
5	6:15.8 - 7:35.2	AC: Brilliant thank you DM: I don't tend to use it, but I guess the benefits would be it saves space and weight because you're not carrying three or four extra things it's convenient it's simple like we all know how to use our phones, so we don't have to fanny around

EC: Well I'm not organised enough getting your notes off your phone onto somewhere else
ALL: Uhumm
EC: Normally if you make notes on your phone they just stay on your phone
DM: Yeah I'm not organised enough to bring a pen and paper [laughs]
ALL: [Laughs]
HK: So I think it is useful in a sense because you can get certain apps that will link it to your computer
AC: Like Evernote?
HK: like...something...I've got...
AC: Dropbox?
HK: No hang on I'll tell you dead quick [Pulls phone out of pocket]
EC: Was it an Apple one?
HK: No it's a Microsoft one
EC: One note?
HK: Oh it's One Drive!
AC: Ah One Drive yeah
ALL: Ahh yeah!
HK: Yeah you get all your Microsoft office stuff linked in
AC: So it's almost as if it's a practical element then in terms of if you had the knowledge to use say Evernote, where you can link everything up, is that something that would interest you or do you still prefer your traditional methods?

	Timespan	Content
6	7:35.2 - 8:49.2	DM: I don't think I'd use it any more, but I probably would use that if it was simple, but I don't think I'd use it more HK: Yeah DM: I'm just comfortable with how I take notes in the moment EC: Yeah JR: I think it's good to have both though because if your phone dies you've got the pen and paper and if the wind or rain or weather whatever then you've got your phone to use, so it's a bit...it's good to have both AC: So you don't want to replace one or the other it's just nice to have the option of both, but I get the sense majority is that you prefer to use pen and paper for notes? ALL: Laugh yeah AC: Which is fine! EC: You think it's simpler then you try and use a touch screen with cold fingers and… DM:...Yeah, my phone does tend to have a little bluh if it's like wet... HK:...I also think DM:...If it's wet and dies... HK:...It's quite say if you're doing something and you don't want to start taking notes because you get distracted because I get distracted when I take notes, and you don't listen properly I think I don't really use it well I've used it once doing it I think it will be quite useful you know to put a recording on? AC: Yeah? EC: Yeah HK: And you've just got them speaking through, but you can take your focus off that and like focus on the practical bit that they're doing if that makes sense? AC: Yeah so that's doing the listening for you yeah?

HK: Yeah

7 8:49.1 - 12:09.1 AC: That's brilliant thank you very much so yeah so when I asked students those who do use mobile technologies on fieldwork these are the four main issues that came out in their concern, so number one was weather damaging the device in fact 83% said that. Is that a concern that you would have if you went to use it?
EC: Yeah
DM: Yeah
JR: Yeah
HK: Not for me because mine is water resistant the phone, so that's good
DM: Mine was supposed to be, but ever since we went climbing since then the little scroll and the tabs haven't been up there I have to go onto settings, so it does damage it
EC: Yeah mine said it was waterproof and I went walking in the lake district and took a photo, and it was its downfall
HK: Mine actually is you know when you get those clear cases to go into the ocean with them? Well I went in like the sea and it was open it wasn't shut properly and because I was nervous I didn't just want to go underwater with it but that had leaked all in so when I came out the thing had all water in it and I was like well I just wiped it, and it still worked.
AC: So what type of phone is it?
HK: It's an iPhone 7
AC: Oh okay
HK: Like they do work I know people who do use them in a shower and everything you can use them in a pool up to a certain depth up to a certain amount of time and you know there was nothing wrong with it when in the past I've had an iPhone 6 where a tiny bit of water will ruin it but that didn't.
AC: For you guys who don't have the phone like that if you are on fieldwork then would you see that as an expense if you had to go and buy something to keep it waterproof if you don't see the benefit of using it?
EC: I put mine in those zip plastic zip lock bags [Laughs]
DM: The food bags?
AC: Ah is it hard to physically use it?
EC: Those food bags yeah or if you go kayaking…
DM: …You can still use the screen…
EC: I just double bag it and that's like what? 15p per bag?
AC: If that!
EC: It's no expense
AC: Do you lose that usability though?
EC: yeah but to me, that's no issue because I know I won't be using it for note taking I won't use it for anything for me it's practically there to use it for a photo quickly maybe of what's happening or for an emergency if I need to call somebody so
JR: See I tend to put it in a dry bag and only bring it out when I need to use it
EC: Yeah
JR: It keeps it from being out of my pocket and keeping me distracted

AC: On the weather damage a lot of students said dropping the device was a concern
EC: Yeah

JR: Yeah
HK: Yeah
DM: Nah mine's a brick!
ALL: [Laughs]
AC: Is it a Nokia 3310? [Laughs]
ALL: [Laughs]
DM: It's a Sony Experia
EC: Oh yeah that's the one that promised me it was waterproof and it wasn't!
DM: It has been in the past, but it's not now
AC: So that is a concern dropping it bar yours?
JR: Yeah it's gotten to the point now where I've had to put a little thing on it
DM: A little girlie strap! A Bra strap!
JR: Just had to be pink didn't it! So whenever I'm on my phone, I have it around my finger it's such an incentive to have my phone and wear it like that on my finger
AC: Ah nice
JR: So not being in bed holding it like that [Laughs] but when I'm on the rocks I'm always really nervous about it falling off but not anymore!
EC: Everyone smashes their phone now though

	Timespan	Content
8	12:09.0 - 13:51.6	AC: If say the university said here is a couple of phones or iPads go and use them on fieldwork how would you feel about that? DM: I prefer using my own I think if they're giving it to us they know the risk so I would be as careful as I can AC: yeah yeah DM: but if I broke it I'm so sorry, but I wouldn't be as panicky if it was my personal device JR: Very true DM: But yeah they have the understanding that they've given it to us knowing the dangers JR: unless they had like certain things behind it to protect it AC: yeah they'd be in cases EC: So a lot of the time if you think about you send like kids on field trips out...why do you do that? You do that to get them out of the house to stop looking at screens and what are you doing? You're sending them outdoors into the mountains and saying here stare at the screen, so everything is becoming about technology and looking at the screens, and it's awful why use a screen a phone or an app when you can just use a piece of paper! DM: Yeah AC: That's a fair point JR: Teachers teachers EC: It's just having it for the sake of having it, and it's making it seem like as if it's the norm and that puts pressure on people to buy the latest stuff, and it just spirals you know? HK: You know there is a case like an Otterbox they're a really good case, but they're expensive like yeah if someone can't afford that they feel like they have to use their other phone its good if you can go and get one AC: If you've got it yeah? HK: Yeah

	Timespan	Content
9	13:51.6 - 15:50.5	AC: So that's great guys so this is something that students came out with the questionnaire of some of the benefits they thought it may give them so I just want to get your ideas on this so one of the things that came out was data collection and sharing element so you may go on fieldwork and use your paper and pen, but you still have to go back into the classroom and put it into excel for example, and then you've got those extra steps whereas these students said they used it to collect data digitally straight onto Excel from their phone or tablet device, and they could all add that stuff in remotely, and there is other skills like employability, so they see that being proficient in using mobile technologies increase their employability skills so out of those two what's your thoughts on that? Would you agree or disagree? EC: Yeah I agree HK: I disagree in the sense that like even when say for instance I'm doing an essay or something I'll write stuff down first I always like to write things first then I've always been like that way AC: Yeah HK: So instead of getting I don't know a graph or something I prefer to write it all down and then go and do it, so it doesn't bother me if it's going to take a while AC: To do the extra steps? DM: And if you do straight from whatever you're doing straight into a document you never go through the stage of re-reading it or processing it or enhancing it from your original notes so like when you do transfer it, you can always you know you're learning rather than just sticking it in there and leaving it AC: And forgetting it yeah? HK: Yeah AC: Really good point...Do you guys agree? JR EC: Yeah AC: Any other benefits or hindrance that you may think that we've talked about? ALL: Nope

	Timespan	Content
10	16:02.7 - 16:41.0	AC: So we mentioned well we touched on this before some of the potential hindrances and problems that students may have so we've kind of discussed distraction already and fails and breaks and the preference for traditional methods and that's come out here, so that's good to know HK: When your phone gets to a certain temperature it just switches off as well! EC: Does it? HK: Yeah so what are you supposed to do if you've got nothing to write down? AC: So yeah it's that technical aspect of it as well

	Timespan	Content
11	16:41.0 - 19:41.4	AC: So if we look at the other graph now this was slightly different this was the University of Chester, and what they've said and this graph is what you guys as a university said EC: Which one? This one? AC: Yeah that's the one it's just slightly different in the way its formatted so this

was basically I asked students to rank what was most important with 1 being most important to five being the very least and it was basically what helps [Interruption] …ranked 1 to 5 so if you look at the graph you've got look number one that came out was helping the connection of what's taught in the classroom and making that link is that something you agree with? Is that the number one most important to you on fieldwork?
EC: Yeah I suppose it's how people learn for me it's putting that knowledge into a practical setting and being able to experience it yourself
AC: So you'd have that as number one for you?
EC: Yeah you can't just learn everything through reading a lot of the time
JR: People learn differently kinetic and astatic? And there is another one visual?
AC: yeah
JR: So you've got to kind of cater for everyone
AC: Yeah...so there are two parts to the graph I want to focus on the 3rd ranked one is social and personal development what is it about fieldwork that you feel is the social and personal development aspect?

JR: You learn from each other
EC: A lot of communication and teamwork a lot of the time
DM: Everyone likes to ask each other a lot of things
EC/HK: Yeah
DM: Which is helpful
JR: No one wants to get it wrong everyone asks each other looking for help but not just help just reassurance
ALL: Yeah
AC: So in terms of that if you're struggling or trying to get information would you ask your classmates first before you went and asked Tim for example or looked it up on the internet for example?

DM: Depends on the question doesn't it?
EC/HK/JR: Yeah Yeah
HK: It depends on if you know someone has got a good skill in something and you just want to ask a certain question to make sure that's the right thing you would ask them whereas if yeah
DM: Well in climbing I wouldn't hesitate to ask EC anything and Paddling it would be Matt but then if it's like a specific learning thing then I'd always ask the tutor usually
EC/HK/JR: Yeah
AC: So you're kind of identifying individual experts...
DM:...Specialists in the group yeah…
AC: And if you don't have that you then go to Tim for example?
All: Yeah

	Timespan	Content
12	19:41.3 - 21:04.8	AC: Brilliant my final one of this across the board the experience a landscape or area in person ranked least the least most important what do you guys think about that? Would you agree with that disagree with that? Out of all those would you rank it as that? EC: So do you mean the area you're going to? AC: Yeah so physically being there and experiencing the landscape HK: No I think...

DM: Maybe how its worded like it's pretty blasé, but I think it is pretty important
EC: I think it's important and it depends what people are looking for
JR: I think it comes under self-development more
EC: On fieldwork, you go and look for a specific thing you're not normally going to look at the greater you're not going to look at the top of Trifan and look at the view potentially you'll be going to look at certain rocks, so I don't know
AC: great anything else?
JR: I think it does encourage a self-learning kind of side to it to have a look for yourself try and work out what you think of it and can do with it and then get the information from someone else

	Timespan	Content
13	21:04.7 - 21:53.8	AC: brilliant thank you and one final question do you ever use social media on fieldwork? DM: Yeah EC: Social Media? AC: Yeah so your Twitter or JR: Oh no DM: Not for the benefit of the fieldwork AC: Just for general use then? EC: Yeah I don't have Twitter or an Instagram account [Laughs] AC: [Laughs] Okay DM: No JR: Not for this only for a self-journal kind of aspect of it like this is what I done then and I can if I need to look at it or doing my ML I've taken loads of photographs and put it on social media and say I've done this and this then log it onto my ML and do it with that AC: Brilliant JR: But personally I don't really do much of that social media person I hate it causes too many arguments DM: [Laughs] EC: I always think why do people want to know DM: Yeah I don't care what you're doing! [Laughs] AC: Right you guys got any other questions or comments? EC/HK/DM: Nope AC: That is literally it from me thank you very much.

APPENDIX M: INTERVIEW CODEBOOK

Code Book before theme generation

NODE	DESCRIPTION	SOURCES	REFERENCES
3d model is good	Indications of positivity around the model	7	17
Delivery of model	Mention of how to deliver the model i.e. pre or post fieldwork	2	6
3d model an intermediate learning boundary between physical and actual	Used in conjunction virtual world and the real world	4	5
3d model before fieldwork	Preference for 3D model to be used before fieldwork for different reasons	7	15
3d model good for teaching	Reference to the model being beneficial for teaching in some capacity	1	3
3d model inclusive for disabilities	Reference to the model being used for disabilities	2	2
3d model increases efficiency in the field	3D model increasing student efficiency in the field	3	4
3d model increases productivity	3D model increases productivity in the field through the ability to plan	3	5
3d model might replace fieldwork	Thoughts about the model replacing physical fieldwork	2	4
3d model prepares students for fieldwork	3D model prepares students for fieldwork	4	8
3d model representation	How the model represents real world environments	4	11
3d model scale	Scale in 3D model	3	5
3d model to be used before and after fieldwork	Mention of the model to be used before and after fieldwork	6	6
3d model used as a discussion tool post fieldtrip	Model used after fieldwork as a discussion tool for practitioners	3	15
3d model useful for student learning	Benefit of model for learning such as efficiency but also discipline specific	7	23

Ability to make mistakes and learn from them in fieldwork	Fieldwork allows an environment to make mistakes and learn from them	2	7
Ability to revisit with mobile technology	Ability to revisit locations or data with mobile technology	2	3
Ability to take photos with mobile technology	Ability to take photographs with mobile technology	4	5
Alternative non-digital resources	Non-digital resources used for an alternative to fieldwork	1	1
Analysing data more efficiently	Can analyse data more efficiently	2	4
Annotation	Types of annotation wanted on the model	6	10
Assessing fundamentals	How practitioners assess the fundamental concepts of the course	4	6
Audio annotation	Audio annotation on the model	2	2
Background information	Background information of respondent	3	4
Barriers to using uav	General barriers to using UAVs	3	5
Benefit of 3d model	General benefits to using the model	5	24
Benefits of fieldwork	Direct benefit of fieldwork (maybe a theme in itself)	7	16
Bringing the field site to the student	model and resources allow the field site to be brought to the student regardless of location	2	3
Centralising data	mobile technologies allowing Applications and others to collate and share data	3	3
Challenge of fieldwork	General challenges of fieldwork	2	2
Changing a fieldtrip to accommodate disability-anxiety	Changing a fieldtrip to accommodate student anxiety or disability	3	6
Changing attitude of uavs	Respondent indicated a change in attitude towards the UAV throughout the interview	1	1

Changing nature of fieldtrips	Field trip delivery or location changing due to pressures or time	5	7
Changing nature of teaching with technology advancement	Fieldwork changing and delivery of fieldwork changing due to the advancement of technology	2	7
Collection of uav data	Mention of collection of data from the UAV such as videos, photographs, models	5	18
Communication	Communication skill developed on fieldwork	1	1
Communities of practice	Mentions of communities of practice evident	1	2
Compulsory fieldwork	Compulsory fieldwork trips	4	6
Concern about dropping and damaging mobile technology	Concern about damaging or dropping the device	1	2
Concern of reliance on technology	Concern about the reliance on technology over traditional skills	2	4
Confidence skill	Confidence skill developed on fieldwork	1	1
Conflicting thoughts on uavs	Respondent conflicted between the good and bad points of UAV operations	1	1
Confliction of virtual fieldtrips	Confliction of feelings over the use of virtual fieldtrips	1	2
Connectivity issues	Connectivity issues of the device to internet or email	3	4
Cost of specialist equipment on fieldwork	High cost of specialist equipment on fieldwork	1	1
Cost of uav-3d model resources	Mention of the cost of the UAV	1	1
Data collection in the real world	Using mobile technology and fieldwork to collect data in the real world or make the connection between the two	3	6
Different learning styles	Mentions of student different learning styles on fieldwork	1	1
Different technology for different purposes	Different technology used for different purposes (versatility?)	1	1

Digital natives	Mention/allude to of digital natives	2	2
Disabilities in fieldwork	Disabilities in fieldwork	3	8
Discipline	What discipline the respondent belongs to	4	11
Disconnect between cost of own and unit equipment	Students place higher value on personal equipment over expensive university equipment	3	6
Distraction on fieldwork	Distraction from mobile tech in fieldwork	2	3
Don't really use smartphones on fieldwork	Students not using smart phones	1	1
Efficiency in the field	Making the most of your time in the field	2	6
E-learning on the move	E-learning on the move	1	1
Employability	Direct mention that fieldwork increases employability	2	2
Engagement with 3d model	Student engagement with 3D model	2	3
Enthusing and motivating students on fieldwork	The role of the tutor and the challenge of keeping students Enthused and motivated on fieldwork	3	6
Equipment out of date	Issue of equipment used on fieldwork out of date or obsolete	1	1
Error of uav collection	UAV can have error in the data such as no GCP	1	1
Ethical concerns of fieldwork	Ethical considerations of fieldwork	1	1
Experiencing a landscape in person	Reference to Experiencing a landscape in person	2	2
Experiential learning	Reference made to experiential learning taking place on fieldwork	6	11
External benefits to 3d model	External benefits outside of fieldwork and H.E	2	4
Familiarise a student with an area	3D model used to familiarise a student with an area	1	2

Fieldwork delivery	Any mention of how fieldwork is delivered i.e. residential/day trips etc.	6	10
Cost of optional fieldwork	Reference to cost of optional fieldwork	1	1
Day fieldtrips	Day fieldtrips that take place in the university	3	7
Optional field trips	Optional fieldtrips that take place in the university	3	3
Overseas fieldtrips	Fieldtrips that are overseas in the department	2	3
Residential fieldwork	Fieldtrips that are residential in the department	3	7
Uk based fieldtrips	Fieldtrips that are based in the UK in the department	2	3
Fieldwork important to discipline	Fieldwork is important and part of the QAA benchmark	2	4
Fieldwork is fundamental	Fieldwork is fundamental to the discipline	1	4
Fieldwork is good	Fieldwork is generally positive	4	12
Fieldwork is not a jolly	Fieldwork is not a holiday	1	2
Fieldwork is why they are teaching	Fieldwork a reason the practitioner teaches	1	1
Fieldwork issue clashing with other subjects	Issue clashing with other subjects	1	1
Fieldwork issue students working in jobs	Students working in jobs	1	1
Fieldwork leads to dissertation research	Leads to dissertation research	1	1
Fieldwork limitation	Fieldwork cannot do everything	2	3
Fieldwork not progressing students learning	Fieldwork does not always progress students learning	2	2
Fieldwork personal motivation	Fieldwork is a personal motivation for them	2	2
Fieldwork putting theory into practice	Reference to fieldwork putting theory into practice	1	1
Fieldwork skill development valuable	Fieldwork develops students skill base	4	6

Fieldwork students express themselves	Students express themselves on fieldwork	1	1
Fieldwork time consuming	Fieldwork time consuming	4	10
Fundamental delivery	How practitioners deliver fundamental concepts to students	3	4
Fundamental principles	Fundamental principles that they require a student to have once they graduate	4	4
Fundamental skill critical thinking	Skill critical thinking developed on fieldwork	1	1
Fundamental skill presentations	Presentation skills developed on fieldwork	2	2
Fundamental skill writing	Writing skills enhanced by fieldwork	1	1
Fundamental skill data collection and analysis	Data collection and analysis skill developed on fieldwork	2	3
Funereal skill gis	GIS skill developed on fieldwork	1	1
Future use of uavs	Future use of UAVs such as increase in sensor capacity for research and teaching	2	2
Get students out in the field	Importance of physically being in a field landscape and "getting out there"	7	14
Get students to do	Getting students to do rather than passively listen on fieldwork is a benefit	4	11
Get students to see	Important element of fieldwork is to get students out there to see it for themselves with their own eyes	6	13
Gis and remote sensing skills needed to get maximum formal data	Extra skills are needed to maximise UAV operations for learning	1	1
Group projects	Mention of group work on fieldwork	2	5
High resolution images	Mention of high resolution images from the UAV or an indication that they would like high res	3	6
Importance of social side of fieldwork	Importance of social side of fieldwork	4	11

Independence skill	Fieldwork promotes independence skill	3	6
Interaction with the model	Interaction with the model and its data such as moving around the model or viewing from different angles	5	12
Issue of 3d model creation rouge artefacts	Rouge artefacts in the model	1	1
Issue of 3d model navigation	Issue of trying to navigate in the 3D model navigation	3	5
Issue of lecturer not allowing mobile tech on fieldwork	Issue of lecturer not allowing mobile tech on fieldwork	1	1
Issue of software procurement	Issue of software procurement to manipulate UAV data for learning	2	2
Issue of speed of model	Model was either too fast or too slow	1	1
Issue of student engagement with online materials	Potential issue of students not accessing online materials	1	1
Issue of student organisation	Issue on fieldwork of student organisation	1	1
Issue of weather and usability with mobile technology	Weather issues with technology	2	4
Layering of historic data in model	wants to Layering of historic data in model	2	3
Learn more through fieldwork than lectures	Students learn more through fieldwork due to the practical nature of it rather than in passive lectures	4	9
Less time for teaching in h.e	Changing landscape of H.E there is less time for teaching	1	1
Link to external resources through annotations	Link to existing data or external data through annotations	4	11
Longevity of uavs	Concern over the life span of UAV use. Will it be replaced by something else?	1	2
Lost enthusiasm for mobile technologies	Practitioner has lost enthusiasm for mobile technology in fieldwork	1	2
Managing student numbers	Managing student numbers on fieldtrips a challenge	1	1
Manipulation of model for viewing	Ability to zoom in and out on the model	1	2

Marketing of fieldwork on degree	Fieldwork a useful marketing tool	3	4
Measurements with in the model	Measurements with in the model	3	4
Mobile technologies good in fieldwork	Reference to 'Good' for using mobile technologies in fieldwork	6	9
Mobile technologies more accurate than traditional methods	Mobile technologies are more accurate in data collection than traditional methods	2	3
Mobile technology allows electronic resources in the field	Access to electronic resources in the field	1	1
Mobile technology allows student to multi-task	Mobile technologies allow students to multi-task	3	4
Mobile technology challenges of integration in h.e	Higher Education struggles to keep up to date or to integrate mobile technology	2	4
Mobile technology distracts	Mobile technology distracts students in some form	2	7
Mobile technology employability skills	Employability skills enhancement	1	1
Mobile technology in fieldwork	Direct mention of mobile technology on fieldwork	7	17
Mobile technology loses some traditional learning	Concern that mobile technology takes away from the fieldwork learning	1	2
Mobile technology made it easier	Mobile technology makes the experience easier	4	8
Mobile technology more convenient	More convenient	4	11
Mobile technology more efficient	Technology more efficient	1	2
Mobile technology more robust than traditional	Mobile tech more robust	1	2
Mobile technology saves weight	Mobile technology is portable	1	1
Mobile technology transportation issues	Technology issues when taking overseas	1	1
Mobile technology apps	Applications	1	1

Model as revision tool	Model used as a revision tool	1	1
Model gives viewpoints cannot access in field	Model provides viewpoints that cannot be accessed in the field	1	4
Model inspires independent study	Model promotes independent study	1	1
Model of other locations wanted	Preference for other models to be made	1	4
Model powerful tool for learning	'powerful tool for learning' in reference to the model	1	4
Model quick to get used to	Easy to use model	1	1
Negative of fieldwork	Negative issues of fieldwork	5	8
Negative thoughts on uav	Negative attitude towards UAVs	3	9
New uses of mobile tech in fieldwork	New ways mobile technology is being used in fieldwork	1	1
No real negatives to using mobile tech in fieldwork	No issues of mobile technologies	1	2
Not having a mobile device a hindrance	Not having a mobile device is a hindrance in today's fieldwork environment	1	3
Number one negative to mobile tech in fieldwork	Number one negative concern about mobile tech in fieldwork	2	2
One shot at fieldwork	Fieldwork is often only a one-shot thing	1	1
Organisational skill	Fieldwork promotes organisational skills	2	4
Other university practices	Mention of other universities and their fieldwork delivery	1	1
Past experiences of fieldwork	Practitioner recalling past experiences of fieldtrips as a student	2	3
Perceived benefits of uavs	Benefits of UAVs	4	14
Practical skills	Practical skill developed on fieldwork	3	5
Practitioner wants from 3d model	What the practitioner stated they would like a model to show be that annotations to resolution	5	14

Practitioners think differently to students about fieldwork	Mention that the practitioner believes they think differently to students about fieldwork	1	1
Preference for traditional methods	Students prefer traditional methods	1	5
Pressures on students	Pressures on students such as leaving home or financial pressures	3	4
Reluctance for students to pay for fieldwork		1	1
Student barrier to fieldwork expense		2	2
Pressures on students to have latest mobile technology	Pressure on student to have the latest equipment on fieldwork	1	1
Problem solving outside of fieldwork		1	1
Privilege to do fieldwork	Practitioner feels privileged to be able to do fieldwork	1	1
Problem solving	Skill development such as problem solving on fieldwork	5	11
Protection of the landscape	3D model can stop people visiting a site in person and thus protecting the landscape	1	3
Rapid change of technology	Rapid changing pace of technology	2	2
Reluctance from students mobile tech use for educational purposes	Mobile device is a personal space and reluctance to use it for educational purposes	4	5
Replacing fieldtrips	3D model replacing fieldtrip thoughts	2	3
Resource limitations on fieldwork	Resource limitations	1	2
Revisit the model post fieldwork	Preference and reasons for using the model post fieldwork	6	12
Risk of loaning out equipment	Risk of loaning out or damaging equipment	2	2
Risks on fieldwork	Risks on fieldwork	1	1

Saving time in the field	Mobile technologies save time in the field	2	3
Social media as a reflection and collection tool	Social media used as a reflection tool	2	2
Social media distraction	Social media a distraction on fieldwork	1	2
Solve real world problems	Fieldwork allows a student to solve real world problems or solve problems in the real world	4	10
Staffing issues	Staffing issues on fieldwork	1	2
Student access to new technology	Accessibility of new technology not filtering down to students	1	1
Student dependant on resources	Students become dependent on resources	2	2
Student discipline on fieldwork		1	2
Student drinking on fieldwork	Students drinking on fieldwork an issue	1	1
Student experience	Students show some disagreement to fieldwork or have issues such as disabilities or anxiousness	4	14
Fieldwork not crucial to some students	Fieldwork not important to some students	1	1
Student upset anxious reluctant to go on fieldwork	Students getting upset or anxious (Can go into student experience)	4	5
Student opinion of fieldwork	Student opinions on fieldwork from a staff or student perspective	4	7
Student reflections	Students using social media as a reflection tool	1	1
Student use mobile tech for notes	Mobile technologies used for note taking	3	4
Student use of mobile technology	How students use mobile technology	2	6
Student wants from 3d model	What students want from the model	2	5

Students and uavs	Student issues of flying them or using it on student fieldwork	3	5
Students are assessment focused	Reference to students being assessment focused	1	2
Students use of unit app and email on smartphone	Students using mobile devices for checking emails	1	4
Students using institutionally owned devices	Students using institutionally owned devices	2	2
Support for anxious or challenges for students on fieldwork	Support for anxious or disabled students	1	3
Surprised of 3d model output	3D model good	1	3
Taking risks with technology	Practitioner identifies themselves as a technological risk taker	3	3
Team work	Team work skill developed on fieldwork	3	4
Time investment in uav	Negative of UAV operations is the time needed to be invested into it	1	6
Time management skills	Time management skill developed on fieldwork	1	1
Too much fieldwork a bad thing	Too much fieldwork can be an issue	1	1
Tool availability for learning	Mobile tech a tool for learning	2	2
Top skill on fieldwork	Top fieldwork skill mentioned by the practitioner	2	3
Travel to the fieldtrip	Mention about the travel or the travel time to the field site as a hindrance	2	3
Uav a distraction	UAV can be distracting	1	2
Uav affecting wildlife	Concern over UAV affecting wildlife while flying on fieldwork	1	2
Uav different perspective on fieldwork	UAVs provide a different perspective on fieldwork	6	11
Uav experience	Previous experience of UAV operations	6	13
Uav for marketing purposes	UAVs for marketing purposes	1	1

Uav for photogrammetry	UAV used for photogrammetry purposes	1	2
Uav for research rather than teaching	Mention of UAVs being used for research purposes rather than teaching	5	9
Uav for teaching	Reference to UAVs being used in teaching	6	14
Uav good	Mention that the UAV is positive	4	5
Uav good for teaching	UAVs good for teaching	4	12
Uav in media	Concerns around media representation of UAVs	1	1
Uav introduction to curriculum	How to introduce the UAV data and flying into the right curriculum	1	3
Uav invasive or disruptive noise	UAV invasive to others such as noise	2	7
Uav laws and licencing	Laws and licencing	6	15
Uav malpractice	UAV malpractice may cause an issue to others and the industry as a whole	2	2
Uav output good for learning	UAV outputs good for learning	4	12
Uav preference not to be used on fieldwork	Preference by students to not use AV on fieldwork due to distraction	1	2
Uav privacy issues	Concerns over UAV privacy issues	2	3
Uav public perceptions and media	Perception of public and media being an issue	2	2
Uav quick to collect data	Quick to collect data with UAVs	1	1
Uav to access data from inaccessible locations	UAV used to access data from inaccessible locations that cannot be accessed on foot on fieldwork	5	7
Uav too complicated	UAV usability an issue	1	1
Uav training	UAV training requirements	2	2
Uav weather issues	UAV affected by weather	2	3

Uavs are interactive	Interactive	1	1
Uavs are they needed	Are you UAVs needed for the task at hand	1	1
Uavs can have high temporal and spatial resolution	High spatial and temporal resolutions	2	2
Use of specialist equipment	Using specialist equipment on fieldwork	1	1
Useful to have old methods and new tech	Preference to have old and new methods to complement each other	1	1
Using own device	Students use of their own device on fieldwork	4	6
Using uav data	How the data collected from the UAV is to be manipulated for learning	1	4
Virtual field guide	Mention of VFG	2	3
Virtual reality	Mention of Virtual Reality	1	2
Weather concerns	UAV weather concerns	3	5
What is a uav	Definition of a UAV	1	1

Student Assignment codes

NODE	REFERENCES
Accessibility	2
Aiding the report	6
Beneficial use of the model	11
Cannot replace fieldwork	2
Concern model may replace fieldwork	1
Context	5
Families student	1
Image of model	12
Image used of map	2
Lack of scale	3
Model depend understanding	7
Model good for comparison	2
Model good wire frame and uv	1
Model high quality	4
Model issue - slow	1

Model issue too responsive	1
Model promoted further study	3
Model quick to get the hang of	1
Model used before fieldwork	2
Model used to explain location	3
Model used to link existing research	2
Powerful tool for learning	2
Revisit the site	2
Tool to be used before fieldwork	1
Use model in different setting	2
Use of external resources	8

APPENDIX N: CODEBOOK WITH THEMES AND SUBTHEMES GENERATED

Theme generation codebook

THEMES ARE IN BOLD SUB THEMES BOLD AND INDENTED NODE NAMES	DESCRIPTION	SOURCES	REFERENCES
3D MODEL THEME	**Overall theme concerning the 3D model**	**7**	**225**
DELIVERY OF THE MODEL	**Theme of model delivery**	**7**	**21**
3D model before fieldwork		7	15
3D model to be used before and after fieldwork	Mention of the model to be used before and after fieldwork	6	6
EXTERNAL BENEFITS TO 3D MODEL	**External benefits outside of fieldwork and H.E**	**2**	**4**
FUTURE WANTS OF MODEL	**What students and practitioners want from a future model**	**7**	**36**
Annotation	Types of annotation wanted on the model	6	10
Audio annotation	Audio annotation on the model	2	2
Link to external resources through annotations	Link to existing data or external data through annotations	4	11
Layering of historic data in model	wants to Layering of historic data in model	2	3
Model of other locations wanted		1	4

Practitioner wants from 3D model	What the practitioner stated they would like a model to show be that annotations to resolution	5	14
Student wants from 3D model		2	5
ISSUE WITH THE MODEL	**Issues Raised With The Model**	**7**	**19**
Confliction of virtual fieldtrips	Confliction of feelings over the use of virtual fieldtrips	1	2
Issue of 3D model creation rouge artefacts	Artefact issues in rendering	1	1
Issue of 3D model navigation	Issue of trying to navigate in the 3D model navigation	3	5
Issue of software procurement	Issue of software procurement to manipulate UAV data for learning	2	2
Issue of speed of model	Model too quick or too slow	1	1
Issues of data collection for VFGs	Data collection issues	1	1
lack of skill in 3D models UAV	Lack of skill to create the model	1	1
Replacing fieldtrips	3D model replacing fieldtrip thoughts	3	6
MODEL PRACTICALITIES	**This theme is about the practicalities of the model such as scale and representation**	**6**	**37**
3D model representation	How the model represents real world environments	4	11
3D model scale	Scale in 3D model	3	5
Engagement with 3D model	Student engagement with 3D model	2	3
Interaction with the model	Interaction with the model and its data such as moving around the model or viewing from different angles	5	12
Manipulation of model for viewing	i.e. Zooming in and out	1	2

Measurements with in the model	Measurements with in the model	3	4
PEDAGOGICAL BENEFITS OF THE MODEL	**The pedagogical advantages of the model**	**7**	**108**
3D model good for teaching	Reference to the model being beneficial for teaching in some capacity	7	25
3D model inclusive for disabilities	Useful for disabled students	2	2
3D model is good	Reference to the model being 'good'	7	18
Bringing the field site to the student	model and resources allow the field site to be brought to the student regardless of location	2	3
Model gives viewpoints cannot access in field	Ability to view different view points	1	4
Model inspires independent study	Model creates independent study	1	1
Model quick to get used to	Model is easy to use	1	1
PEDAGOGICAL SKILL DEVELOPMENT	**The pedagogical development that is skill developemnt**	**7**	**39**
3D model an intermediate learning boundary between physical and actual	used in conjunction virtual world and the real world	4	5
3D model increases efficiency in the field	3D model increasing student efficiency in the field	3	4
3D model increases productivity	3D model increases productivity in the field through the ability to plan	3	5
3D model prepares students for fieldwork	3D model prepares students for fieldwork	5	10
3D model used as a discussion tool post fieldtrip	Model used after fieldwork as a discussion tool for practitioners	3	15
Protection of the landscape	3D model can stop people visiting a site in person and thus protecting the landscape	1	3

Revisit the model post fieldwork	Preference and reasons for using the model post fieldwork	6	12
ADVANTAGES OF MOBILE TECHNOLOGY THEME	**THIS THEME IS THE ADVANTAGES MOBILE TECHNOLOGIES HAVE IN FIELDWORK**	**8**	**101**
DATA	**References to data**	**7**	**21**
Ability to take photos with mobile technology	Ability to take photographs with mobile technology	4	5
Analysing data more efficiently	Can analyse data more efficiently	2	4
centralising data	mobile technologies allowing Applications and others to collate and share data	3	3
Data collection in the real world	Using mobile technology and fieldwork to collect data in the real world or make the connection between the two	3	6
Mobile technology allows electronic resources in the field	Access to resources	1	1
Social Media as a reflection and collection tool	Social media used as a reflection tool	2	2
IMPROVING FIELDWORK EXPERIENCE	**Mobile technologies improving fieldwork experience for staff and students such as data collection or experience**	**8**	**43**
Mobile technologies more accurate than traditional methods	Mobile technologies are more accurate in data collection than traditional methods	2	3
Mobile technology made it easier	Mobile technology makes the experience easier	4	8
Mobile technology more convenient	Mobile technology more convenient	4	11
Mobile technology more efficient	technology more efficient than traditional methods	3	5

Mobile technology more robust than traditional	mobile technology more robust than traditional	1	2
Mobile technology saves weight	Mobile technology is portable	1	1
No real negatives to using mobile tech in fieldwork	No negatives	1	2
Student use of mobile technology	How students use mobile technology	3	11
Mobile technology in fieldwork	Direct mention of mobile technology on fieldwork	7	18
PEDAGOGICAL BENEFITS OF MOBILE TECHNOLOGY	**Pedagogical benefits to mobile technologies**	**8**	**19**
Ability to revisit with mobile technology	Ability to revisit locations or data with mobile technology	2	3
Mobile technologies good in fieldwork	Reference to mobile technologies being 'good'	6	9
Mobile technology allows student to multi-task	Mobile technologies allow students to multi-task	3	4
Mobile technology employability skills	Enhancement of employability skills	1	1
Tool availability for learning	Mobile tech a tool for learning	2	2
BACKGROUND INFORMATION OF PARTICIPANTS	**Information about the participants**	**6**	**18**
Background Information	Background information of respondent	3	4
Discipline	What discipline the respondent belongs to	4	11
Past experiences of fieldwork	Practitioner recalling past experiences of fieldtrips as a student	2	3
CHANGING NATURE OF FIELDWORK AND H.E	**External changes to fieldwork that has influenced fieldwork in H.E**	**5**	**11**
Changing nature of fieldtrips	Field trip delivery or location changing due to pressures or time	5	7
Less time for teaching in H.E	Changing landscape of H.E there is less time for teaching	1	1
Taking risks with technology	Practitioner identifies themselves as a technological risk taker	3	3

DISADVANTAGE OF MOBILE TECHNOLOGY	**Disadvantages of mobile technologies in fieldwork**	**6**	**66**
PEDAGOGICAL CHALLENGES OF MOBILE TECH	**Pedagogical challenges of mobile technology in fieldwork**	**6**	**52**
Cost of specialist equipment on fieldwork	High cost of specialist equipment on fieldwork	1	1
Issue of student engagement with online materials	Potential issue of students not accessing online materials	1	1
Lost enthusiasm for mobile technologies	Practitioner has lost enthusiasm for mobile technology in fieldwork	1	2
Mobile technology distracts	Mobile technology distracts students in some form	3	9
Mobile technology loses some traditional learning	Concern that mobile technology takes away from the fieldwork learning	1	2
Not having a mobile device a hindrance	Not having a mobile device is a hindrance in today's fieldwork environment	1	3
Number one negative to mobile tech in fieldwork	Number one negative concern about mobile tech in fieldwork	2	2
OTHER ISSUES	**Other issues of fieldwork**	**5**	**18**
Changing nature of teaching with technology advancement	Fieldwork changing and delivery of fieldwork changing due to the advancement of technology	3	9
Mobile Technology challenges of integration in H.E	Higher Education struggles to keep up to date or to integrate mobile technology	2	4
Preference for traditional methods	Students prefer traditional methods	1	5
TECHNICAL ISSUES	**Technical issues of fieldwork and mobile technologies**	**5**	**13**
Connectivity issues	Connectivity issues of the device to internet or email	3	4
Equipment out of date	Issue of equipment used on fieldwork out of date or obsolete	1	1

Mobile technology transportation issues	Issues of transportation i.e. abroad	1	1
Weather concerns	Weather related concerns such as damage and usability in weather	3	7
STUDENT CONCERNS	**Students concerns about the use of mobile technologies on fieldwork**	**4**	**14**
Concern about dropping and damaging mobile technology	Concern about damaging or dropping the device	1	2
Concern of reliance on technology	Concern about the reliance on technology over traditional skills	2	4
Issue of lecturer not allowing mobile tech on fieldwork	Issue of lecturer not allowing mobile tech on fieldwork	1	1
Pressures on students to have latest mobile technology	Pressure on student to have the latest equipment on fieldwork	1	1
Reluctance from students mobile tech use for educational purposes	Mobile device is a personal space and reluctance to use it for educational purposes	4	5
Student access to new technology	Accessibility of new technology not filtering down to students	1	1
FIELDWORK	**THIS THEME IS IN RELATION TO FIELDWORK**	**8**	**226**
ADVANTAGES TO FIELDWORK	**Perceived advantages of fieldwork**	**8**	**155**
FUNDEMENTAL SKILL DELVELOPMENT	Development of skills on fieldwork	**7**	**98**
Fieldwork putting theory into practice	Facilitates putting theory into practice	1	1
Fieldwork students express themselves	Facilitates a place for students to express themselves	1	1

Get students out in the field	Importance of physically being in a field landscape and "getting out there"	7	14
Get students to do	Getting students to do rather than passively listen on fieldwork is a benefit	4	11
Get students to see	Important element of fieldwork is to get students out there to see it for themselves with their own eyes	6	13
SKILLS	**What skills are developed on fieldwork**	**6**	**58**
Communication	Communication skill developed on fieldwork	1	1
Confidence skill	Confidence skill developed on fieldwork	1	1
Fieldwork skill development valuable	Fieldwork develops students skill base	4	6
Fundamental skill critical thinking	Critical thinking	1	1
Fundamental skill presentations	Presentation skills developed on fieldwork	2	2
Fundamental skill writing	Writing skills enhanced by fieldwork	1	1
Fundamental skill data collection and analysis	Data collection and analysis skill developed on fieldwork	2	3
Fundamental skill gis	GIS skill developed on fieldwork	1	1
Independence skill	Fieldwork promotes independence skill	3	6
Organisational skill	Fieldwork promotes organisational skills	2	4
Practical skills	Practical skill developed on fieldwork	3	5
Problem solving	Skill development such as problem solving on fieldwork	5	14

Team work	Team work skill developed on fieldwork	4	9
Time management skills	Time management skill developed on fieldwork	1	1
Top skill on fieldwork	Top fieldwork skill mentioned by the practitioner	2	3
OTHER ADVANTAGES TO FIELDWORK	**Other advantages of fieldwork**	**8**	**57**
Benefits of fieldwork	Direct benefit of fieldwork (maybe a theme in itself)	7	24
Efficiency in the field	Making the most of your time in the field	2	6
Employability	Direct mention that fieldwork increases employability	2	2
Fieldwork important to discipline	Fieldwork is important and part of the QAA benchmark	2	6
Fieldwork leads to dissertation research	Promotes further research	1	1
Fieldwork personal motivation	Fieldwork is a personal motivation for them	2	3
Importance of social side of fieldwork	Importance of social side of fieldwork	4	11
Marketing of fieldwork on degree	Fieldwork a useful marketing tool	3	4
DISADVANTAGES TO FIELDWORK	**This theme relates to disadvantages in fieldwork**	**7**	**61**
DISABILITY ON FIELDWORK	**Reference to disabilities on fieldwork**	**4**	**14**
Changing a fieldtrip to accommodate disability-Anxiety	Changing a fieldtrip to accommodate student anxiety or disability	3	6
Disabilities in fieldwork	Disabilities in fieldwork	3	8
ETHICS AND RISK	**Ethical and risk associated concerns on fieldwork**	**1**	**2**
Ethical concerns of fieldwork	Ethical considerations of fieldwork	1	1
Risks on fieldwork	Risks on fieldwork	1	1

OTHER NEGATIVES OF FIELDWORK	**Other negative connotations associated with fieldwork**	**6**	**24**
Fieldwork not progressing students learning	Fieldwork does not always progress students learning	2	2
Issue of student organisation	Issue of students being organised on fieldwork	1	1
Negative of fieldwork	Negative issues of fieldwork	5	15
One shot at fieldwork	Fieldwork is often only a one-shot thing	1	1
Practitioners think differently to students about fieldwork	Mention that the practitioner believes they think differently to students about fieldwork	1	1
Too much fieldwork a bad thing	Too much fieldwork can be an issue	1	1
Travel to the fieldtrip	Mention about the travel or the travel time to the field site as a hindrance	2	3
PRESSURES ON STUDENTS	**Pressures on students such as leaving home or financial pressures**	**3**	**4**
Fieldwork issue clashing with other subjects	Fieldwork clashing with other subjects making it difficult to attend	1	1
Fieldwork issue students working in jobs	Students working jobs can be an issue for attendance	1	1
Student barrier to fieldwork expense	Students don't want to pay	2	2
STUDENT EXPERIENCE	**Students show some disagreement to fieldwork or have issues such as disabilities or anxiousness**	**4**	**14**
Fieldwork not crucial to some students	Some students do not value it	1	1
Student discipline on fieldwork	Lack of discipline from students on fieldwork	1	2
Student drinking on fieldwork	Students drinking on fieldwork an issue	1	1
Student upset anxious reluctant to go on fieldwork	Students getting upset or anxious (Can go into student experience)	4	8

Student opinion of fieldwork	Student opinions on fieldwork from a staff or student perspective	4	7
RESOURCE LIMITATIONS	**Issue of resource limitations on fieldwork**	**5**	**17**
Fieldwork Time Consuming	Fieldwork time consuming	4	10
Managing student numbers	Managing student numbers on fieldtrips a challenge	1	1
Resource limitations on fieldwork	Lack of resources	1	2
Staffing issues	Staffing issues on fieldwork	1	2
Student dependant on resources	Students become dependent on resources	2	2
FUNDMENTALS OF DELIVERY AND LOGISTICS OF FIELDWORK	**DELIVERY OF FIELDWORK SUCH AS LOGISTICS**	**6**	**10**
FIELDWORK DELIVERY	**Any mention of how fieldwork is delivered i.e. residential/day trips etc.**	**6**	**10**
Compulsory fieldwork	Compulsory fieldwork trips	4	6
Cost of optional fieldwork	cost of optional fieldwork	1	1
Day fieldtrips	Day fieldtrips	3	7
Enthusing and motivating students on fieldwork	The role of the tutor and the challenge of keeping students Enthused and motivated on fieldwork	3	6
Fundamental delivery	How practitioners deliver fundamental concepts to students	3	4
Fundamental principles	Fundamental principles that they require a student to have once they graduate	4	4
Optional field trips	Optional fieldtrips that take place in the university	3	3

Overseas fieldtrips	Overseas fieldtrips	2	3
Residential fieldwork	residential fieldwork	3	7
Uk based fieldtrips	UK based fieldtrips	2	3
INSTITUITONALLY OWNED DEVICE VS BYOD	**DEBATE OF BYOD VS. IOD**	**6**	**16**
BYOD	Bring your own device	4	6
using own device	Students use of their own device on fieldwork	4	6
IOD	Institutionally owned device	5	10
Disconnect between cost of own and uni equipment	Students place higher value on personal equipment over expensive university equipment	3	6
Risk of loaning out equipment	risk of loaning out or damaging equipment	2	2
Students using institutionally owned devices	Students using institutionally owned devices	2	2
LEARNING THEORY	**REFERENCE TO LEARNING THEORIES ON FIELDWORK**	**8**	**33**
Assessing fundamentals	How practitioners assess the fundamental concepts of the course	4	6
Communities of practice	Mentions of communities of practice evident	1	2
Different learning styles	Mentions of student different learning styles on fieldwork	1	1
Digital Natives	Mention/allude to of digital natives	2	2
E-Learning on the move	E-learning on the move	1	1
Experiential learning	Reference made to experiential learning taking place on fieldwork	7	19
Students are assessment focused	Students are driven by assessment	1	2
UAVS	**THIS THEME IS IN REFERENCE TO UAVS**	**6**	**173**

ADVANTAGES OF UAVS	**Any Advantages To Uav Use In Teaching Or Fieldwork**	6	54
PERCIEVED BENEFITS OF UAVS	**Benefits of UAVs**	**4**	**14**
UAV different perspective on fieldwork	UAVs provide a different perspective on fieldwork	6	11
UAV for marketing purposes	UAVs used for marketing for departments	1	1
UAV Good	Mention that the UAV is positive	4	5
UAVs are interactive	Interactive data	1	1
UAV DATA COLLECTION ADVANTAGES	**UAV as a advantageous tool for data collection in teaching and fieldwork**	**6**	**40**
Collection of UAV data	Mention of collection of data from the UAV such as videos, photographs, models	5	18
High resolution images	Mention of high resolution images from the UAV or an indication that they would like high res	3	6
UAV for photogrammetry	UAV used for photogrammetry purposes	1	2
UAV quick to collect data	Quick to collect data	1	1
UAV to access data from inaccessible locations	UAV used to access data from inaccessible locations that cannot be accessed on foot on fieldwork	5	7
UAVs can have high temporal and spatial resolution	Data can have high temporal and spatial resolution	2	2
Using UAV data	How the data collected from the UAV is to be manipulated for learning	1	4

DISADVANTAGES OF UAVS	**DISADVANTAGES OF UAVS IN TEACHING AND FIELDWORK**	**6**	**52**
Changing attitude of UAVs	Respondent indicated a change in attitude towards the UAV throughout the interview	1	1
Conflicting thoughts on UAVs	Respondent conflicted between the good and bad points of UAV operations	1	1
Cost of UAV-3D model resources	Mention of the cost of the UAV	1	1
Error of UAV collection	UAV can have error in the data such as no GCP	1	1
longevity of UAVs	Concern over the life span of UAV use. Will it be replaced by something else?	1	2
negative thoughts on UAV	Negative attitude towards UAVs	3	9
LAWS AND LICENCING	**Any mention of laws and licencing concerning UAVs**	6	20
UAV laws and licencing	UAV specific laws and licences	6	17
UAV Malpractice	UAV malpractice may cause an issue to others and the industry as a whole	2	2
UAV too complicated	UAV usability an issue	1	1
OTHER UAV ISSUES OF FLYING	**Other issues of UAVs**	5	21
Students and UAVs	Student issues of flying them or using it on student fieldwork	3	5
UAV Invasive or disruptive noise	UAV invasive to others such as noise	2	7
UAV Privacy issues	Concerns over UAV privacy issues	2	3

UAV public perceptions and media	Influence of negative opinions from public perception and media	3	3
UAV Weather issues	UAV affected by weather	2	3
Time investment in UAV	Negative of UAV operations is the time needed to be invested into it	1	6
UAV EXPERIENCE	**Previous experience of UAV operations**	**6**	**13**
UAVS IN TEACHING	**HOW ARE OR COULD UAVS BE USED IN TEACHING**	**6**	**54**
UAV NEGATIVES IN TEACHING	**Negative thoughts on UAVs in teaching and fieldwork**	**6**	**13**
UAV a distraction	UAV can be distracting	1	2
UAV for Research rather than teaching	Mention of UAVs being used for research purposes rather than teaching	5	9
UAV preference not to be used on fieldwork	Preference by students to not use UAV on fieldwork due to distraction	1	2
UAVS POSITIVE FOR TEACHING	**UAVS as a positive tool for teaching and fieldwork**	**6**	**41**
UAV for teaching	Direct benefit of UAVs in teaching	6	14
UAV good for teaching	UAVS being good for teaching	4	12
UAV introduction to curriculum	How to introduce the UAV data and flying into the right curriculum	1	3
UAV Output good for learning	UAV outputs good for learning	4	12

APPENDIX O: RISK AND PARTICIPANT INFORMATION SHEETS

PARTICIPANT INFORMATION SHEET

Participant Information Sheet for Thurstaston Assignment Evaluation: 'Investigating the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education'

The researcher requests if you are willing for the researcher to use your anonymous (to the researcher) evaluation of the Virtual Field Guide from your assignment in this research. Before you decide to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please do ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?
This research explores the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education. This section of research investigates student's thoughts of the Virtual Field Guide of Thurstaston that has been created by a UAV.

Why have I been chosen?
You have been chosen due to your involvement on Geoscience fieldwork as a student.

Do I have to take part?
Your decision to participate or not will not provide any advantage or disadvantage to you. I would, however, greatly appreciate you taking the time to participate. You are free to withdraw your written evaluation at any time, without giving a reason and that this will not affect your legal rights or your marks for the module.

What will happen to me if I agree to take part?
If consent is provided by yourself, the course leader (Prof Tim Stott) will select the model evaluation section from the assignment, place them in a password protected word file and send them anonymously to the researcher via secure LJMU email. The researcher will therefore be unaware of which student each evaluation is attributed to. Your completion of the informed consent form will be taken as your consent for this to happen.

Who is organising and funding the research?
This research is being funded LJMU.

What will happen to the results of the research study?
The results will be analysed by the researcher detailed below. When any results and findings of this research project are presented or reported to others inside or outside of the University, **your anonymity is guaranteed**. All documents will be kept on a secure password protected LJMU M drive. Your anonymity is important in this study. Your signed consent form will be held in a locked filing cabinet on the LJMU premises.

What if something goes wrong?

If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this research, please contact my director of studies: Dr. Fran Tracy - F.E.Tracy@ljmu.ac.uk or If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Ethically approved
This research has been ethically approved by LJMU Ethics Committee **No.**

Contact details
If you have any questions then please feel free to email Anthony David Cliffe on A.D.Cliffe@2016.ljmu.ac.uk

Thank you for taking the time to read this Participant Information Sheet

Consent Form

Use of your evaluation section of your assignment for the purpose

'Investigating the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education'

Researcher: Anthony Cliffe
Faculty: Education, Health & Community.

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐
2. I understand that my participation is voluntary and that I am free to withdraw my written evaluation at any time, without giving a reason and that this will not affect my legal rights or my marks for the module. ☐
3. I understand that any personal information (or views expressed in my report) collected during the study will be anonymised and remain confidential. ☐

Name of Participant:	Date:	Signature:
Name of Researcher: Anthony Cliffe	Date:	Signature:

PARTICIPANT INFORMATION SHEET

Participant Information Sheet for Focus Group:
'Investigating the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education'

You are being invited to take part in a Focus-Group interview as part of a wider PhD research study. Before you decide to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please do ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?
This research explores the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education.

Why have I been chosen?
You have been chosen due to your involvement on Geoscience fieldwork at LJMU as either a student or a staff member.

Do I have to take part?
Completion of the focus group is entirely voluntary. Your decision to participate or not will not provide any advantage or disadvantage to you. We would, however, greatly appreciate you taking the time to participate.

What will happen to me if I agree to take part?
You will confirm whether you are willing to participate in the Focus group. A date and time will then be arranged dependent upon your availability. It is expected that the focus group should take approximately one hour to complete. Your completion of the informed consent form will be taken as your consent to participate in the research.

Why do you ask me what faculty, department and course I am in?
This is part of the qualifying process to select potential focus group members from Geoscience based subjects. If you are not part of Geoscience based subjects, unfortunately you will not qualify for taking part in this research. I will ask for your department and course to understand the differences between subjects within Geoscience. However if for whatever reason you wish to withhold this information, then that is allowed. Students will only be in student focus groups and staff will be in staff only focus groups.

Who is organising and funding the research?
This research is being funded LJMU.

What will happen to the results of the research study?
The results will be analysed by the researcher detailed below. When any results and findings of this research project are presented or reported to others inside or outside of the University, **your anonymity is guaranteed**. Reference to specific people, who you may mention, will also be removed from any quotations that are used. Recordings will be kept on a secure password protected LJMU M drive and once transferred from the device to the M drive will be deleted from said device. The M drive will also include coding sheets and other identifying data such as

Pseudonyms. Your anonymity is important in this study. Your signed consent forms will be stored in a locked filing cabinet on the LJMU premises.

What if something goes wrong?
If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this research, please contact my director of studies: Dr. Fran Tracy - F.E.Tracy@ljmu.ac.uk or If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Ethically approved
This research has been ethically approved by No.

Contact details
If you have any questions then please feel free to email Anthony David Cliffe on A.D.Cliffe@2016.ac.uk

Thank you for taking the time to read this Participant Information Sheet

PARTICIPANT INFORMATION SHEET

Participant Information Sheet for Semi-structured Interviews:
'Investigating the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education'

You are being invited to take part in a semi-structured interview as part of a wider PhD research study. Before you decide to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please do ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?
This research explores the pedagogical use of mobile technologies and unmanned aerial vehicles in Geoscience fieldwork education.

Why have I been chosen?
You have been chosen due to your involvement on Geoscience fieldwork at LJMU as either a student or a staff member.

Do I have to take part?
Completion of the interview is entirely voluntary. Your decision to participate or not will not provide any advantage or disadvantage to you. We would, however, greatly appreciate you taking the time to participate.

What will happen to me if I agree to take part?
You will confirm whether you are willing to participate in an interview. A date and time will then be arranged dependent upon your availability. It is expected that the interview should take approximately one hour to complete. Your completion of the informed consent form will be taken as your consent to participate in the research.

Why do you ask me what faculty, department and course I am in?
This is part of the qualifying process to select potential interviews from Geoscience based subjects. If you are not part of Geoscience based subjects, unfortunately you will not qualify for taking part in this research. I will ask for your department and course to understand the differences between subjects within Geoscience. However, if for whatever reason you wish to withhold this information, then that is allowed.

Who is organising and funding the research?
This research is being funded LJMU.

What will happen to the results of the research study?
The results will be analysed by the researcher detailed below. When any results and findings of this research project are presented or reported to others inside or outside of the University, **your anonymity is guaranteed**. Reference to specific people, who you may mention, will also be removed from any quotations that are used. Recordings will be kept on a secure password protected LJMU M drive and once transferred from the device to the M drive will be deleted from said device. The M drive will also include coding sheets and other identifying data such as

Pseudonyms. Your anonymity is important in this study. Your signed consent form will be held in a locked filing cabinet on the LJMU premises.

What if something goes wrong?
If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this research, please contact my director of studies: Dr. Fran Tracy - F.E.Tracy@ljmu.ac.uk or If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Ethically approved
This research has been ethically approved by LJMU Ethics Committee **No. 16/TPL/011**

Contact details
If you have any questions then please feel free to email Anthony David Cliffe on A.D.Cliffe@2016.ac.uk

Thank you for taking the time to read this Participant Information Sheet

LIVERPOOL JOHN MOORES UNIVERSITY

Title of Project: Investigating the pedagogical use of mobile technologies and unmanned aerial vehicles in geoscience fieldwork education

Researcher: Anthony D. Cliffe

Faculty: Education, Health and Community

This research has been ethically approved: No.

4. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

5. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights.

6. I understand that any personal information collected during the study will be anonymised and remain confidential.

7. I agree to take part in the above study (please circle)

   Semi structured Interview   Focus Group

8. I understand that the interview/focus group will be audio recorded and I am happy to proceed.

9. I understand that parts of our conversation may be used verbatim in future publications or presentations but that such quotes will be anonymised. I also agree to keep what is said in the interviews, stays in the interviews and not to be discussed with others outside of the interview process.

Name of Participant: Date: Signature:

Name of Researcher: Anthony Cliffe Date: Signature:

LIVERPOOL JOHN MOORES UNIVERSITY

Health and Safety Unit

Assessment Number

Risk Assessment			
Building	Holemfield House	Date of Risk Assessment	17/10/2016
School/Service Department	Education	Assessment carried out by	Anthony David Cliffe
Location	TBC	Signed	A. Cliffe
Activity	Observations/Photogrammetry with UAVs	Persons consulted during the Risk Assessment	Supervisory team
STEP 1 What are the Hazards? *Spot hazards by* • *Walking around the workplace* • *Speaking to employees* • *Checking manufacturers instructions*	• UAV flying above head height and within the mapping area. • Encroachment of persons/ general public within the mapping area. • Weather – serve winds can affect the performance of the UAV. • UAV being in confliction with regulations i.e close to airspace or built up areas. • UAV not returning to the pilot in command.		
STEP 2 Who might be harmed and how? *Identify groups of people.* *Staff and students are obvious, but please remember*	• Staff and Students. • General public (if they encroach on the mapping area).		

• *Some staff/students have particular needs* • *People who may not be present all the time* • *Members of the public* • *How your work affects others if you share a workplace*	
STEP 3 (a) What are you already doing? *What is already in place to reduce the likelihood of harm, or to make any harm less serious*	• Mapping area: The area that is to be mapped by the UAV is cordoned off with signs placed around the boundary of the mapping area warning the general public of the presence of a UAV. 'Spotters' are placed around the boundary of the mapping area to warn the general public. If a member of the public breaches the cordon the spotters are in direct contact with the safety officer who will then inform the pilot and the UAV will be brought to a safe landing until the mapping area is sterile again. • Weather: In the run up to a flight, specialist aviation weather software will be used to assess the weather. A full briefing on weather will be issued by the pilot in command on the day. If the weather is not suitable the pilot will call a halt to flying operations until the weather improves. At present a 400 foot cloud base, no rain, 1 mile visibility and winds less than 20 knots is the minimum weather that is deemed acceptable for flight. • All staff and students in the mapping area will wear hard hats and wear high-vis vests. These vests are further colour co-ordinated with assigned roles. Pilot in Command (RED), Safety Officer (Green), Spotters (Orange), Others (Yellow). • Full mission planning will take place both before and on site using a variety of software. This is to ascertain that the planned UAV flight will not be in confliction with air traffic or built up environments. On site assessment will take place to identify hazards such as power lines and trees which may affect the safety of the flight. • UAV is fully equipped with a GPS return to home function. Should the unlikely happen and the UAV become unresponsive, after 20 seconds the UAV automatically returns to the landing point. • All flights will follow the strict Civil Aviation Authority (CAA) regulations for UAV use. The key points are not to land the UAV within 50m of anyone other than the pilot. Not to fly above 50m of those who are not under the control of the pilot and not to fly below or around 150m of a congested and built environment.
STEP 3 (b) What further action is needed?	

Compare what you are already doing with good practice. If there is a gap, please list what needs to be done.	• The UAV pilot in command will be fully trained by the CAA. • The UAV pilot will constantly consult the regulations and be kept abreast of any changes.
STEP 4 How will you put the assessment into action? *Please remember to prioritise. Deal with the hazards that are high risk and have serious consequences first*	• All mission planning will take place in the week leading up to the UAV flight, including weather, hazards and planned flight route. • On-site planning of additional hazards will take place pre-flight. • In order for the UAV to operate safely, the manufacturer's procedures will be followed. • Before the flight takes place all hard-hats and high visibility clothing must be warn and the mapping area to be mapped, sign posted and cordoned off. • The safety officer must have confirmation from all spotters that the mapping area is sterile. Once this is confirmed it is up to the pilot in command to commence the flight. The pilot in command has the final say on when to start or to stop a flight. The safety officer will continue to monitor the weather and spotters to ensure the safe flight of the UAV.

Review as necessitated by changes.

APPENDIX P: UK CAA UAV Laws

Article 94: Small unmanned aircraft requirements

1) A person must not cause or permit any article or animal (whether or not attached to a parachute) to be dropped from a small unmanned aircraft so as to endanger persons or property.

2) The SUA operator of a small unmanned aircraft may only fly the aircraft if reasonably satisfied that the flight can be safely made.

3) The SUA operator of a small unmanned aircraft must maintain, direct unaided visual contact with the aircraft sufficient to monitor its flight path in relation to other aircraft, persons, vehicles, vessels and structures for the purpose of avoiding collisions.

4) If a small unmanned aircraft has a mass of more than 7kg excluding its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight, the SUA operator must not cause or permit the aircraft to be flown, and the remote pilot in charge of the aircraft must not fly it.

   a) In class A, C, D or E airspace unless the permission of the appropriate air traffic control unit has been obtained or
   b) Within an aerodrome traffic zone during the notified hours of watch of the air traffic control unit (if any) at that aerodrome unless the permission of the control unit has been obtained.

(4A) Paragraph (4) does not apply to any flight within the flight restriction zone of a protected aerodrome (within the meaning given in article 94B)

5) The SUA operator must not cause or permit a small unmanned aircraft to be flown for the purposes of commercial operations, and the remote pilot of a small unmanned aircraft must not fly it for the purposes of commercial operations, except in accordance with permission granted by the CAA

Article 94A: Small unmanned aircraft: height restrictions on flights

1) The SUA operator must not cause or permit a small unmanned aircraft to be flown at a height of more than 400 feet above the surface, and the remote pilot of a small unmanned aircraft must not fly it at a height of more than 400 feet above the surface, unless the permission of the CAA has been obtained.

2) This article does not apply to any flight within the flight restriction zone of a protected aerodrome (within the meaning given in article 94B)

Article 94B: Small unmanned aircraft: restrictions on flights that are over or near aerodromes

(1) This article applies to a flight by a small unmanned aircraft within the flight restriction zone of a protected aerodrome.

(2) The "flight restriction zone" of a protected aerodrome consists of the following two zones—
(a) the "Inner Zone", which is the area within, and including, the boundary of the aerodrome;
(b) the "Outer Zone", which is the area between—
 (i) the boundary of the aerodrome, and
 (ii) a line that is 1 km from the boundary of the aerodrome (the "1 km line").

(3) In the circumstances set out in an entry in column 1 of the following table—
(a) the SUA operator must not cause or permit the small unmanned aircraft to be flown in the Inner Zone or the Outer Zone, and
(b) the remote pilot of the small unmanned aircraft must not fly it in the Inner Zone or the Outer Zone,

(4) The 1 km line is to be drawn so that the area which is bounded by it includes every location that is 1 km from the boundary of the aerodrome, measured in any direction from

any point on the boundary.

(5) In this article, “protected aerodrome” means—
(a) an EASA certified aerodrome,
(b) a Government aerodrome,
(c) a national licensed aerodrome, or
(d) an aerodrome that is prescribed or of a prescribed description.

Article 95:

1) The SUA operator must not cause or permit a small unmanned surveillance aircraft to be flown in any of the circumstances described in paragraph (2), and the remote pilot of a small unmanned surveillance aircraft must not fly it in any of those circumstances, except in accordance with a permission issued by the CAA

2) The circumstances referred to above are:

a) Over or within 150 meters of any congested area
b) Over or within 150 meters of an organised open-air assembly of more than 1000 persons
c) Within 50 meters of any vessel, vehicle or structure which is not under the control of the SUA operator or the remote pilot
d) Within 50 meters of any person

3) During takeoff or landing, the aircraft must not be flown within 30 meters of any person.

4) (2 d & 3) do not apply to the remote pilot of the aircraft or a person under the control of the remote pilot of the aircraft.

APPENDIX Q: OPERATIONS MANUAL

OPERATIONS MANUAL

ANTHONY DAVID CLIFFE:

RPAS Aerial Photogrammetry

Anthony David Cliffe – August 2017 Version 1.2

The purpose of this document is to describe all Anthony David Cliffe's flight operations.

It has been developed to satisfy the requirements of the UK Civil Aviation Authority and that of other National Aviation Authorities in obtaining permissions and exemptions for Commercial Operation.

The operational need, availability and use of a drone belonging to Anthony David Cliffe will not supersede the requirement for safety as mandated by the CAA, the ICAO and all entities involved in regulating aviation safety.

All personnel involved in any way with Anthony David Cliffe's flight operations shall be familiar with this manual and must comply with all of its provisions. Any and all changes to the manual shall be promptly disseminated.

Amendment Record

Amendment Number	Amendment Date	Amendments Incorporated	Incorporated By
1.0	08/08/2017	First Release	Anthony David Cliffe
1.1	16/10/2017	Copy of PfCO added	Anthony David Cliffe
1.2	10/08/2018	To comply with new regulations the following has been added. • The terms "SUA Operator" has replaced the term "SUA Operator" and "Remote Pilot" replaces all reference to the pilot flying i.e. SUA Operator • 2018 Amendment to the Air Navigation Order updated and included and reflected throughout the procedures • Night Operations procedure added • Font changed	

Document Reference:

Anthony David Cliffe – Operations Manual - Issue 1.2

Commitment of the SUA Operator

As the SUA Operator, this Operations Manual describes the organisation, systems, personnel, flight operations and procedures by which Anthony David Cliffe carries out its Small Unmanned Aircraft, i.e. Drone Operations.

It is accepted that the contents of this document do not override the necessity of reviewing and complying appropriately with any new or amended regulation published by the CAA or the appropriate National Aviation Authorities where Anthony David Cliffe intends to operate based on this document.

Signed……………………………………………

SUA Operator: **ANTHONY D. CLIFFE**

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PART A – GENERAL POLICY

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to outline the policy and procedures that will be adhered to in order to safely conduct the operation of a Small Unmanned Aircraft by Anthony David Cliffe. This document describes the operational procedures, flight roles and safety considerations for a succesful flight of a SUA.

1.2 SCOPE

This Operations Manual applies to all personnel involved in the operation of an SUA under 7kgs. This includes the Remote Pilot and any informed observers i.e. site manager.

1.3 SAFETY POLICY AND NATIONAL PERSPECTIVE

In order to fly the SUA as safely as possible, all flights will be conducted in occurdance to CAP 393 Air Navigation Order and the PfCO. This operations manual will be for operations in the United Kingdom only. This company is small in nature and therefore no formal training will be undertaken outside of the required ground and flight school exams by an NQE. However, the SUA Operator and Remote Pilot will conduct regular flying at least two hours every three months to stay current. The SUA Operator is a member of ARPAS and will seek to attend relevant courses if applicable. Regular checks on the DJI forum and other forums such as ARPAS will be conducted, in order to be up to date with any firmware issues or any defects of the equipment. All flights will be conducted under set procedures which are outlined in this document via memory recall and set checklists.

1.4 Safety Goals

Safety is the primary goal and an important aspect that underlines everything this company does with regards to flying SUAs. All flights will be conducted within the regulations of CAP 393 Air Navigation Order, the company's PfCO and within any restrictions contained within this OM. As flight safety is paramount, under no circumstances will safety standards be compromised in order to complete any flight requests.

1.5 Safety Training

Due to the small size of the company, there is no current safety training schedule. However, the SUA Operator will conduct regular reviews of the manufacturers' forum to assess any issues relating to firmware or operational systems for any safety notices or defects. The SUA Operator will also keep up to date on any such issues via the ARPAS forum and UAVair. The SUA Operator will take responsibility to log flight hours and will aim to maintain at least two hours for every three months of flying. This will be stored on the DJI go application and will be stored electronically via an excel spreadsheet.

2 Outline of Operations – Safety Assurance

When initial contact is made by a client to Anthony David Cliffe, the SUA Operator will initially conduct a feasibility report to assess whether the planned job can be conducted safely. The feasibility report includes;

- Date of the planned flight
- Location
- Distance to hazards, isolated structures and congested areas
- Airspace classification

If deemed that the mission can be conducted safely from the preliminary feasibility report, the mission profile and location will be planned for in greater depth. A Flight Planning form is then created by the Remote Pilot. The Flight Planning form includes;

- Date of the planned flight and assigned a specific job number
- Location: Address and site Co-Ordinates
- Airspace classifications
- Airport and ATZ proximity (Including ensuring at least 1km from the boundary)
- Permissions required
- Hazards
  - Danger Areas
  - Restricted Areas
  - Prohibited Areas
  - Other airspace hazards e.g. HIRTA
- NOTAMs
- Local Bylaws
- Obstructions i.e. Public Access, Congested Areas and Isolated Structures
- Habitation and Recreational Activities
- Weather

Once the flight planning form has been completed, on the day of the flight the Remote Pilot will conduct an On-Site assessment form. This form includes:

- Hazards:
  - Trees, Cables
  - Isolated structures
  - Congested areas
  - External Interference Sources
  - Take-off, Landing and Alternative areas marked, suitable ground state with 30m

clearance
- Public Access

Once this has been completed and the Remote Pilot is happy that the flight can be conducted safely, the Remote Pilot will follow a set assembly and pre-flight checklist. After the flight has been completed, the Remote Pilot will follow the Post-Flight checklist and will complete a battery log, an incident log and a service and maintenance log.

3 DEFINITIONS & ABBREVIATIONS

Acronym	
AGL	Above Ground Level
AMSL	Above Mean Sea Level
ANO	Air Navigation Order
ATC	Air Traffic Control
ATZ	Aerodrome Traffic Zone
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CSC	Combination Stick Command
GPS	Global Positioning System (Satellite Navigation)
HIRTA	High Intensity Transmission Area
LiPo	Lithium Polymer battery
MOR	Mandatory Occurrence Report
MTOM	Maximum Take Off Mass
NOTAM	Notice to Airmen
NQE	National Qualified Entity

OAT	Outside Air Temperature
OM	Operations Manual
PfCO	Permission For Commercial Operation
REMOTE PILOT	Pilot in Command/Pilot Flying
RPAS	Remotely Piloted Aircraft System
RTH	Return to Home
SUA	Small Unmanned Aircraft
UAS	Unmanned Aerial System
VLOS	Visual Line of Sight

4 Document Control and Amendment Process

The SUA Operator is responsible for recording and updating this operations manual. The current version of this OM is listed on page 2. All amendments are signed off by the SUA Operator.

4.1 Referenced Documents

Document	Version
CAP 382	Version 10 – December 2016
Air Navigation Order	Air Navigation Order 2018 (As amended)
CAP 722	6th Edition – 31/03/2015
DJI Phantom 4 Pro Manual	Version 1.2 – 14/03/2017

5 ORGANISATIONAL STRUCTURE

Insurance Information

Insurers: Moonrock Drone Insurance

Limit of Indemnity: Public Liability £1,000,000

Policy Number: 9483450

Period of Validity: From: 00.00 on 10th August 2018

To: 23.59 on 9th August 2019

CHIEF PILOT/ CAMERA OPERATOR

Anthony Cliffe

Anthony David Cliffe

6 NOMINATED PERSONNEL

Name: Anthony David Cliffe

Position: SUA Operator

Tel: Mob:

Email:

7 Management Responsibilities and Pilot-In Command

7.1 SUA Operator

The SUA Operator is responsible for the current operations of this company. The SUA operator is currently also the Remote Pilot. The SUA Operator is responsible for the feasibility flight planning, training and running of the company i.e. handling client requests, payments.

The SUA Operator is a fully qualified SUA pilot and will ensure that proficiency and currency are maintained. The SUA Operator holds the responsibility to:

- Maintain the Flight Operations Manual and update when necessary
- Ensure that all Training and Flight logs are recorded and kept up to date
- Conduct any incident report and logs
- Conduct initial feasibility report
- Enforce company procedures and checklists
- Conduct any maintenance or firmware upgrades
- Conduct Test Flights
- Final decision on who becomes a Remote Pilot and Ground Crew Observers

7.2 Remote Pilot

The Remote Pilot is fully responsible for all flying related matters with the SUA from the moment it is taken from storage until the moment it returns.

The Remote Pilot is responsible for the following:

- Conducting a Flight Planning Report
- Conducting an On-Site Assessment Report
- Conduct a site specific Risk Assessment
- Transport the aircraft to and from the site
- To follow company procedures and checklists
- Ensure the aircraft is safe to fly i.e. No defects recorded and all software is up to date
- Assembly and disassembly of the aircraft
- Responsible for the briefing of GCOs
- Conducting the flight i.e. Flying the aircraft in a safe and legal manor
- Refusing to complete the flight if safety is to be compromised
- Keeping all flight, Battery and Technical logs up to date

8 Responsibilities of Support Personnel

While on site, the Remote Pilot may use the client or other members on site to help with the operation. This will consist of these people becoming Ground Crew Observers with the responsibility for spotting, incursions, set up of the site and to help in emergencies.

8.1 Ground Crew Observers (GCO)

The client or other member of the operation may be called upon by the Remote Pilot to be a ground crew observer. Their primary purpose is to assist the Remote Pilot in helping to conduct the flight as safely as possible.

- **Spotting:** The GCO is responsible for the spotting of the aircraft to ensure that the Remote Pilot maintains visual contact with the aircraft at all times. If the pilot loses VLOS the GCO should be able to maintain VLOS and help guide the pilot in such situations. They should also look for hazards such as bird activity.
- **Incursions:** The GCO is responsible for the spotting of any surface or aerial incursions. The GCO should relay such information to the Remote Pilot who will take the required action. GCOs may be used to mitigate surface incursions.
- **Alerting Remote Pilot of an emergency situation**: As stated above the GCO is responsible for reporting to the Remote Pilot of a VLOS failure or a surface/ground incursion. The GCO is also responsible for reporting any issues from the aircraft i.e. detection of visible smoke or fire.
- **Site set up:** GCOs may be used by the Remote Pilot to ensure the landing and take-off zones are set up, and that mitigations such as cones are in place.

9 Aircraft Systems and Technical Description

Anthony David Cliffe currently operates the DJI Phantom 4 Pro. Below are the specifications listed, for a full specification sheet see Appendix G 7.4.

9.1 DJI Phantom 4 Pro

Name of aircraft:	DJI Phantom 4 Pro
Manufacturer:	DJI
Distributer:	DJI
Make:	Phantom
Model:	4 Pro
Type:	Quadcopter
Serial Number:	**OAXDDBROA20286**
Company Serial Number:	**ADC 0001**

Overall Diameter (m):	0.35m
Command and Control Frequency:	2.4GHz & 5.8GHz
Number of Motors:	4
Flight Controller:	DJI Phantom 4 Pro Controller
Firmware Release:	v01.01.03.00

Type of Propulsion

Engine Type:	Electric
Battery type:	Lithium Polymer 45
Battery Capacity:	5870 mAh
Battery Voltage:	15.2V
Propeller size:	24x 7.6 x 4.1 cm
MTOM:	1388g

9.2 DETAILED DESCRIPTION

The DJI Phantom 4 Pro is a SUA Quadcopter that weighs 1388g. This SUA is equipped with a 15.2v Intelligent LiPo 45 flight battery with a capacity of 5870 mAh that equates to around 30 minutes of flight time. This SUA comprises the airframe and a built-in gimbal and camera. Safety features of this aircraft include the use of both GPS and GLONASS satellite systems to ensure redundancies are in place for keeping the required satellite number at 6. This is important to record the home point and in aiding the return to home function. This aircraft includes 360 degree vision system and infrared system which helps to avoid collisions with objects under certain conditions. The aircraft has three primary flight modes, *Position, Sport and Attitude* mode. It has further *intelligent* flight modes and they are as follows; *Course Lock, Home Lock, Point of Interest, Follow Me* and *Waypoints.*

9.3 MODES OF CONTROL

9.3.1 POSITION MODE (P-MODE)

The SUA will use GPS & GLONASS data along with the Vision System and Infrared sensing system to hover over the current position over the ground *(accuracy: Vertical with Vision Positioning +-0.1m; GPS positioning +-0.5. Horizontal with Vision Positioning =- 0.3m; GPS positioning =-1.5m).* While in this mode, the pilot still has full control over the flight of the SUA. Any flight command control will change the hold location over the ground. Neutralising the flight controls will immediately make the current position the new Hold Position. Height control is maintained via the GPS/GLONASS, Vision and Infrared systems and an internal barometer. In this mode the SUA can avoid objects and can track moving subjects. Only in this mode can the intelligent flight modes be activated. The aircraft has a max speed of 31mph and a max tilt angle of 25º.

9.3.2 SPORT MODE (S-MODE)

The SUA will use the same principles and accuracy as that of Position mode when in a hover. However the collision avoidance feature is no longer active in this mode. Sport mode significantly increases the handling characteristics of the aircraft and increases the maximum speed from 31mph to 45mph. Maximum tilt angle is also increased to aid speed and manoeuvrability from 25º to 42º. Intelligent flight modes cannot be accessed from this mode. The pilot has full control over the SUA in this mode.

9.3.3 ATTITUDE MODE (A-MODE)

The SUA will only use the internal barometer to maintain height and orientation but not position in this mode. GPS/GLONASS and Vision Systems will not be used to maintain a hover. However GPS/GLONASS is not disabled, it still is active in the background in case of a return to home event. In order to maintain a position over the ground the pilot must make inputs to the right control stick in order to keep the SUA over the same hold point. No throttle is required as the aircraft will maintain height in this mode. Intelligent flight modes and collision avoidance are also disabled in this mode. In A-Mode the aircraft max speed increases to 36mph and a maximum tilt angle of 35º. The pilot has full control of the SUA in this mode.

9.4 RETURN TO HOME FUNCTIONS

On this SUA there are three types of return to home (RTH) functions, *Failsafe RTH, Smart RTH & Low Battery RTH.* The RTH function is to bring the aircraft back to the last recorded home point which is usually the last take off point of the aircraft. In order for this to work there must be a strong GPS signal at the point of take-off. The aircraft will climb to a designated height set by the pilot and will then fly towards the home point before descending. If the pilot has selected Forward Positioning System on the aircraft before take-off the aircraft will avoid obstacles by climbing or descending on its route back to the home point if lighting conditions are sufficient. However, it cannot move left, right or rotate when returning to home when Forward Position System is enabled. The pilot does not have control of the aircraft in some RTH modes.

9.4.1 FAILSAFE RTH

Failsafe RTH is a mode that will bring the aircraft back to the recorded home point if signal is lost from the remote control to the aircraft for more than three seconds. If this happens the aircraft will immediately hold position, then climb to the pre-set RTH altitude and will then make its way back to the home point. The aircraft will hold position for ten seconds over the home point and will wait for signal commands from the remote controller, if this does not occur the aircraft will land itself at the home point and shutdown. The pilot can disable the RTH function by re-establishing the connection between the aircraft and the remote controller. This function only works if the GPS signal is sufficient (at least 6 satellites connected). Failsafe RTH will not bring the aircraft back to the home point if connection between the controller and aircraft is lost within a 20m radius of the home point. The aircraft will hover at the position of the lost connection and will immediately land itself.

9.4.2 SMART RTH

This mode is activated by the pilot either via the RTH button on the controller or through the RTH button in the DJI GO 4 app. If the pilot activates this mode the aircraft will ascend to the designated RTH altitude and will use the camera to plan a safe return home to the last recorded home point. During smart RTH process the pilot has the ability to control the aircraft by altering altitude and speed if needed to avoid a collision. In smart RTH the pilot does not need to control the aircraft unless to avoid a collision. Smart RTH can be cancelled and a pilot regains full control of the aircraft by pressing the RTH home button again to cancel. The aircraft will not RTH if the GPS signal is insufficient. Smart RTH will not bring the aircraft back to the home point if activated within a 20m radius of the home point.

9.4.3 Low Battery RTH

This mode is an automatic mode that is enabled when the battery reaches a predetermined level. On this aircraft the pilot can select what percentage of battery life the aircraft will enable the RTH function to become active. Once this percentage is reached in flight, an audible and visual warning will be made to the pilot. If the pilot does not cancel the RTH function, the aircraft will fly back to the last recorded home point. If the pilot elects to cancel the RTH function at the low battery warning and continues to fly, the aircraft will calculate a *critical battery warning* level based on distance from the home point and current altitude. Once critical battery level has been reached, the aircraft will descend and land automatically at its current location and will not return to the recorded home point.

9.4.4 Landing Protection during RTH

During the landing phase of the RTH functions, the aircraft is equipped with a landing protection system. This system determines if the ground is suitable for landing. If it is, then the aircraft will reduce its rate of descent when close to the ground in order to land gently. If the system does not think the ground is suitable, the aircraft will remain in a hover until the pilot inputs a command to a land.

9.5 Intelligent Flight Modes

These modes include Course Lock, Home Lock, Point of Interest, Follow me and Waypoints and are used to assist users in the capture of video and still photography. These flight modes are accessed via the DJI GO app while in flight. They can only be activated if the aircraft is in *P mode*.

9.5.1 COURSE LOCK

This mode locks the current nose direction of the aircrafts forward orientation. The aircraft will move in the locked orientation regardless of yaw angle. Throttle and all other controls are under the control of the pilot.

9.5.2 HOME LOCK

Regardless of orientation of the aircraft in this mode if the pilot pulls the pitch stick backwards, the aircraft will move towards the recorded home point. The pilot can still control elevation in this mode.

9.5.3 TAPFLY

This mode the aircraft can be controlled via the DJI GO app. The aircraft must be at least 2m AGL in order to be activated and have at least 50% battery. The pilot can tap on an area of the screen and the aircraft will fly to that location. The pilot can use control inputs to control the aircraft in flight such as speed and height. The aircraft using the vision and infrared systems will automatically detect and avoid obstacles if the lighting is greater than 300 lux and lower than 10,000 lux. TapFly has three modes, *Forward mode, backwards mode* and *Free mode.*

Forward mode: The aircraft will fly towards the designated target and the forward vision system is activated.

Backwards mode: The aircraft will fly away from the designated target and the rear vision system is activated.

Free mode: The aircraft will fly towards the designated target but the pilot can use the controller to input yaw movements. Obstacle Sensing and avoidance is disabled in this mode.

The pilot can exit TapFly mode at any time by pressing the "STOP" button on screen, by pulling the pitch stick back and holding for 3 seconds or pressing the intelligent flight pause button on the controller. In all instances the aircraft will hover in its current position until a new target is selected or the pilot makes a control input.

9.5.4 Draw mode

In this mode the aircraft will fly along a flight path that has been drawn by the pilot on the screen of the DJI GO app. The aircraft will automatically brake and hover if it detects an obstacle in its path, providing lighting in sufficient (300-10,000lux). This mode is accessed via the DJI GO app and the aircraft must have 50% battery, be higher than 2m AGL and be in P-mode. The pilot creates a flight path by tracing their finger on the screen in the path they want the aircraft to fly. Once drawn the pilot taps "GO" and the aircraft will automatically fly along the path. The pilot can still control the aircraft movement such as height and speed during this phase of flight. To exit this mode this can be done any time by pressing the "STOP" button on screen, by pulling the pitch stick back and holding for 3 seconds or pressing the intelligent flight pause button on the controller. In all instances the aircraft will hover in its current position until a new path is created or the pilot makes a control input.

9.5.5 Waypoints

In this mode the aircraft will fly along a pre-set flight path that has been created by the pilot. The aircraft will continue to fly along that path while the pilot controls the camera and the orientation of the aircraft. The flight plan can be saved and re-uploaded for each flight.

9.5.6 ActiveTrack

This mode enables the aircraft to position itself and fly around a marked subject. The aircraft will automatically avoid obstacles in its flight path. This mode is used to track people, animals, bikes and other vehicles. The aircraft must have at least 50% battery, be 2m AGL and have the controller in P-mode. This mode is activated via the DJI GO app. To use ActiveTrack the pilot must select the ActiveTrack icon from the Intelligent Flight options on the DJI GO app. The pilot selects on screen the subject they wish to track and will draw a box around the subject. The box will be highlighted green if tracking is successful. There are three ActiveTrack modes; *Trace, Spotlight* and *Profile*.

Trace mode: The aircraft will track the subject at a constant distance. The pilot can input roll movements on the controller to circle the subject.

Spotlight mode: The aircraft will not automatically trace the subject like in trace mode. Instead, the aircraft will keep the camera orientated in the direction of the subject. The pilot can use input commands on the controller to manoeuvre the aircraft however yaw is disabled.

Profile mode: The aircraft will track the subject at a constant angle and distance from the side. The pilot can input only roll movements in order to circle the subject.

The pilot can exit ActiveTrack by pressing the "STOP" button on the DJI GO app or the intelligent flight pause button on the controller. The aircraft after exiting the mode will remain in a hover until the pilot inputs a control command.

9.5.7 POINT OF INTEREST

This mode enables the aircraft to circle around a designated point of interest. The aircraft will not avoid obstacles in this mode. The aircraft must have at least 50% battery, be 10m AGL and have the controller in P-mode. This mode is activated via the DJI GO app by selecting the point of interest mode in the intelligent flight options. To activate this mode the pilot will fly over the designated point of interest with the camera orientated 90º downwards. Once over the desired point of interest the pilot selects "OK" and will then move away at least 5m from that point latterly. The pilot will yaw the aircraft so that the camera is now facing at the desired point of interest. Once at the desired the distance away, selecting start and the aircraft will continue to circle the object. The pilot can control direction (clockwise/anticlockwise), height via the throttle control and speed using the speed indicators on the GO app. The pilot cannot change the yaw orientation of the aircraft once this mode is activated. The pilot can exit Point of Interest mode by pressing the "STOP" button on the DJI GO app or the intelligent flight pause button on the controller. The aircraft after exiting the mode will remain in a hover until the pilot inputs a control command.

9.5.8 GESTURE MODE

In gesture mode the aircraft remains in a hover and allows a person to control the camera hands free to take a Picture. This is usually however not done by the pilot but by the subject of the Picture.

9.5.9 TRIPOD MODE

In tripod mode the aircrafts' speed performance is reduced to a maximum of 5.6mph and the braking distances reduced to 2m. Responsiveness to control movements are also reduced in order for the aircraft to exhibit smoother controlled movements. This mode is primly used for smoother videography.

9.5.10 TERRAIN FOLLOW MODE

The downward vision system is used in this mode to maintain a height above ground between 1 to 10m. This mode is primarily used for grasslands that slope no more than 20°.

9.6 TELEMETRY

All flight data from the aircraft is recorded on an internal flight recorder. Such data includes the flight telemetry such as height, speed and distance, aircraft status information such as battery percentage and temperature, and other parameters such as camera settings. This data can be accessed by connecting the aircraft via USB to a computer and launching the DJI Assistant 2 application.

The pilot can see flight information displayed on the main display screen which is attached to the remote controller. There are up to 25 different telemetry information displayed on the screen.

9.6.1 PRIMARY TELEMETRY

The primary telemetry is the flight telemetry located on the bottom hand side of the screen. It shows the following;

26.1.1.1 *Flight attitude and Radar Function:*

The aircrafts flight attitude is indicated by the target-like icon.

- The red arrow indicated which direction the aircraft is facing.
- The ratio of the grey area to the blue area indicates the aircrafts pitch.
- The horizontal level of the grey area indicates the aircraft's roll angle.

26.1.1.2 *Flight parameters:*

- Altitude: Vertical distance from the Home Point.

- Distance: Horizontal distance from the Home Point.

- Vertical Speed: Movement speed across a vertical distance.

- Horizontal Speed: Movement speed across a horizontal distance.

- Aircraft Distance: The horizontal distance between the aircraft and the remote pilot.

9.6.2 MAP

This shows the aircrafts position on a map along with a trace of the flight path.

9.6.3 TOP BAR TELEMETRY

The following are in order along the top bar of the display moving left to right across the screen.

- *System Status:* This is located on the top bar of the display screen. Here indicates the flight status such as "Ready to go (GPS)" and any warnings such as insufficient GPS will appear here.
- *Obstacle Detection Status:* A series of bars in a semi-circle appear in the top centre of the display screen when the aircraft is close to and detects an object. The bars decrease as the aircraft moves closer to an object. Orange bars represent the aircraft detecting the obstacle and will change to red along with a reduction in bars when the aircraft is in close proximity to the obstacle.
- *Battery Level Indicator:* This shows the battery level of the aircraft. The coloured zones on the battery level indication represent the power levels needed to carry out different functions such as flight intelligent modes and warning battery level percentage.
- *Flight mode:* This tells the pilot which flight mode the aircraft is currently in i.e. P-Mode, S-Mode, A-Mode.
- *Camera Parameters:* This displays the camera settings and space left on the Micro SD card. Information such as ISO and shutter speeds are displayed here.
- *GPS Strength:* Shows current GPS strength and the number of satellites connected to the aircraft.
- *Obstacle Sensing Function Status*: This shows the pilot if the Obstacle Sensing systems is enabled or disabled.
- *Remote Controller Signal Strength:* This shows the strength of the remote control signal.
- *HD Video Link Signal Strength:* This shows the signal strength of the HD video downlink connection between the aircraft and the remote controller.
- *Battery Level:* This icon shows current battery level in percentage and displays voltages. Temperature can also be displayed. Clicking this icon will open up a window of more battery telemetry.

9.6.4 BOTTOM BAR TELEMETRY

The following are located from top to bottom on the right hand side of the display screen.

- *Focus/Metering:* This shows if the camera is in focus or metering mode.
- *Auto Exposure Lock:* Shows if the AE function is locked or unlocked.

- *Photo/Video Button:* Shows the pilot if the camera is in photography or video recording modes.
- *Gimbal Slider:* Displays the pitch of the gimbal.
- *Shoot/Record button:* Displays if the camera is recording.

Other icons located on the left of the screen do not show telemetry but can access certain flight controls they are; intelligent flight mode, Smart RTH, Auto Take-off/Landing. Livestream and DJI app.

9.7 CAMERA

For this SUA the camera and gimbal are an integrated system. The camera which is integrated into the gimbal assembly is a small camera that can take 20 megapixel stills and video of up to 4096x2160p at 60fps.

The gimbal operates on a 3-axis basis providing a stable platform for the attached integrated camera. The gimbal has a 120^0 tilt angle. $+30^0$ from the horizontal and -90^0 from the horizontal 0^0 degrees. There are two gimbal modes available.

Follow Mode: The angle between the gimbal's orientation and the aircrafts nose remains constant at all times.

FPV Mode: The gimbal will synchronize with the movement of the aircraft to provide a first-person perspective flying experience.

10 AREA OF OPERATION

The primary area of operation for this company is to use the SUA for surveying UK landscapes. The SUA will operate in open countryside and along sections of coast to conduct photogrammetry surveys. A secondary use will be to use the SUA for general video/photography.

11 Operating Limitations and Conditions of Use

11.1 Technical Specifications

Condition	Minimum	Maximum
Max Take Off Mass (kg)	1.4 Kg	1.4 Kg
Wind-Speed (knots)	0	19
OAT (°C)	0	+ 40
Max Physical Ceiling (ft.)	N/A	19685 amsl
Max Endurance (mins)	0	30 mins

11.2 Legal Limitations

Legal	Minimum	Maximum
VLOS Horizontal (m) from the Remote Pilot	0	500
VLOS Vertical (ft.) from the Remote Pilot	0	400
Isolated structures (m)	50	N/A
Persons or vehicles (m)	50	N/A
Landing (m)	30	N/A
Congested Area ANO (m)	150	N/A
Congested Area Standard Permission (m)	50	N/A
Person or Structure under the control of the Remote Pilot (m)	0	N/A

Open air Assembly of more than 1000 (m)	150	N/A

11.2.1 Small unmanned aircraft: requirements 94

94 (1) A person must not cause or permit any article or animal (whether or not attached to a parachute) to be dropped from a small unmanned aircraft so as to endanger persons or property.

(2) The remote pilot of a small unmanned aircraft may only fly the aircraft if reasonably satisfied that the flight can safely be made.

(3) The remote pilot of a small unmanned aircraft must maintain direct, unaided visual contact with the aircraft sufficient to monitor its flight path in relation to other aircraft, persons, vehicles, vessels and structures for the purpose of avoiding collisions.

(4) If a small unmanned aircraft has a mass of more than 7 kg excluding its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight, the SUA operator must not cause or permit the aircraft to be flown, and the remote pilot in charge of the aircraft must not fly it -

(a) in Class A, C, D or E airspace unless the permission of the appropriate air traffic control unit has been obtained; or

(b) within an aerodrome traffic zone during the notified hours of watch of the air traffic control unit (if any) at that aerodrome unless the permission of any such air traffic control unit has been obtained

(4A) Paragraph (4) does not apply to any flight within the flight restriction zone of a protected aerodrome (within the meaning given in article 94B).

(5) The SUA operator must not cause or permit a small unmanned aircraft to be flown for the purposes of commercial operations, and the remote pilot of a small unmanned aircraft must not fly it for the purposes of commercial operations, except in accordance with a permission granted by the CAA.

11.2.2 Small unmanned aircraft: height restrictions on flights

94A (1) The SUA operator must not cause or permit a small unmanned aircraft to be flown at a height of more than 400 feet above the surface, and the remote pilot of a small unmanned aircraft must not fly it at a height of more than 400 feet above the surface, unless the permission of the CAA has been obtained.

(2) This article does not apply to any flight within the flight restriction zone of a protected aerodrome (within the meaning given in article 94B).

11.2.3 Small unmanned aircraft: restrictions on flights that are over or near aerodromes

94B (1) This article applies to a flight by a small unmanned aircraft within the flight restriction zone of a protected aerodrome.

(2) The "flight restriction zone" of a protected aerodrome consists of the following two zones -

(a) the "Inner Zone", which is the area within, and including, the boundary of the aerodrome;

(b) the "Outer Zone", which is the area between -

(i) the boundary of the aerodrome; and

(ii) a line that is 1 km from the boundary of the aerodrome (the "1 km line")

(3) In the circumstances set out in an entry in column 1 of the following table -

(a) the SUA operator must not cause or permit the small unmanned aircraft to be flown

in the Inner Zone or the Outer Zone; and

(b) the remote pilot of a small unmanned aircraft must not fly it in the Inner Zone or the Outer Zone if the flight breaches a flight restriction set out in the entry in column 3 of the table which relates to that zone in those circumstances.

Circumstances	**Zone**	**Flight Restriction(s)**
There is an air traffic control unit or a flight information service unit (or both) at the protected aerodrome, and the flight takes place during the notified hours of watch of the air traffic control unit or flight information service unit.	Inner Zone or Outer Zone	A flight at any height is prohibited unless the permission of the air traffic control unit or flight information service unit has been obtained.
(a) There is neither an air traffic control unit nor a flight information service unit at the protected aerodrome; or (b) There is either an air traffic control unit or a flight information service at the protected aerodrome, and the flight takes place outside the notified hours of watch	Inner Zone	(1) A flight at a height up to and including 400 feet above the surface is prohibited unless the permission of the operator of the aerodrome has been obtained. (2) A flight at a height of more than 400 feet above the

of the air traffic control unit or flight information service unit; or (c) There are both an air traffic control unit and a flight information service unit at the protected aerodrome, and the flight takes place outside the notified hours of watch of the air traffic control unit and outside the notified hours of watch of the flight information service unit.		surface is prohibited unless both (a) the permission of the operator of the aerodrome has been obtained; and (b) the permission of the CAA has been obtained.
	Outer Zone	A flight at a height of more than 400 feet above the surface is prohibited unless the permission of the CAA has been obtained.

(4) The 1 km line is to be drawn so that the area which is bounded by it includes every location that is 1 km from the boundary of the aerodrome, measured in any direction from any point on the boundary.

(5) In this article, "protected aerodrome" means -

(a) an EASA certified aerodrome;

(b) a Government aerodrome;

(c) a national licensed aerodrome; or

(d) an aerodrome that is prescribed or of a prescribed description.

11.3 Operational (Company Limitations)

Condition	Minimum	Maximum
Max Take Off Mass (kg)	1.4	1.4
Wind-Speed (knots)	0	15
OAT/C	0	+ 35
Operational Ceiling/ft.	N/A	19685 amsl
Operational Endurance	0	30 mins

11.3.1 Company Weather minima

No precipitation or fog is needed to fly the SUA. The cloud base must be at least 500ft high and a horizontal visibility of 600m or greater.

11.3.2 Company Software, Firmware and Maintenance

The aircraft must operate with the latest software and firmware (within two weeks of the published date). Unless an issue has been reported with the software or firmware. The aircraft will revert to an older version until the new version has been debugged. The aircraft is to be inspected every 10 flight hours/ every 3 months.

12 Supervision of Drone Operations

The Remote Pilot is responsible for all aspects of flying operations including flight planning and log keeping. The Remote Pilot is also responsible for the briefing and inclusion of ground personnel, if and when needed.

13 Accident Prevention and Flight Safety Programme

The Remote Pilot is responsible for the safe operation of the aircraft and must comply with all procedures in this manual and with the current requirements of the ANO and PfCO standard permissions. In the event of an incident no matter how slight, will be recorded and investigated by the SUA Operator and any crew members present at the time of the incident. This investigation will follow the procedure as detailed below following the definitions as outlined in CAP722.

13.1 What is an Accident?

An occurrence which takes place between the times any person comes into contact with the drone with the intention of flight until such time as all such persons cease activity, where:

a) A person suffers a fatal or serious injury as a result of:
   i) direct contact with any part of the drone, including parts which have become detached from the aircraft;
   except when the injuries are from natural causes, self-inflicted or inflicted by

   other persons; or

b) the drone sustains damage or structural failure which:
   i) adversely affects the structural strength, performance or flight characteristics of the aircraft; and
   ii) would normally require major repair or replacement of the affected component except for damage limited to propellers, or for fixed-wing drones wing tips,

   antennas, tyres, brakes; or

c) the aircraft is missing or is completely inaccessible.

13.1.1 What is a Serious Incident?

An incident involving circumstances indicating that an accident nearly occurred.

13.1.2 What is an Incident?

An occurrence, other than an accident, associated with the operation of an aircraft which affects, or would affect, the safety of operation. Examples include:

a) Unusual flight behaviour

b) Drone failures that do not result in damage or loss

13.2 Incident Logging

Internal incident reporting is completed through completing an incident log, *Appendix D 4.2*. The incident reports are kept in an incidents folder and if the incident is serious enough to warrant further action then the Remote Pilot can elect to submit a reporting form via http://www.aviationreporting.eu/.

The SUA Operator of this company is responsible for ensuring that the incident log is updated and completed when any incident occurs.

As a minimum, the incident report includes

- *Date:* The date and as close to accurate time as possible that the incident occurred.
- *Aircraft:* The aircraft type involved in the incident.
- *Location:* The location of the incident.
- *Description of Incident/Observation:* A narrative including as much detail as possible about the events leading up to the incident and the incident itself.
- *Evident collected:* Any pictures or videos of the incident and the aftermath.
- *Completed pre-site & on-site assessments:* attached if electronic or passed to the investigating officer when requested.

13.3 Investigation Procedures

The investigation will attempt to find out what happened and what can be done to stop it happening again. The investigation procedure is not to apportion blame but is to make continued safety improvements to SUA operations.

When an incident occurs it is the responsibility of the Remote Pilot at the time to ensure that details of all personnel involved and any evidence of the incident is recorded. Once this has taken place at the scene of the incident, the details should be added to the incident form within 48 hours. Within this 48 hour period an initial meeting should be held with the Remote Pilot and any persons involved in the incident. While every attempt will be made to have this as a face to face meeting, if availability is limited then electronic or phone meetings can be conducted.

If the incident is serious enough that it requires further investigation by an outside agency be that the CAA or the Police and evidence is requested to be submitted, it is to be made clear that no blame is attributed to the evidence.

Once the investigation has concluded, if lessons can be learnt that directly affect the operations of this company, changes will be implemented immediately. If new procedures are introduced or changed in light of the incident then they will be reflected in an updated version of this OM. If the improvements are of significance to the aircraft type then the SUA Operator will submit a report via ECCAIRS portal and will communicate the issues via aircraft specific forums.

The Remote Pilot involved should remain grounded until the completion of the internal investigation has taken place. This will be reviewed by the SUA Operator and or an external advisor such as another qualified SUA pilot. In this case another Remote Pilot can be sought to complete any outstanding missions.

13.4 MANDATORY OCCURRENCE REPORTING SCHEME (MORS)

Mandatory occurrence reporting (MORs) is currently part of CAP382 and this occurrence reporting in the UK and the rest of Europe is governed by European Regulation 376/2014. It enables the reporting of any safety related event which endangers or which if not addressed could endanger an aircraft or other person. The system is designed to collect information to improve safety and like the incident form, is not to apportion blame. The submission is via the ECCAIRS portal at http://www.aviationreporting.eu/.

13.4.1 What should be reported?

Any incident which endangers or which if not corrected, would endanger an aircraft or any other person should be reported. The Remote Pilot should understand the regulations and the reporting schemes as outlined in CAP722.

Accidents and serious incidents (Definition in 13.1) should also be separately reported to the AAIB.

The following aircraft categories are specifically covered by the MOR Scheme (i.e. all occurrences must be reported):

• Any aircraft operated under an Air Operator's Certificate granted by the CAA;

• Any turbine-powered aircraft which has a Certificate of Airworthiness issued by the CAA.

Although these categories would appear to exclude the vast majority of SUA applications, all occurrences related to SUA operations which are considered to have endangered, or might have endangered, any aircraft (including the subject unmanned aircraft) or any person or property, must still be reported to the CAA via the MOR Scheme. This applies equally to all UAS categories, regardless of the aircraft's mass or certification state. It also includes UK registered UAS operating outside UK airspace.

Occurrences such wake vortex, bird strikes and airprox can be completed via the European portal, to which the CAA will still receive such reports. More information about occurrence reporting can be accessed here: https://www.caa.co.uk/Our-work/Make-a-report-or-complaint/MORS/

14 FLIGHT TEAM COMPOSITION

For this company, operations can occur with only the sole pilot operating. The sole pilot for this company is currently the SUA Operator and the Remote Pilot for all operations.

14.1 SUA OPERATOR AND REMOTE PILOT

The SUA Operator is responsible for the current oversight of operations of this company. Such as handling client requests, keeping the operations manual up to date and conducting feasibility reports. The Remote Pilot is responsible for the handling of all paperwork and equipment in relation to flight operations and for following all procedures in relation to flying. For a full outline of the SUA Operator and Remote Pilot's role see Chapter 7.2 & 7.6.

While operations can occur with one flight member the Remote Pilot will use if available, the client or other member of the team to act as a Ground Crew Observer. They do not have to be an employee of Anthony David Cliffe but will be fully briefed by the Remote Pilot as to what their role should entail. For a further outline of the GCO role see Chapter 8.2.

14.2 RESPONSIBILITIES

All crew members (including the pilot and GCO if available) will visually monitor the flight.

- The Remote Pilot is responsible for flying and for monitoring the aircraft systems and any hazards (i.e. airspace and ground space monitoring).
- The GCO is responsible for monitoring for Airspace Hazards and Ground incursions and if needed to help the Remote Pilot to action emergency procedures.

15 OPERATION OF MULTIPLE TYPES OF DRONE

Not applicable at this present time.

16 Qualification Requirements

Only the Remote Pilot will hold any formal qualifications within the flight team.

16.1 Remote Pilot

In order to fly the DJI Phantom 4 Pro the Remote Pilot should hold as a minimum:

- Successfully completed a ground school course with a CAA recognised/approved NQE.

16.2 Loss of Ability to Operate Commercially

The stipulations of loss of ability to operate commercially will happen if:

- Any crew involved in an accident or serious incident pending a review by an external advisor who will be sought such as a qualified SUA pilot.

17 CREW HEALTH

The Remote Pilot should be able to conduct the flight safely and this means that they must be generally fit for duty. The Remote Pilot must not conduct the flight if they feel they are not fit to do so, for example being physically ill.

17.1 ALCOHOL POLICY

Zero alcohol consumption within 8 hours of the planned flight and only light consumption within 12 hours.

17.2 DRUG POLICY

The Remote Pilot should not take or be under the influence of any illegal drugs as set out in the Misuse of Drugs Act 1971 and the Misuse of Drugs Regulations 2001.

Prescription drugs are allowed however, the Remote Pilot must follow all information, such as the ability to operate machinery.

17.3 DUTY AND REST GUIDANCE

To minimise any chance of fatigue when flying, the Remote Pilot is to adhere to the following:

- 10 hours off duty after completing all post flight activities prior to being required for a subsequent flight.
- Recommended a total maximum of 90 minutes of flight time in any twenty four hour period.
- The maximum crew duty time for single piloted operations = 12 hours.

18 Logs and Records

18.1 Logs

The following logs are kept.

- Pilot Flight Logs
- Technical Logs
  (a) Aircraft Technical Log
  (b) Battery Log
  (c) Propeller Log
  (d) Defect Log
  (e) Maintenance Log
- Incident Log
- Risk Assessment

18.1.1 Pilot Flight Logs

This includes the Remote Pilot name, observer name if present, location and flight duration. See *Appendix D 4.1.1.*

18.1.2 Technical Log

This technical log is used to record the technical aspects of the aircraft including flight time, battery usage and defects and maintenance. The technical log includes:

- Aircraft technical Log
- Battery Log
- Propeller Log
- Defect Log
- Maintenance Log

These can be found in *Appendix D.*

18.1.3 Privacy

Any record keeping of any clients will be kept on a password protected file. All logs are on a password protected Google Drive server for ease of access. They are also stored on a password protected computer which regularly backs up to the cloud.

18.1.4 Risk Assessment

This is a site and job specific risk assessment.

19 Maintenance

19.1 Software and Firmware Updating

The Remote Pilot is responsible for the software and firmware upgrades. A minimum wait of at least one week from the date that a new firmware is published before commencing the upgrade to the newest version. The Remote Pilot will monitor the DJI Forum and networks such as ARPAS forum in order to ascertain if any issues have arisen that may affect the safety of the aircraft. Only once the Remote Pilot is satisfied that the new firmware is stable and bug free will the upgrade begin. This upgrade will be documented on the maintenance log book by the Remote Pilot. The number of the firmware and what new features or bugs have been resolved will also be documented.

19.2 Testing firmware

The aircraft after the newest firmware has been updated must only be flown by the Remote Pilot for the test flight. A series of manoeuvres will take place in order for the Remote Pilot to assess the firmware upgrade. These manoeuvres are as follows:

- Test of Gimbal movement
- Test of camera settings
- Control link and data link stability
- Aircraft control across all three flight modes P,S and A modes

- Throttle responsiveness
- Hover
- Forward, Back, Left and Right

If any issues have been noted during the test flight then such information will be logged in the incident book and should be disseminated on the DJI forum.

19.3 Maintenance Principles and Regime

The Remote Pilot is responsible for the maintenance of the aircraft. The aircraft must follow the following inspection routines.

19.3.1 Routine inspection

- 10 flight hours / every 3 months

The aircraft must be inspected by the Remote Pilot after every 10 flight hours or 3 months whichever comes first. This inspection is to look for any visible damaged part of the airframe. The inspection should also look for signs of fatigue. This can be in the form of landing gear cracks or spider cracks in the bearings. All screws and fittings must be tested that they are securely fastened. Batteries should be checked for fatigue and wear.

Aircraft:

The servicing of the aircraft involves replacing the propellers after every 10 hours of flight time or 6 months, whichever occurs first. Every 6 months, the motor bearings must be checked for excessive wear by turning each motor while exerting a tensile force away from the top of the motor and then repeated with a sideways force, both applied by hand.

Motors:

If excessive noise occurs from one of the motors or if excessive wear is identified on one motor then all four motors and their securing clips must be replaced in order to have even wear on the components.

Propellers:

Propellers should be replaced as a set every 10 hours or 6 months. If one propeller is damaged then the entire set must be replaced. If one propeller is damaged while spinning then despite a visual inspection the entire set must be replaced.

Cables:

Any cable inspections or maintenance should be contracted out to a DJI recommended repair centre.

Camera:

The camera and gimbal are integrated components of this aircraft. A detailed visual inspection of the camera and gimbal for any damage and making sure they run freely and clean are the only servicing options. The camera lens protector if damaged can be replaced by unscrewing by hand. The gimbal component will make sure all parts are securely attached to the aircraft.

Recording:

All maintenance work is recorded and logged in the technical aircraft log under the maintenance file, Appendix D 4.3.

19.3.2 Replacement of parts

- Propellers to be replaced as a set every 10 hours of flight.
- Batteries every two years unless inspection requires earlier replacement.
- Motor and bearings must be replaced when fatigue or damage occurs. As these bearings are brushless, they have a longer operating life and low maintenance needs.

19.4 Final inspection pre-flight

A final inspection must be conducted before the first flight of the day.

- Visual inspection of the airframe to assess for any visible damage or lose items
- That the gimbal guard has been removed and gimbal is free to move
- Battery inspected and secured
- Propellers inspected before fitting. Post fitting check securely fitted.

A similar inspection must be conducted post flight by the chief pilot before the aircraft is stored.

PART B – OPERATING PROCEDURES

1 DETERMINATION OF THE INTENDED TASK AND FEASIBILITY

When a possible client makes contact with Anthony David Cliffe to discuss a potential mission the SUA Operator must assess whether the flight is feasible. This is a feasibility assessment and if deemed feasible, the Remote Pilot shall complete a flight planning form.

The initial process is to document the dates of the planned flight. The location of the site should be searched through www.googlemaps.com. While the company recognises that Google Map satellite views are not always up to date, it gives a relatively accurate representation to the pilot about the lay of the land and any associated hazards that may be present. The following website www.freemaptools.com is used to assess distance from any objects during the flight, to public access areas and to any congested areas. The SUA Operator should use the co-ordinates of the site location on Sky Demon to understand any airspace restrictions or proximity to airports.

If the SUA Operator deems that the site and planned flight is feasible then further discussion with the client are to take place in order to create a flight plan that will achieve the required goals. The Remote Pilot must then conduct a flight planning report.

1.1 OPERATING SITE LOCATION AND ASSESSMENT

The Remote Pilot should record the following items on the Flight Planning report form *Appendix B 2.1*.

A. **Airspace:** The airspace whether the site is in controlled or uncontrolled is recorded here. In order to attain such information, the Sky Demon Light website www.skydemonlight.com is used. This is then cross-referenced with CAA aeronautical charts at 250:000 & 500:000 scales.
B. **Airports & Airfields*:*** Airports/Airfields within 5nm of the site are recorded along with the distance to the inner and outer boundary of an airfield as indicated in the table below as part of Article 94B of the Air Navigation Order. In order to attain such information, Sky Demon Light website is used www.skydemonlight.com to assess distance and airport names. The names and contact details along with their operational times are sourced from the UK Aeronautical Information Service www.ais.org.uk. For smaller airfields which are not present on AIS, Pooley's Flight Guide United Kingdom 2017 and http://ukga.com/airfield/bypostcode will be used to access information.

C. **Hazards:** Paper and online charts are used to record any potential hazards.
- *Danger Areas:* Can be found on Sky Demon and Paper charts and are cross referenced with the AIP on ais.org.uk to find out more detailed information about the specific area.
- *Restricted Areas:* Can be found on Sky Demon and Paper charts and are cross referenced with the AIP on ais.org.uk to find out more detailed information about the specific area.
- *Prohibited Areas:* Can be found on Sky Demon and Paper charts and are cross referenced with the AIP on ais.org.uk to find out more detailed information about the specific area.
- *NOTAM restrictions:* Accessed via www.notaminfo.com
- *Other airspace hazards:* Can be found on digital and paper charts and via NOTAMs
D. **Local Bylaws:** Accessed via Bing Maps and the ordinance survey map option www.bing.com/maps.
E. **Obstructions:** This includes; isolated structures, powerlines and congested areas. Using the satellite view on www.googlemaps.com , Ordinance survey maps on Bing maps along with paper OS maps.
F. **Extraordinary Restrictions:** This can be identified on CAA aeronautical charts and on Sky Demon. Items that come under this category, more information can be accessed via the AIP on www.ais.org.uk
G. **Habitation and recreational activities:**
Habitation – Can be accessed via http://www.magic.gov.uk/MagicMap.aspx and includes habitat and species information.
Recreational activities – This can be found on ordinance survey maps and digitally via google maps.
H. **Public Access*:*** Can be found on paper OS maps or via the OS Map layer on Bing maps.
I. **Permission from Landowner:** Google maps to see which land will be affected by the flight.
J. **Likely operating site and alternative sites:** Google maps satellite view to mark alternative operating sites.
K. **Weather conditions for the planned event:**
Planning – www.weather.com will be used to list the weather for the planned event in advance. www.uavforecast.com will be used to attain space and KP index weather.
On the day: Various weather sites will be used for weather on the day. These include - www.weather.com
- METAM application
- Rain Alarm Pro application

1.2 Risk Management

The remote pilot must conduct a site and job specific risk assessment after completing the flight planning report. Risk is the combination of the probability of an event occurring and the severity of its consequence. Therefore, in order to minimize the risk to operations to a level that is As Low As Reasonably Practical (ALARP), this company operates under the Hierarchy of Control Measures.

The company used the ERICPD acronym:

- **E**liminate The hazard totally (Don't fly if weather or people around, new processes).
- **R**educeThe risk to ALARP (Training, Ground Observers, Barriers rectified and Checklists and procedures followed).
- **I**solate The hazard to a minimum of people (securing the site if possible, fly at quieter times of the day).
- **C**ontrol The hazard (Steps to minimize danger such as notifications via signs or official channels).
- **P**ersonal Protective Equipment (Hi-Viz, hardhat when required, safety equipment).
- **D**iscipline Safe system of work on site (checklists and procedures) along with a positive safety culture for all involved in flight operations.
-

An example of how a **Risk Assessment Form** is completed can be found in *Appendix F.*

1.3 Communications

During the flight planning phase any airports or airfields within 5nm of the location will be identified via Sky Demon and via Aeronautical charts. Their contact details are to be sought via the AIP on www.ais.org.uk if the airfield due it is size is not listed in the AIP, Pooley's Flight Guide book and http://ukga.com/airfield/bypostcode will be used. These numbers are recorded on the flight planning form by the Remote Pilot, along with their direction from the location. If the flight is in controlled airspace or within the ATZ of an airfield, the Remote Pilot should notify the airport via telephone and or email, prior to operations and on the day.

1.4 Pre-Notification

If the flight takes place within the ATZ of an airfield then the Remote Pilot should inform the appropriate ATC unit, preferably at least a week prior to flight, with 24 hours being a minimum with details of the flight. These details must include the area of operation, anticipated duration and maximum height AGL. This is to assess any potential conflicts during this time at the airfield or any areas that should be avoided. The pilot should also inform ATC prior to the commencement of the flight and once the operation is finished. All contact should be made via phone or email if possible. Time and person spoke to will be recorded.

Other notifications:

- Local Police: May be notified if deemed necessary at least 24 hours prior to flight via phone of the intended operation. If possible, a reference number will be sent via email as confirmation.
- Local airspace users e.g. gliding clubs should be notified via phone at least 24 hours before a flight if applicable in the operating area.
- If NOTAM is needed following the NSF procedures on the NATS website http://www.nats.aero/nsf/Details.aspx . This must be submitted with a minimum of 21 days' notice.
- Local Hospital – In case of an emergency, A & E number for the nearest hospital is noted on the flight planning form.

1.5 Site Permission

The Air Navigation Order does not specifically address the issue of Trespass, as this is a completely separate area of law. However,

'Operators must be aware of their responsibilities regarding operations from private land and any requirements to obtain the appropriate permission before operating from a particular site. In particular, they must ensure that they observe the relevant trespass laws and do not unwittingly commit a trespass whilst conducting a flight…'

Permission from the landowner or person who has been granted permission from the landowner to approve the flight must be obtained by the Remote Pilot. The land from which the drone will take off and land must be sought and details recorded via email or on paper. In addition, anyone within 50m of the drone whilst in flight or 30m for take-off and landing must be brought under the control of the Remote Pilot. Permission should also be sought for any land the aircraft will fly over.

This information must be recorded on the flight planning form.

1.6 WEATHER

There are certain weather restrictions for the safe flying of the SUA. All weather checks will be done in the flight planning stage by the Remote Pilot and again once on site before the flight commences.

1.6.1 WIND LIMITS

The company maximum wind speed is 15 knots. This should be measured on site by the Remote Pilot or if present, a GCO with an anemometer. If indicated in the forecast (weather app) and TAF (above Prob 40) for strong winds, particular notice is made for the strength of the maximum gusts. If the maximum gust is to be outside the set limits then the flight will not go ahead. Particular attention is also made to any potential turbulence from structures or landforms. This should be assessed on the day during the site assessment and briefed in the pre-flight briefing by the Remote Pilot.

1.6.2 Precipitation

The aircraft should not be flown in any precipitation types, such as rain or snow. Weather will be monitored by METARs if an airfield is within 10 nautical miles and precipitation will be monitored via the rain-alarm pro application. If precipitation is within one mile of location or fog is present, then batteries should not be connected. This will be determined by the alarm feature on the Rain Alarm Pro app.

1.6.3 Temperature Limits

The minimum OAT for operations is 0C and the maximum is +35c. Temperature on the day is identified via weather.com, METAR (If there is an airfield within 5nm) and use of the thermometer on the anemometer.

When operating in cold environments the batteries are to reach 20c before the aircraft can take off. This is monitored on the DJI Go application.

1.6.4 Visibility Minima

The aircraft must not fly in fog. The company minima is 600m visibility from the take off point. Weather.com and METARs will be used to identify visibility and cloud base.

1.6.5 Solar Activity

Solar activity is monitored through www.uavforecast.com for the latest and predicted KP index. KP index which is higher than 7 can cause some potential issues with GPS signals and therefore a flight should not occur at KP7 or greater.

2 ON SITE PROCEDURES AND PRE-FLIGHT CHECKS

A final inspection must be conducted before the first flight of the day.

- Visual inspection of the airframe to assess for any visible damage or lose items
- That the gimbal guard has been removed and gimbal is free to move
- Battery inspected and secured
- Propellers inspected before fitting. Post fitting check securely fitted.

A similar inspection must be conducted post flight by the SUA Operator before the aircraft is stored.

2.1 PREPARATION

The Remote Pilot is responsible for the setting up of the aircraft. Before the aircraft is transported to the location, it is the Remote Pilots responsibility to ensure all equipment is packed, all maintenance logs are checked and that the latest stable firmware is installed. If a new firmware/software is available and the flight commences within a week of the new published version, that version must not be installed and should use the latest old stable installed version.

Once at the location the Remote Pilot should remove the aircraft from the transportation case and will carry out a detailed visual inspection of the airframe and components. This is to ensure no damage has occurred in transit and that the aircraft is visually ready for flight. This aircraft has four motors with four fitted propellers and a moveable gimbal, the rest of the aircraft is internal electronics. They are the only moving parts of this aircraft. The gimbal is held in place securely for transport purposes. This gimbal guard must be removed after the visual inspection. The pre-flight checklist ensures that the gimbal cover is removed and stowed, that the propellers have been inspected and securely attached to the airframe and that the battery has been visually inspected and securely attached to the aircraft. A final visual inspection must occur to ensure all items have been addressed in the checklist and that all parts are secure before the commencement of the flight.

2.2 SITE SURVEY

When on site the Remote Pilot must conduct a visual inspection of the site. This includes a walk around of the flight area, a visual inspection of the Take-off and landing area and the alternative areas. Any potential hazards must be noted on the site assessment form, *Appendix B 2.2*. The Remote Pilot should discuss if relevant with the landowner or site manager to assess any potential hazards that may also occur within the operating area.

2.3 SELECTION OF OPERATING AREAS AND ALTERNATE

The take-off and landing area and alternative areas should have the following requirements:

- At least 30m clear of any obstacles
- Avoid excessive slope angle
- Any ground vegetation must not be higher than the clearance of the propellers
- Must be kept clear at all times (this can be achieved by cordoning off the sites).

The Remote Pilot shall make the final decision on whether the sites are suitable.

The take-off, landing and alternative areas should be marked out on a satellite image of the area on the flight planning form. These must also be clearly communicated by the Remote Pilot to the ground observers if present, during the pre-flight briefing. It is the role of the Remote Pilot and if present a GCO, to ensure that the primary and alternative areas are clear at all times.

2.4 CREW BRIEFING

Crew briefing must be given before the start of flight by the Remote Pilot and involves all members of the flight operations. The briefing consists of the following:

- *The nature of the flight:* What the planned mission goal is, expected flight time and manoeuvres to be conducted.
- *The take-off, landing & alternate areas:* Clearly identified by the Remote Pilot verbally and visually by the ground crew observers

- *Responsibilities:* Their respective responsibilities as per Part A – Section 8
- *Weather:* Any potential weather issues that may affect the flight
- *Emergency briefing:* Outline any hazards that may affect the flight and detail the emergency procedures should a ground/airspace incursion occur or if an in-flight emergency occurs.
- *Questions:* The briefing will conclude with an opportunity to ask questions to ensure all members of the operation understand the task and their roles and responsibilities.

2.5 CORDON PROCEDURE

2.5.1 GROUND ENCROACHMENT

Ground encroachment can occur in any flight, especially those taken over public land. Therefore, if a high probability that this may occur is identified, the flight crew can adopt the following measures.

- *Notification:* Signs may be displayed on the edges of the flight area to warn the general public that an SUA flight will be in progress.
- *Barriers:* The primary and alternative take-off and landing zones can be marked off via tape to ensure that 30m between aircraft is kept from non-trained people.

Observers must be made aware by the Remote Pilot in the pre-flight briefing of any potential access points for the general public. If this occurs, they must relay the information to the Remote Pilot. While the ground observers on public land cannot restrict a person from entering the area, they can only advise verbally to avoid and tell them about the dangers. If this fails, then they must communicate this to the Remote Pilot who will follow the ground infringement emergency procedure.

In the case of a flight emergency when a rapid landing is required and the landing area is not secure or clear, an audible warning (a shout) should be given from the Remote Pilot and repeated by the ground observers (if present) to warn others. Under no time should the aircraft be within 50m of any persons or structures while in flight, or within 30m for landing, unless they are under the control of the Remote Pilot.

2.5.2 Flight Encroachment

The Remote Pilot and GCOs must remain vigilant to the possibility of a flight encroachment. The likelihood of this occurring increases if operating close to airfields/airports or within an Area of Intense Aerial Activity or Military Low Flying Area. If this is the case, it must be highlighted to the GCO's by the Remote Pilot during the pre-flight briefing along with what procedures should occur if this happens.

The procedure is as follows:

- Aircraft heard and the person who hears it makes it known to the Remote Pilot.
- Remote Pilot and or observer attempts to make visual contact with the aircraft.
- If the aircraft is identified: approximate direction and aircraft type is passed to the Remote Pilot. The Remote Pilot will assess the threat and reduce altitude or carry on and monitor the aircraft, depending on the nature of the aircraft threat.
- If the aircraft is not identified: Reduce altitude immediately and if possible move the aircraft to the designated holding area until visual contact is made.

2.6 Communications

2.6.1 Drone Frequencies

The DJI Phantom 4 Pro operates over two radio bands 2.4GHz and 5.8 GHz. The 2.4 GHz band is used by other services and may be prone to interference in built up environments.

- Loss of this radio link will affect the safety of the flight. If the link with the aircraft is lost, the aircraft will enter the failsafe return to home function.

This aircraft transmits live HD video link back to the Remote Pilot that also displays telemetry such as battery levels and altitude information. This operates on two bands 2.4 GHz and 5.8GHz. The Remote Pilot can select either one or can allow the aircraft to switch between the two automatically. This vastly reduces the likelihood of the camera link being lost or disrupted.

- If this occurs, the flight can still continue however, the camera feed may be of importance to the mission and therefore the Remote Pilot should elect to return to land.

The Remote Pilot should then try to identify potential sources of interference and take steps to mitigate.

2.6.2 Operating Crew Communication

If the Remote Pilot and the GCO are within close proximity then they should communicate via voice. However if the Remote Pilot and GCO are to be positioned far enough apart that voice warnings and instructions cannot easily be heard, then communication must be done via a hands free method i.e. phone communication.

Only strict information relating to the flight should be communicated and the observers should only pass information if it endangers the flight such as a ground or air infringement or unless the Remote Pilot asks for specific information.

2.6.3 External Interference Sources

26.1.1.3 *GPS:*

GPS is an important part of SUA flying. For example, the on-board navigation control relies on a good GPS signal; this is mainly due to the need to accurately record the “Return to Take-Off Point”. This is important as for example if a loss of flight control signal occurred, then the SUA can fly back to this point accurately. GPS is also used in order to “hold position” or to fly a predetermined flight path using waypoints and is an essential part to this aircrafts intelligent flight modes.

For the GPS system to work, the aircraft must also have an accurate detection of the Earth’s magnetic field in order to know in which direction it is required to fly. Both the GPS reception quality and the Earth’s magnetic field can be degraded by strong solar flares hitting the Earth. Therefore, it is important for the Remote Pilot to check the KP index and to avoid any flying above 7 KP.

Before any flight commences, the Remote Pilot must ensure that the aircraft is receiving a signal from at least 6 GPS satellites. In an open environment free from obstacles and hills, the number of satellites received should be significantly higher. This aircraft uses both GPS and GLONASS satellite systems to increase the number of satellites it can connect to.

26.1.1.4 *Mobile phone devices:*

While mobile phone devices can potentially increase the likelihood of interference, they are needed for the operation of the aircraft. Mobile phones may be needed to contact emergency services in case of a serious emergency, or to contact any local ATC.

2.7 WEATHER CHECKS

The aircraft must not be flown if the weather conditions exceed the company limits in Part B – 1.6. Weather on the day of the flight should be assessed via weather.com, uavforecast.com and via METAM app and Rain Alarm App. The aircraft batteries must not be connected in fog or mist. If precipitation is 1nm away from the take-off position then batteries must not be connected. If prevailing winds are in the direction of the take-off site then the aircraft should be stored immediately until the precipitation has passed. This will be determined by the rain alarm pro application.

The company wind restriction is 15 knots at take-off. This is measured on the day by a handheld anemometer by the Remote Pilot or a GCO. Caution must be taken when the aircraft is landing and taking off when the wind speed is close to maximum wind limits. This increases the likelihood of the aircraft being destabilised and potentially toppling over during landing and take-off. If this occurs, the pilot must follow emergency minor incident procedure *Appendix E 5.1.8*.

2.8 Charging and Fitting Batteries (Refuelling)

It is important that LiPo batteries are never overcharged, deep discharged (below 3v per cell), exposed to high temperatures above 40°C or below -10°C, short circuited or physically damaged. Any of the above can lead to a thermal runaway event, which will most likely lead to venting and ignition of flammable gases as well as an extremely high internal temperature, which can cause secondary fires if near flammable materials. This aircraft is equipped with intelligent flight batteries that prevent the batteries from being overcharged, over current, over discharge and short circuit protection.

2.8.1 Charging

The supplied DJI intelligent battery charger can only be used with these batteries. The charger is connected to the power source and then plugged into the battery. The battery is placed within a LiPo bag on a heatproof surface before the power source is turned on. Batteries are never to be left unattended while charging. When the battery is charging each battery level indicator will flash and then go solid green when that cell has charged. The Intelligent flight battery is fully charged when all battery level indicator lights are extinguished.

2.8.2 Defects

Visual inspections of the battery must occur before, during and after charging of the battery by the Remote Pilot. Voltage and current levels are checked on the battery page of the DJI Go application but can only be accessed once the battery is connected to the aircraft and turned on. If one cell shows an erroneous cell voltage then the battery should be discharged to a safe level and then disposed of in the correct manor.

2.8.3 RECORDS

Battery percentages pre and post flight are recorded by the Remote Pilot in the aircraft technical log under the battery log. *Appendix D 4.13*

2.8.4 STORAGE

When transporting the batteries they should be kept in the DJI transport case. However when in storage the batteries should be discharged to 65% and placed in sealed LiPo bags. They are clearly labelled as batteries and highly flammable. A small powder fire extinguisher should be present also.

2.9 LOADING OF EQUIPMENT

The aircraft the DJI Phantom 4 Pro currently carries a payload of an integrated gimbal and camera. The payload is secured within the body of the aircraft and payload is fixed (non-changeable camera). The camera and gimbal are always fixed to the aircraft. The gimbal is secured during transport through the fitting of a gimbal guard which attaches to the outboard legs of the aircraft and holds the gimbal and camera in place for transport. The aircraft itself fits into a specially moulded transportation case that keeps the aircraft firmly in place. This transport case also includes a compartment for the controller, up to three batteries and up to two sets of spare propellers. It is the responsibility of the Remote Pilot to unbox and box the aircraft prior and after flight.

2.10 PREPARATION AND CORRECT ASSEMBLY OF THE DRONE

The preparation and assembly of the aircraft follows an expanded version of the manufacturers recommended practices. They are explored in more detail below. The Remote Pilot is responsible for the transportation and setting up of the aircraft.

Before transportation: Remote Pilot must ensure all batteries are charged and all items are stowed correctly.

Post transportation: Remote Pilot must remove the aircraft from the transportation case and must carry out a detailed visual inspection of the airframe and components.

Set up:

- Gimbal guard removed
- Propellers inspected and attached
- Controller set up and device attached and secure
- Battery connected and securely fastened but only attached when the aircraft is ready for flight.
- Another visual inspection of aircraft

After take-off a control check must be made by the Remote Pilot to ensure the aircraft is working.

2.11 PRE-FLIGHT CHECKS

Pre-flight checks are the final line of defence, some pre-flight checks have been covered so far and a full pre-flight checklist can be found in *Appendix C 3.1 & 3.2* however a summary of the stages are outlined below. The Remote Pilot must ensure that the following checklists have been completed.

2.11.1 PRE-FLIGHT

- Site assessment completed
- Briefing given
- Emergency equipment check
- Aircraft assembly
- Aircraft powered on
- System check & flight plan loaded

If the Remote Pilot is satisfied that the *Assembly* checklist has been completed, then the Remote Pilot must follow a *Before Start* checklist

2.11.2 Final checks before take-off

- Assembly checklist completed
- Battery level sufficient
- Satellite number sufficient
- Winds level checked
- Take-off area clear check
- "STARTING" announced
- Start Engines

2.12 Night Operation

Operation at night is permitted provided the following conditions are met. This requires that:

– The aircraft is fitted with sufficient lighting to maintain visual contact and correctly assess orientation, without adversely aff ecting the Remote Pilot's night vision

- The aircraft uses a RTL failsafe that can be activated in the event of a lighting failure

– The landing and take-off zone is sufficiently lit

-A site visit must be conducted during daylight, prior to night operation. The site assessment process should include an element specific to the hazards associated with night flying, such as noting the location of unlit obstacles.

3 Flight Procedures

3.1 Assembly and Start

3.1.1 Before Powering the Aircraft

Before the battery is connected to the aircraft by the Remote Pilot, the remote control transmitter is turned on by the Remote Pilot. Before turning the transmitter on the Remote Pilot must check that the aircraft battery is disconnected. When turning the controller on, one press of the on button gives the pilot a battery level indication. The battery must show as four bars in order to fly for the first time that day. At least two bars must be illuminated for subsequent flights which means at least 50% battery remains.

The controller has four white lights that are illuminated when the device is on.

3.1.2 DIAGNOSTICS

Battery instillation:
Before fitting the battery to the aircraft a visual inspection of the battery must be completed by the Remote Pilot. A visual check of the battery charge must also be performed by pressing the on switch once which illuminates the charge level of the battery. If this is sufficient then the battery is connected to the aircraft and the aircraft is turned on.

Calibration:
The Remote Pilot must ensure that the aircrafts compass is fully calibrated. A compass calibration is required to be done before the start of the flying day or at any new location. The compass calibration follows the manoeuvres set out on screen on the DJI Go app.

Home Point Recorded:
Once the compass calibration is completed, the Remote Pilot must wait for sufficient numbers of satellites until the home point is recorded. A message will appear on screen and an audible cue will be given by the DJI GO app. The Remote Pilot must then set the return to home altitude based on surrounding terrain and obstacles. The Remote Pilot must ensure the transmitter failsafe mode is set to RTH.

Telemetry:
The Remote Pilot should ensure there is a stable telemetry and video downlink connection to the aircraft. The telemetry check is to ensure sufficient battery percentage, voltage and temperature are operating within the normal parameters. It is to check that the home point and compass are working, that the flight mode is set to the correct and corresponding flight mode on the controller and that there are sufficient satellites (at least 6). It is important to note that error messages will appear on this screen such as a compass issue, vision system error or strong interference.

3.1.3 CALIBRATION

Compass:

The compass on the DJI Phantom 4 Pro must be calibrated at the start of each flying day or if travelling between locations in a flying day by the Remote Pilot. The process is as follows. The Remote Pilot should make sure that the aircraft is away from any potential strong magnetic interference such as magnetite, parking structures, and steel reinforcements. During the calibration process, the Remote Pilot must remove any ferromagnetic materials from their persons, such as a mobile phone. To start the process the Remote Pilot should enter the aircraft settings tab on the DJI GO 4 app, then select advanced settings, then sensor state, then compass, then calibrate compass.

A series of instructions will appear on the screen for the Remote Pilot to follow. To calibrate the compass, the aircraft is raised by hand to chest height and is extended outwards horizontally from the Remote Pilot. The Remote Pilot is to then complete a 360^0 anti-clockwise circle coming to rest at the start point; the aircraft indicator lights will turn green to show that the first part of the calibration is complete. The Remote Pilot should now point the aircraft nose towards the floor and will completed the same 360^0 anti-clockwise circle until the aircraft indicator lights turn green. Now the calibration process has been completed. If the calibration was unsuccessful, a warning message will appear on the DJI GO app.

Gimbal and Camera:

Once the aircraft has been set up to fly, one of the final tests before starting the motors is to check that the gimbal is working correctly. This is done by moving the gimbal through its full pitch range. The camera is set up via the camera settings tab on the DJI GO app to ensure the settings are correct and that the system is working.

3.2 TAKE OFF

Before take-off, the Remote Pilot must ensure that the assembly checklist and the before start checklist have been completed. The start procedure is as follows:

- Check the wind via anemometer
- Check battery levels and satellite numbers
- Observers notified that take off is ready to occur
- Check take off area clear
- Shout "STARTING"
- Note time on paper
- Start motors

To start the motors the Remote Pilot must use a Combination Stick Command (CSC). Both sticks are brought to the bottom inner corners of their control range to start the motors. Once motors have spun up, the Remote Pilot releases the control sticks to their original neutral position.

After take-off the Remote Pilot must perform a control check. This is usually completed at head height and after a hover for 10 seconds will follow short, sharp aggressive control inputs in accordance to the following manoeuvres. Away from the Remote Pilot, to the left, to the right, towards the Remote Pilot, then back to centre. If the Remote Pilot is satisfied that all systems are running normally, they will announce "READY" and the mission can begin. If the Remote Pilot is unsatisfied with the control behaviours of the aircraft they will announce "LANDING" and will land the aircraft.

3.3 IN FLIGHT

During flight the Remote Pilot must continue to monitor the following:

- Telemetry such as – Battery usage, levels and voltage, Satellite numbers, any system warnings
- Visual scans for other air uses. If an air incursion occurs then the *"Airspace incursion"* emergency procedure is to be followed.
- Ground scans for any encroachment. Particularly important in the landing phase of flight. (Ground Crew Observer if present will continue to place emphasis on scanning the ground for any infringements). If the Remote Pilot or observer detects a potential infringement the "*Ground infringement*" emergency procedure is to be followed.
- Weather conditions: Precipitation, cloud base and wind levels. (Ground Crew Observer if present will be in the possession of a switched on anemometer to visually check wind speeds in flight.

3.4 LANDING

The landing phase is one of the most critical phases of flight and care must be taken by the Remote Pilot and GCO to ensure that aircraft and public safety, is maximized.

The priority of the Remote Pilot with support from a GCO if present is to:

- Ensure that the public are a safe distance away (30m from the landing area). This is done via a visual inspection.
- The landing area is still clear and free from hazards and that the alternative landing site is clear also. This is done via a visual inspection.

- Weather: The Remote Pilot should be aware of any potential weather, extra care must be taken in winds that are gusting or are at close to maximum limits.

3.4.1 *LANDING PHASE*

The Remote Pilot must announce “LANDING” and descend the aircraft to head height above the take-off and landing zone positioning the nose of the aircraft into the prevailing wind. This enables greater control over the aircraft in the landing phase. The positioning of the nose of the aircraft into wind on landing reduces the likelihood of the aircraft toppling over. The likelihood of the aircraft toppling over in a crosswind is increased and should try to be avoided. After a five second hover to assess handling characteristics the Remote Pilot should lower the aircraft from head height into a slow and controlled manor to avoid a vortex ring state scenario. When the aircraft is a few centimetres above ground the Remote Pilot should lower the aircraft to the ground and immediately cut the motors and the time of shut down noted on the flight planning form.

3.4.2 *CUTTING MOTORS PROCEDURE*

To cut the motors once the aircraft has landed the Remote Pilot must pull the throttle stick (left stick) fully down and hold for three seconds until the motors have stopped.

3.5 SHUTDOWN

The shutdown procedure for the motors must be completed as per detailed in 3.4.

After the motors have been shut down the Remote Pilot must note down the battery capacity, voltage and temperature in the battery log. Once this information has been recorded the battery and therefore aircraft, should be shut down. To do this the Remote Pilot must press the battery ON button twice and hold until all lights are extinguished. The Remote Pilot is to then switch off the transmitter and then remove the battery. The Remote Pilot must give an "ALL CLEAR" message. The Remote Pilot is to then ensure that the following checklists have been completed.

3.5.1 POST-FLIGHT CHECKLIST

- Ensure battery telemetry has been logged in the battery log
- Visual inspection of the battery to ensure no damage has occurred
- Set batteries aside to be air cooled until they have reached room temperature
- Visual inspection of the aircraft

26.1.1.5 *If this is the final flight of the day:*

- Detach propellers – Commence visual inspection and stow
- Attach gimbal guard
- Once batteries have cooled, stow them
- Secure aircraft and remote control are stowed
- Technical log completed
- Pilot log completed

3.6 STANDARD CALLOUTS

Standard callouts are used if a ground observer is present.

Bold is the callout, other text is the response.

Condition	Remote Pilot	Support Personnel
Start	**'Starting Motors'**	'Check'
Take-Off	**'Aircraft Airborne'**	'Check'
Flight Controls	**'Flight Controls Checked'**	'Check'
Public Incursion	'Check'	**'Public approaching'**
Aircraft Incursion	'Check'	**'Aircraft Infringement'**
Landing	**'Landing'**	'Checked and area clear'
Battery removed	**'All clear'**	'All clear'

4 Emergency Procedures

Some emergency scenarios require the activation of the return to home function. The main RTH function used during these emergency procedures is the Failsafe RTH.

4.1.1 *Return to Home*

On this SUA there is are three types of return to home (RTH) functions, *Failsafe RTH, Smart RTH & Low Battery RTH*. The RTH function is to bring the aircraft back to the last recorded home point which is usually the last take off point of the aircraft. In order for this to work there must be a strong GPS signal at the point of take-off. The aircraft will climb to a designated height set by the pilot and will then fly towards the home point before descending. If the pilot has selected Forward Positioning System on the aircraft before take-off the aircraft will avoid obstacles by climbing or descending on its route back to the home point if lighting conditions are sufficient. However, it cannot move left, right or rotate when returning to home when Forward Position System is enabled. The pilot does not have control of the aircraft in RTH mode unless RTH is disabled.

4.1.2 *Failsafe RTH*

Failsafe RTH is a mode that will bring the aircraft back to the recorded home point if signal is lost from the remote control for more than three seconds. The aircraft if this happens will immediately hold position, then climb to the pre-set RTH altitude and will then make its way back to the home point. The aircraft will hold position for ten seconds over the home point and will wait for signal commands from the remote controller, if this does not occur the aircraft will land itself at the home point. The pilot can disable the RTH function by re-establishing the connection between the aircraft and the remote controller. This function only works if the GPS signal is sufficient (at least 4 satellites connected). Failsafe RTH will not bring the aircraft back to the home point if connection between the controller and aircraft is lost within a 20m radius of the home point. The aircraft will hover at the position of the lost connection and will immediately land itself.

4.2 Platform Specific

4.2.1 Engine Failure/Loss of Power to Motors

In the event of a sudden engine failure or loss of power to the motors there is little input a pilot can do to arrest the crash of this type of aircraft. The Remote Pilot should attempt to manoeuvre the aircraft away from any potential hazards and must shout an audible warning. Once the aircraft has landed, the Remote Pilot should secure the crash site and deal with any fires. The following steps are taken to minimise the potential risk of this occurring and minimising the aftermaths. The Remote Pilot must follow a regular maintenance schedule for the aircraft and engine and motor procedures, along with visual pre and post flight inspection of the components. Emergency procedures in place to mitigate potential aircraft crash by using powdered extinguisher to put out any potential fire and the informing of the emergency services if necessary. Following this, the collection of evidence will begin.

4.2.2 Aircraft Battery Failure

If the battery fails on the aircraft then the aircraft can crash. This is usually a sudden drop vertically. There are however steps to reduce this happening. The battery is only handled by a trained operator and all procedures are done within accordance to the manufacturer's guidelines, such as operating within the temperature limits. The batteries are inspected pre and post flight for any signs of damage and replaced if necessary. The signs of a battery failure can be evident from a decrease or increase in battery voltage and temperature. Therefore, the Remote Pilot must monitor the battery voltage and temperature during their telemetry scans in flight. Such information is clearly displayed on screen for the pilot to see.

If however the battery failure occurs, the pilot must shout an audible warning and will follow the steps in Part B – 4.1.1

4.2.3 Transmitter (Battery) Failure

In the event of a transmitter (battery) failure there may be a warning sign of a slow blinking red light on the transmitter along with an audible chime. This indicates a transmitter error however does not diagnose if the issue is with the battery, it only highlights a fault.
In the worst case scenario of the battery on the transmitter failing which would break the control link between the transmitter and the aircraft, the aircraft will enter the failsafe RTH function and will return to the designated take-off and landing position. The Remote Pilot is to shout an audible warning to the GCOs that the aircraft has entered failsafe mode and is returning.

4.2.4 Loss or Interference of Control Frequency

Numerous items could potentially cause a loss or an interference of the control frequency. This could be due to a high number of similar devices on the same frequency (such as a number of Wi-Fi hot spots). There could be a transmitter battery problem or a GPS/Compass malfunction. Issues such as this are difficult to diagnose in flight and the Remote Pilot should elect to land the aircraft as soon as possible back at the designated or alternative landing site. If the Remote Pilot can regain control of the aircraft and is confident that the link is now stabilised they should elect to land manually. If in doubt about the reliability of the transmitter link then the Remote Pilot should use the RTH function.

If the source of the interference can be identified and the Remote Pilot is content that the interference has been mitigated against and is happy that the aircraft can perform safely, then they may elect to continue the flight. If the source of interference is not apparent then the Remote Pilot should make a note of the interference type, what issues where raised and what time it occurred. An investigation should then be carried out to understand the issue and if need be to raise it with the wider RPAS community.

4.2.5 Ground Control Station Fire

In the event of a Ground Control Station Fire the Remote Pilot should shout an audible warning. An attempt to isolate the Ground Control Station should be made. If possible, remove the source i.e. mobile or tablet device. The area should be cleared and assistance requested. In the result of a fire, the Remote Pilot is to follow the Fire on the ground procedure 4.3.1.

4.2.6 Pilot Incapacitation

In the event of pilot incapacitation, there are ways to bring the aircraft back to land safely. Some of the procedures involve either the Remote Pilot or a GCO if present, using the RTH function on the aircraft. The following procedure should be followed:

- Pilot aware that they are losing the ability to safely control the aircraft, they should communicate this to the observer if present and if possible land manually and switch off the aircraft.
- Pilot aware that they are losing the ability to safely control the aircraft, informs the observer and hands control to them. The observer activates the RTH function by pressing the on button twice to switch the aircraft transmitter off and therefore entering the aircraft into the Failsafe RTH mode.
- Observer briefed before flight about this scenario. Pilot incapacitated and unable to communicate to the observer. The observer should switch off the transmitter as briefed and advised. Aircraft enters the failsafe RTH function and returns.

4.2.7 Aircraft Incursion

There may be times when an aircraft may incur on the operation zone. During the flight planning phase the Remote Pilot should be aware of any local airfields, Heli lanes, AAIA or low flying systems in the area of operation. This should make the Remote Pilot aware of an increased likelihood of an air incursion and potentially what type of aircraft and direction it may occur from. Such information should be briefed to themselves and any observers that are present so that they can make visual contact with an aircraft incursion and follow the airspace incursion emergency procedure. That procedure is as follows:

- Aircraft noise is heard in the area. Remote Pilot and or Observer verbally communicate to the team that they can hear.
- Remote Pilot and or Observer attempt to make visual contact with the aircraft.

If the aircraft is not visually located:

- Remote Pilot should immediately reduce the height of the aircraft below the tallest obstacle in the area and hover. If possible, the Remote Pilot should move the aircraft to the designated holding area until visual contact is made. Once visual contact is made they should follow the steps below.

If aircraft is visually located:

- Remote Pilot assesses threat and aircraft poses a threat: Remote Pilot should reduce altitude or land at the alternative or designated landing point ASAP. Remote Pilot should be aware of the increased likelihood of inducing a ring vortex state with a rapid vertical descent. The DJI Phantom 4 Pro is limited in its descent speeds in GPS mode. If GPS mode is too slow to descend the Remote Pilot should elect to switch to *Sport* or *Atti* mode to increase descent rate. The course of action should always be to descend. However, there may be a time when the aircraft must climb to avoid an aircraft. The Remote Pilot should climb but not break the 400ft ceiling. Again, if the rate of ascent is insufficient the Remote Pilot should change to either *Sport* or *Atti* mode.
- Remote Pilot assesses threat and aircraft poses no threat: Continues flight as planned and monitors incursion aircraft by maintaining visual and minimum separation.

The pilot under no circumstances is to ever climb the aircraft higher than 400ft, move 500m horizontally away from the Remote Pilot and must always maintain a clear line of sight to the aircraft.

4.2.8 SITE/GROUND INCURSION

There may be times when the public incur on the operation site. During the planning phase and during the site assessment, potential areas of infringement should be highlighted and briefed before flying commences.

If the Remote Pilot is the sole operator and a site incursion occurs they should:

- Reposition the aircraft immediately to keep the minimum separation distance of 50m.
- If the public continue to incur on the Remote Pilot. If practical, place the aircraft into GPS mode to reduce pilot workload and hover.
- If safe to do so and with minimum separation achieved, they should attempt to verbally communicate with the person who has incurred. Informing them of the operation and if possible if they could move 30m away from the Remote Pilot so that they can land the aircraft and will come and talk to them once the aircraft is safely on the ground.
- If the person moves 30m away, the Remote Pilot should land the aircraft as normal, shut down the aircraft to make it safe and only then, should they go over to the person in question.

- If the person does not comply and does not give 30m separation, the Remote Pilot should land the aircraft immediately in the safest position that is 30m away from any structures or people. They should ensure the aircraft is safely shut down and then should talk to the person in question.

If the Remote Pilot has a ground observer present:

- Remote Pilot or GCO spots a potential public incursion and verbally passes the message of this, including direction and distance to the Remote Pilot.
- Remote Pilot repositions the aircraft immediately to keep the minimum separation distance of 50m.

If the public continue to incur on the Remote Pilot.

- If practical, place the aircraft into GPS mode to reduce pilot workload and hover.
- If safe to do so and with minimum separation achieved, the ground observer should attempt to verbally communicate with the person who has incurred and should approach them. Informing them of the operation and the legal requirements and if possible if they could move 50m away.
- If the person does not comply the observer should inform the Remote Pilot.
- The observer should inform the person that in order for the Remote Pilot to land the aircraft and to come and talk to them once the aircraft is safely on the ground, they need to move at least 30m away.
- If the person moves 30m away, the Remote Pilot should land the aircraft as normal, shut down the aircraft to make it safe and only then, should they go over to the person in question.

If the person does not comply and does not give 30m separation, the Remote Pilot should land the aircraft immediately in the safest position that is 30m away from any structures or people. They should ensure the aircraft is safely shut down and then should talk to the person in question.

4.2.9 FLY AWAY

In the event of an aircraft flyaway where the aircraft flies away with no working control of the flight system there is little the pilot can do to bring the aircraft under control. However, there are procedures to mitigate against the effects of the flyaway aircraft to minimise the risk to air traffic and to the public.

In the event of a fly away and if all attempts to regain control have failed. I.e. switching to ATTI mode and reducing throttles. A "Fly Away" should be communicated to any observers. When this occurs, the Remote Pilot and Observers should:

- Monitor the direction, height and attitude of the aircraft
- Open the Flight Planning Form to see the direction of the closest airfield and their contact details.
- If the aircraft flies in the direction of one of the airfields make contact with the appropriate ATC unit stating aircraft type, heading, height, if climbing or descending and approximately how many minutes of flight time the aircraft has left.
- If needed contact emergency services such as the police to inform them of the event and the direction of the flyaway aircraft.

4.3 FIRE SPECIFIC

4.3.1 FIRE ON THE GROUND

Due to the nature of LiPo battery fires there should be no attempt to extinguish a LiPo fire. The following procedure is to deal with any resulting fires to external equipment or surroundings.

- Ensure the area is clear of people and if possible remove any potential hazards around the aircraft or battery
- Request assistance
- Contact emergency services if required
- If safe to do so, attempt to put out any resultant fires using a powder extinguisher
- Disconnect battery if possible and allow to cool
- Collect information for a post fire investigation

4.3.2 FIRE IN THE AIR

If there is any evidence of smoke and/or fire coming from the aircraft, the following procedure should be undertaken:

- Verbal communication of the notice of fire or smoke
- Manoeuvre the aircraft to the nearest safe landing point and land
- Switch the aircraft motors off

Then follow steps in 4.3.1. – Fire on the ground

PART C – TRAINING

Not applicable at this time.

PART D – APPENDICES

1. APPENDIX A – COPY OF THE PFCO

CIVIL AVIATION AUTHORITY
Air Navigation Order 2016

Civil Aviation Authority

PERMISSION – Small Unmanned Aircraft / Small Unmanned Surveillance Aircraft

1. The Civil Aviation Authority, in exercise of its powers under Article 94(5) and Article 95(1) of the Air Navigation Order 2016, as amended, hereby permits **Anthony Cliffe Trading As Anthony David Cliffe,** ("the person in charge") being the person in charge of a Small Unmanned Aircraft (SUA) / Small Unmanned Surveillance Aircraft (SUSA) ("the said aircraft") of the following class(es):

   (a) SUA Multirotor / Helicopter with a Maximum Take-Off Mass (MTOM) not exceeding 7kg;

   to conduct commercial operations with the said aircraft.

2. This Permission is granted subject to the following conditions, namely, that the said aircraft shall not be flown:

   General Operating Conditions for all Classes of SUA / SUSA:

   (a) Other than by persons employed by or contracted to **Anthony Cliffe Trading As Anthony David Cliffe** whilst being holder(s) of an appropriate qualification issued by a UK National Qualified Entity for SUA/SUSA pilot competency, or an alternative pilot competency qualification acceptable to the CAA (CAP722 refers);

   (b) Unless there is insurance cover for the aircraft that meets the requirements of EC Regulation No. 785/2004;

   (c) At a height exceeding **400 feet** above ground level;

   (d) Unless the aircraft is maintained within the direct, unaided Visual Line of Sight (VLOS) of:

      (i) The person in charge of the said aircraft or;

      (ii) A competent observer, under the control of the person in charge who is operating in accordance with procedures specified in the approved Operations Manual;

   out to a maximum range of **500** metres unless a lesser radio transmission range has been specified by the manufacturer;

   (e) Over or within 150 metres of an organised open-air assembly of more than 1,000 persons;

   (f) Within 50 metres of any person, vessel, vehicle or structure that is not under the control of the person in charge of the said aircraft, except that during take-off and landing this distance may be reduced to 30 metres;

   (g) Unless it is equipped with a mechanism that will cause the said aircraft to land in the event of disruption to or a failure of any of its control systems, including the radio link, and the person in charge of the said aircraft has satisfied himself that such mechanism is in working order before the aircraft commences its flight;

   (h) Unless the person in charge of the said aircraft has reasonably satisfied himself that any load carried by the aircraft is properly secured, that the said aircraft is in an airworthy condition and that the flight can safely be made taking into account the wind and other significant weather conditions;

   (i) Unless the flights are conducted in accordance with the current operations manual of the person in charge of the said aircraft and a site safety assessment has been completed. Site safety assessments are to be made available to the Authority on request;

   (j) Unless the person in charge of the said aircraft maintains records of each flight made pursuant to this Permission and makes such records available to the Authority on request;

Page 1 of 2

Additional Requirements for all Classes where the said aircraft has a MTOM greater than 7 kg but not exceeding 20 kg:

In addition to the conditions set out in paragraph 2(a-j) above, any SUA/SUSA with a MTOM greater than 7 kg but not exceeding 20 kg must not be flown:

(k) In controlled airspace (Class A, C, D and E), except with the permission of the appropriate air traffic control unit;

Such flights will be processed for NATS-administered controlled airspace under either Non-Standard Flight (NSF) or Enhanced Non-Standard Flight (ENSF) approval procedures. These procedures are set out on the NATS website www.nats.aero/nsf/rpas.aspx. Further details of the NSF/ENSF procedures are published at AIP ENR 1.1, section 4, paragraph 4.1.8 www.ais.org.uk

If approval is granted, the person in charge of the said aircraft is to fly the said aircraft entirely within the limits of the stated lateral and vertical operating area. No safety assurance against other Unusual Air Activities taking place in the same area is given or implied. NATS approval to fly within controlled airspace or an Aerodrome Traffic Zone does not absolve the operator from the responsibility for avoiding all other aircraft.

(l) Within an aerodrome traffic zone during the notified hours of watch of the air traffic control unit (if any) at that aerodrome unless with the permission of any such air traffic control unit has been obtained;

(m) Directly over or within 150 metres of any congested area.

3. Within the London Restricted Areas EG R157 (Hyde Park), EG R158 (City of London) and EG R159 (Isle of Dogs), the person in charge of the said aircraft, **of any MASS**, is required to obtain an ENSF clearance as referred to in paragraph 2 (k) (above). This is mandatory for all flights below 1400 feet AMSL and will involve authorisation by the Diplomatic Protection Group (DPG).

4. Further detailed guidance on SUA operations within London and other towns and cities is available at: www.caa.co.uk/in2014190 and CAP722.

5. This Permission shall have effect during daylight hours from **20 September 2017 until and including 20 September 2018** unless previously varied, suspended or revoked.

CAA 0041

Date: 20 September 2017
Ref: 20170920Anthony Cliffe Trading As Anthony David CliffePAndEUAV4855
Certificate Number: 1
SSC Technical Services 01293 768374 / uavenquiries@caa.co.uk

for the Civil Aviation Authority

Distribution: Anthony Cliffe Trading As Anthony David Cliffe (01515 265 105 / 07471 815 160, a.d.cliffe@2016.ljmu.ac.uk); [File]

NOTE 1: Aircraft operators and pilots should be aware that the collection of images of identifiable individuals, even inadvertently, when using surveillance cameras mounted on a small unmanned surveillance aircraft, may be subject to the Data Protection Act. Further information about the Data Protection Act and the circumstances in which it applies can be obtained from the Information Commissioner's Office and website: https://ico.org.uk/for-the-public/drones/

NOTE 2: Operators must be aware of their responsibilities regarding operations from private land and any requirements to obtain the appropriate permission before operating from a particular site. In particular, they must ensure that they observe the relevant trespass laws and do not unwittingly commit a trespass whilst conducting a flight.

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2. Appendix B – Forms

2.1 Flight Planning form

Section 1: Job Details			
Date of flight:		Job Number	
Remote Pilot:		Mission Summary:	
Observer:			
Section 2: Site Details			
Landowner:		Site Address:	
Tel:			
Email:			
Permission Granted			
Site coordinates			
Vehicle Access			
Site Altitude (ft. Amsl)			
Local Hospital:			
Contact Number:			
Police:	111/999 (emergency only)		
Section 3a: Airspace			
Controlled or Uncontrolled in area of operation	C/U		

Airspace classification in area of operation			
ATC Permission req.?	Y/N		
Any other controlled airspace within 5nm?	Y/N	Classes:	
Section 3b: Airports (within 5NM) Inner/Outer zone distance			
Airport Name:	Operation in (M)ATZ	Permission required	Contact name/ Number
	Y/N	Y/N	
	Y/N	Y/N	
	Y/N	Y/N	
Section 3C: Airspace Hazards (within 5NM)			
Item:	Airspace Ref Number	SUA Prohibited	Comment/Restriction
Danger Areas: EG D	D	Y/N	
Restricted Areas: EG R	R	Y/N	
Prohibited Areas EG P	P	Y/N	
Other Airspace		Y/N	
NOTAM Restriction		Y/N	
Section 4: Ground Assessment			
Item:	Comments/restrictions	Mitigations	
Congested areas: (within 500m)			
Isolated Structures:			

Conservation areas' including by-laws		
Third party infringement risk and site control:		
Roads and rights of way:		
Livestock:		
Recreational spaces:		
Other restrictions:		

Section 5: Weather Forecast

Item:	Comments
Wind Strength:	
Temperature (max/min):	
Humidity (approx.):	
Sunrise/Sunset:	
K index (space weather):	
TAF/METAR:	
General Forecast:	

Section 6: Additional Notes

TAKE OFF TIME:

LANDING TIME:

TOTAL TIME:

Section 7: APPROVAL TO

On the basis of the flight planning assessment I believe the flight can be conducted safely, in accordance with the Air Navigation order.

Prepared by:	Signed:	Date:

26.2 2.2 On-Site Assessment form

Section 1: Job Details			
Date of Flight:		Job Number:	
Remote Pilot:		Mission Summary	
Observer:			
Aircraft Type:			
Section 2: Weather			
Item:	Comments		
Wind Strength (Max 15 knots):			
Temperature:			
Relative Humidity (approx.):			
Sunrise/Sunset:			
Solar Weather KP index:			
Latest METAR/TAF			
General weather comments:			
Section 3: Contacts			
Person:	Contact Name	Number:	Details:
Remote Pilot:			
Observer:			
Client:			
Local Hospital:			

ATC 1:			
ATC 2:			

Section 4: Site Assessment

Item:	RISK	Comments	Mitigation
NOTAMS:	Y/N		
Obstructions:	Y/N		
Sources of Radio Interference	Y/N		
Livestock:	Y/N		
Public Access:	Y/N		
Proximity to structures	Y/N		
Proximity to roads	Y/N		
Line of sight obstructions	Y/N		
Surface conditions			

Section 5: Operations

Site Secure:	
Two way communications: (radio/verbal/other)	
Take-off & landing zone identified:	
Emergency Landing area:	
Emergency Inflight holding area:	

Section 6: Approval to Operate			
On the basis of the site assessment I believe the flight can be conducted safely in accordance with the Air Navigation Order.			
Prepared by:	Signed:	Date:	

3. Appendix C – Normal Checklists

27.1 3.1 Before Take-Off Checklists

27.1.1 3.1.1 Assembly Checklist

ASSEMBLY CHECKLIST	
LANDOWNERS PERMISSION IF REQ:	**OBTAINED**
SITE ASSESSMENT	**COMPLETED AND REVIEWED**
➢ Site assessment form completed and reviewed ➢ Any actions needed to mitigate risk and secure site ➢ Notifications given ➢ Primary and Alternative landing sites identified and secured	
TECHNICAL LOG	**REVIEWED**
➢ Review technical logs for any recorded defects and changed parts	
EMERGENCY EQUIPMENT	**CHECKED**
PRE ASSEEMBLY INSPECTION	**COMPLETED**
➢ Visual inspection of the aircraft after removing it from carry case. Inspection for any defects or damage on the airframe	
GIMBAL GAURD	**REMOVED AND STOWED**
PROPELLERS	**ATTACHED AND SECURED**
➢ Inspection of blades ➢ Silver to silver/ black to black ➢ Secure mounting	
BATTERY VISUAL INSPECTION	**COMPLETED**

➢ No defects or swelling ➢ Battery level at least 50%	
FPV SCREEN	**ATTACHED AND SECURE**
➢ FPV screen attached to the controller ➢ Mobile device connected ensure brightness 100% and DO NOT DISTURB setting selected	
BATTERY	**INSERTED AND SECURED**
➢ Battery connected to the aircraft ➢ Checked that it is securely mounted	
BRIEFING	**COMPLETED**
➢ Mission outline ➢ Take-off, landing, alternative sites and holding area ➢ Responsibilities ➢ Emergency briefing ➢ Questions	
CHECKLIST COMPLETED	

27.1.2 3.1.2 Before Start Checklist

BEFORE START CHECKLIST	
ASSEMBLY CHECKLIST	**COMPLETED**
REMOTE CONTROL TRANSMITTER	**ON**
➢ Battery sufficient and turned on ➢ Screen loaded and connected	
FINAL VISUAL AIRFRAME INSPECTION	**COMPLETED**
BATTERY	

ON
➢ Battery level checked at least 50% ➢ Battery on
CONNECTION ESTABLISHED **CHECKED**
➢ Connection established with the control link ➢ Enter DJI GO app and GO FLY
COMPASS CALIBRATION **COMPLETED**
HOME POINT AND RTH **SET**
BATTERY PERCENTAGE **RECORDED**
BATTERY PARAMETERS **NORMAL AND RECORDED**
➢ At least 50% charge ➢ Normal voltage ➢ Temp 20^0 C minimum
GIMBAL **TESTED**
CAMERA **SET**
CHECKLIST COMPLETED

27.1.3 3.1.3 Before Take-Off Checklist

BEFORE TAKE-OFF CHECKLIST	
BEFORE START CHECKLIST	**COMPLETED**
WIND SPEED	**WITHIN LIMITS**
SATTELITE NUMBERS AT LEAST 6	**SUFFICIENT**
BATTERY LEVEL	**CHECKED**
OBSERVERS	**NOTIFIED**
TAKE-OFF AREA CLEAR	**CHECKED**
“STARTING”	**ANNOUNCED**
START ENGINES	**STARTED**
TIME	**NOTED**
TAKE-OFF	
CHECKLIST COMPLETED	

3.2 In-Flight and Post-Flight Checklist

27.1.4 3.2.1 After Take-Off Checklist

AFTER TAKE-OFF CHECKLIST	
TAKE-OFF CHECKLIST	**COMPLETED**
CONTROL AND RESPONSE	**TESTED**
➢ Stable hover for 10 seconds ➢ Move away, left, right, centre	
CHECKLIST COMPLETED	

27.1.5 3.2.2 After Landing Checklist

AFTER LANDING CHECKLIST	
ENGINES	**OFF**
SHUT DOWN TIME	**NOTED**
BATTERY PARAMETERS	**LOGGED**
➢ Percentage recorded ➢ Voltage recorded ➢ Temperature recorded	
BATTERY	**OFF & DISCONNECTED**
REMOTE CONTROL TRANSMITTER	**OFF & DISCONNECTED**
ALL CLEAR SIGNAL	**COMMUNICATED**
CHECKLIST COMPLETED	

27.1.6 3.2.3 Post Flight Checklist

POST FLIGHT CHECKLIST	
BATTERIES	**SECURE & STOWED**
➢ Air cooled to room temperature ➢ Inspected ➢ Safely stowed	
PROPELLERS	**REMOVED & STOWED**
➢ Propellers removed ➢ Propellers inspected ➢ Propellers stowed	
GIMBAL GAURD	**ATTACHED**
AIRFRAME INSPECTION	**COMPLETED**
AIRFRAME	**SECURE & STOWED**
FPV SCREEN	**DETACHED**
REMOTE CONTROL TRANSMITTER	**SECURED & STOWED**
TECHNICAL LOG	**COMPLETED**
➢ Aircraft records ➢ Battery log ➢ Maintenance & Defect if required	
PILOT LOG	**COMPLETED**
EMERGENCY EQUIPMENT	**STOWED**
CHECKLIST COMPLETED	

4. Appendix D – Logs

28.1 4.1 Pilot, Battery and Propeller Logs

28.1.1 4.1.1 Pilot Log example

Pilot Flight Log					
Pilot in Command	Date (DD/MM/YY)	Job Number	Aircraft	Location	Flight Duration (Minutes)
A Cliffe	18/02/2017	TRG001	DJIP4P	HIGH TOWN	6
A Cliffe	18/02/2017	TRG002	DJIP4P	HIGH TOWN	6
A Cliffe	18/02/2017	TRG002b	DJIP4P	HIGH TOWN	8

- The Date is used to record the day that a flight took place
- The job number relates to the specific job. Flights prefixed with **TRG** are training flights
- Location to record location of the flight (nearest town or landmark)
- Flight duration in minutes

28.1.2 4.1.2 Aircraft log example

Technical Log Part 1: Aircraft Log: DJI Phantom 4							
Date (DD/MM/YY)	Job Number	Flight Duration(MM)	Battery 1 High Capacity consumed	Battery 2 Capacity Consumed	Propeller set used	Defect raised (Y/N)	Defect Numbers
xx	xx	xx	xx	xx	xx	xx	xx

- Date to record the date of the flight and should correspond to the entry in the pilot log
- Job number relates to the specific job and should correspond to the pilot log
- Flight duration in minutes
- Battery 1 is the High Capacity battery/ Battery part 2 is the low capacity battery and here is recorded how much battery was consumed. This data is pulled from the Technical log Part 2: Battery log
- Propeller set used. Individual propellers are not recorded but are recorded as sets. Each propeller in the set has the same flight time. This data is transferred into the Technical Log part 4: Propeller Log
- Any defects are raised here to be entered into the defect and maintenance log
- Defect given a number to track it in the defect log

28.1.3 4.1.3 Battery log example

Techinal Log Part 2: Battery Log High Capacity														
Battery 1: High capacity									Battery 1: High Capacity					
Job	Date	Before flight: Cell Voltage	Before flight: Cell Voltage	Before flight: Cell Voltage	Before flight: Cell Voltage	Before Flight: Total Voltage	Before flight: Battery Temp C		Post flight: Cell Voltage	Post flight: Cell Voltage	Post flight: Cell Voltage	Post flight: Cell Voltage	Post Flight: Total Voltage	Post flight: Battery Temp C
		0	0	0	0	0	0		0	0	0	0	0	0
Cumulative total		0	0	0	0	0			0	0	0	0	0	

The Technical Log Part 2 a & b: Battery log. This is used on site to record the battery cell voltage and temperature pre and post flight. All temperatures and voltages should be relatively equal across all cells. This log is used to identify at an early stage any potential issues with the batteries. Technical Log Part 2a is for the High capacity battery and 2B is for the low capacity battery.

28.1.4 4.1.4 Propeller log example

Technical Log Part 3: Propeller log				
Date	**Propeller set number 1 flight time**	**Propeller set number 2 flight time**	**Propeller set number 3 flight time**	**Propeller set number 4 flight time**
Cumulative total:	00:00:00	00:00:00	00:00:00	00:00:00

The propellers are not recorded individually but as a set. This log keeps a track of set usage flight time and are replaced after 10 hours of flight. Sets are stored separately to each other and are in labelled boxes.

28.2 4.2 Incident Log

Post Incident Report			
Date of flight:		Job number:	
Pilot in Command:		Mission Summary:	
Observer:			
Description of Incident			
Written description:			
Sketch of the incident:			
Weather details:			
Police report details			
Post incident checklist			
Evidence collected	Yes	Type:	
File ASR	Yes	Ref no & Date	
File MOR		Ref no & Date	
Included flight paperwork	Yes		

28.3 4.3 Service and Maintenance Log

Technical Log Part 4: Defect and Maintenance					
Defect or maintenance number	Defect raised/maintence reason	Work carried out	Parts replaced	Cleared for flight by A CLIFFE (Y/N)	Date:
M01	New Fireware update needed	New firmware installed number V xxxxx and IMU recallibrated succesfully	N/A	Y	12/03/2017

Technical Log Part 4: Defect and Maintenance keeps track of any defects or maintenance requirements on the aircraft. In the example above a firmware update is recorded with the firmware number included.

5. Appendix E – Emergency Checklists

29.1.1 5.1.1 Engine Failure/Loss of Power to Motors

LOSS OF ENGINE POWER

- ATTEMPT TO MANOEUVRE AIRCRAFT TO SAFE LOCATION
- SHOUT WARNING
- Monitor aircraft decent

Secure aircraft crash site and attend to any fire. Follow Post crash emergency procedure.

29.1.2 5.1.2 Aircraft Battery Failure

AIRCRAFT BATTERY FAILURE

- SHOUT WARNING
- Monitor aircraft decent

Secure aircraft crash site and attend to any fire. Follow Post crash emergency procedure.

29.1.3 5.1.3 Transmitter (Battery) Failure

TRANSMITTER BATTERY FAILURE

Failure of the signal between the transmitter and aircraft.

- COMMUNICATE AIRCRAFT ENTERING FAILSAFE MODE
- AIRCRAFT ENTERS FAILSAFE MODE

Monitor aircrafts decent and secure aircraft after landing

29.1.4 5.1.4 Loss or Interference of Control Frequency

LOSS OF OR INTERFERENCE OF CONTROL FREQUENCY
❖ COMMUNICATE CONTROL FREQUENCY ISSUES ❖ LAND ASAP MANUALLY IF ABLE at take-off point or alternative IF NOT ACTIVATE RTH MODE ❖ CHECK INTERFERENCE ON DJI GO APP Use the DJI GO app to monitor signal strength and interference. ❖ SWITCH FREQUENCIES AND ASSESS POSSIBLE INTERFERENCE SOURCES If successful: ❖ CONTINUE FLIGHT AND MONITOR If unsuccessful: ❖ STOP FLIGHT AND INVESTIGATE

29.1.5 5.1.5 Ground Control Station Fire

GROUND CONTROL STATION FIRE or SMOKE
Smoke and/or fire coming from Ground Control Station. ❖ AUDIBLE WARNING GIVEN ❖ ISOLATE GROUND CONTROL STATION Move away from aircraft and people if safe to do so. ❖ ATTEMPT TO REMOVE THE DEVICE I.E TABLET/MOBILE Clear area of people and hazards from around the aircraft ❖ REQUEST ASSISTANCE Raise the alarm and request assistance (emergency services if required) ❖ GATHER SAFETY EQUIPMENT If safe to approach: ❖ EXTINGUISH FIRE Use CO2 or powder extinguisher ❖ LEAVE TO COOL

29.1.6 5.1.6 Pilot Incapacitation

PILOT INCAPACITATION
Pilot becomes unwell to the extent that the safety of the flight is compromised. ❖ ADVISE GROUND CREW MEMBER ❖ LAND AIRCRAFT Return the aircraft to the landing zone or the nearest safe location.

If unable to maintain control of the aircraft: ❖ ACTIVATE RTH MODE If pilot unable to activate RTH mode ❖ GCO ACTIVATE FAILSAFE MODE Ground crew observer should switch off transmitter ❖ AIRCRAFT ENTERS FAILSAFE MODE

29.1.7 5.1.7 Aircraft Incursion

AIRCRAFT INCURSION
Aircraft noise heard in the area. ❖ AUDIBLE WARNING COMMUNICATED "AIRCRAFT INCURSION" ❖ ATTEMPT TO MAKE VISUAL CONTACT WITH THE AIRCRAFT If unable to locate aircraft: ❖ REDUCE ALTITUDE Reduce aircraft height and hover. If possible manoeuvre aircraft to the designated holding area. Prepare to land if necessary. If aircraft is located: ❖ ASSESS THREAT If threat identified: ❖ REDUCE ALTITUDE OR LAND ASAP If no threat: ❖ CONTINUE FLIGHT AND MONITOR – MAINTAIN VISUAL

29.1.8 5.1.8 Site/ground incursion

SITE/GROUND INCURSION
Incursion of 50m (30m when t/o or landing) by person or vehicle not under the control of the Remote Pilot. ❖ AUDIBLE WARNING COMMUNICATED "GROUND INCURSION" ❖ ENTER GPS MODE if available ❖ REPOSITION AIRCRAFT Reposition the aircraft to increase separation to **50m**. If feasible manoeuvre the aircraft to the dedicated holding area. If not, hold until third party is clear or minimum separation is established. ❖ ATTEMPT TO INFORM Try to verbally inform the incursion to move to 50m/30m (for landing) If third party continues to encroach site or approaches pilot: ❖ LAND ASAP Land at first available safe location. Secure the aircraft. IF GCO PRESENT ❖ REPOSITION AIRCRAF TO MAINTAIN 50M ❖ GCO ATTEMPT TO INFORM Try to verbally inform the incursion to move to 50m/30m (for landing). If third party continues to encroach site or approaches pilot: ❖ INFORM REMOTE PILOT AND LAND ASAP Land at first available safe location. Secure the aircraft.

29.1.9 5.1.9 GPS Flyaway

GPS FLYAWAY
Operating in GPS mode control of aircraft is lost or becomes erratic. ❖ SELECT 'ATTI' MODE & LAND ASAP If unsuccessful: ❖ LAND ASAP Reduce throttle to increase rate of decent – attempt to land If unsuccessful: ❖ SHOUT "FLY AWAY" ❖ MONITOR DIRECTION, HEIGHT AND ATTITUDE OF AIRCRAFT ❖ CONTACT ATC IF REQUIRED Contact ATC or appropriate authority – Refer to numbers in the flight planning form. Inform ATC of direction of travel and approx. height.

29.1.10 5.1.10 Fire on the ground

FIRE ON GROUND
❖ ENSURE AREA IS CLEAR ❖ REQUEST ASSISTANCE Contact emergency services if required ❖ DISCONNECT BATTERY ❖ EXTINGUSH SURRONDING FIRE ❖ COLLECT INFORMATION

29.1.11 5.1.11 Fire in the air

FIRE IN THE AIR
❖ VERBAL COMMUNICATION GIVEN ❖ MANOEUVRE THE AIRCRAFT TO A SAFE LOCATION ❖ FOLLOW FIRE ON THE GROUND PROCEDURE

29.1.12 5.1.12 Post-Crash Minor

POST-CRASH (MINOR)
❖ PROTECT Clear people and hazards from around the aircraft. Turn off the motors and controller. ❖ REQUEST ASSISTANCE Inform team members of the event. ❖ GATHER SAFETY EQUIPMENT If there is any risk of battery damage, use appropriate personal protective equipment. ❖ CONTROL THE DAMAGE If safe to approach, DISCONNECT BATTERY LEAVE TO COOL ❖ COLLECT EVIDENCE Gather as much information as possible. Pictures and statements from witnesses.

29.1.13 5.1.13 Post-Crash Major

POST-CRASH (MAJOR)
❖ PROTECT Clear people and hazards from around the aircraft. Provide first aid if required DO NOT APPROACH THE AIRCRAFT ❖ REQUEST ASSISTANCE Raise the alarm and request assistance from emergency services if required ❖ GATHER SAFETY & MEDICAL EQUIPMENT ❖ CONTROL THE DAMAGE If safe to do so EXTINGUSH FIRE and DISCONNECT BATTERY. LEAVE BATTERY TO COOL. ❖ COLLECT EVIDENCE: Gather as much information as possible. Pictures and statements from witnesses.

6. Appendix F – Risk Assessment

Risk is the combination of the probability of an event occurring and the severity of its consequences. In flying an SUA there are inherent risks to the operation from damage to the aircraft to damage to third parties. It is almost impossible to eliminate all risks in SUA flying, however as seen below actions can be taken to reduce these risks so that they are As Low as Reasonably Practical (ALARP).

Below is a table which is used in the risk assessment exercise to reduce any identified risk below the line of acceptable tolerance. This line represents a level of likeliness and severity of impact that the Remote Pilot is happy that a flight can take place below this line.

Key to the table:

(a) The likelihood of a risk occurrence
(b) The resulting severity of the impact if the occurrence happens.

Multiplying A and B together will give you the overall score.

The thick black line is the "Line of tolerance".

Anything above this represents an unacceptable level of risk and requires additional analysis and mitigation before any job may proceed.

LIKELIHOOD OF OCCURRENCE (A)						
	Very Likely 5	5	10	15	20	25
	Likely 4	4	8	12	16	20
	Feasible 3	3	6	9	12	15

	Likelihood of Occurrence (A)		Severity of Impact (B)
1 - Very unlikely	*(hasn't occurred before)*	1 - Insignificant	*(have no effect)*
2 - Slight	*(rarely occurs)*	2 - Minor	*(little effect)*
3 - Feasible	*(possible, but not common)*	3 - Significant	*(may pose a problem)*
4 - Likely	*(has before, will again)*	4 - Major	*(Will pose a problem)*
5 - Very Likely	*(occurs frequently)*	5 - Critical	*(Immediate action required)*

Slight 2	2	4	6	8	10
Very Unlikely 1	1	2	3	4	5
	Insignificant 1	**Minor** 2	**Significant** 3	**Major** 4	**Critical** 5
	SEVERITY OF IMPACT (B)				

Green = Low risk, **Amber 9 = Medium risk**, **Amber 10 –12 high risk**, **Red = High risk**

In this appendix the general threats and risk to SUA flying are outlined. For each individual job there will be different risks and threats that will be outlined in detail for that jobs risk assessment.

30.1 6.1 General Threats and Risks

- Below is the breakdown of the risk assessment exercise for the general risks of SUA flying and this company's reduction of said threats and risks as set out in the Emergency Procedures listed in Part B – Section 4.

The company uses the above table to reduce the risk to the acceptable tolerance level. The numbers and their meaning is as follows:

Who/What is at Risk is:

- E = Employees, C = Client, S = Spectators, P = Public, A = All of the Above

30.1.1 6.1.1 Engine failure/ Loss of power to the motors

Hazard Descripion	Who/What is at risk?	Severity of impact	Likelihood of occurance	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurance	Risk (post)
4.1.1 Engine Failure/ Loss of Power to Motors	A	5	3	15	Following regular maintenance schedule for the aircraft and engine and motor procedures, along with visual pre and post flight inspection of the components. Emergency procedures in place to mitigate potential aircraft crash	5	1	5

The hazard of having an engine failure or loss of power to the motors is a risk that could impact everyone. The severity of such an event is likely to be very high due to this meaning there would be a loss of control to the aircraft and the aircraft is likely to crash. While this type of event is not common it is possible. This hazard if left without mitigations scores 15 which is a *High Risk* event and therefore mitigations need to be in place.

Mitigations:

- Regular maintenance on a set schedule for the aircraft and its engine components are carried out. This includes a detailed visual inspection and testing the bearings in line with the servicing schedule.
- Visual inspections take place every pre-flight and post flight event. This is to look for damage or wear outside of the scheduled maintenance.
- Emergency procedures are in place to limit the effects of a loss of aircraft. This emergency procedure can be found in *Appendix E*.

Risk:

Following these mitigations the severity of the event is still critical however the likelihood of such an event now occurring is reduced to 1. The risk factor has now decreased to a 5 which is now *low risk*.

30.1.2 6.1.2 Aircraft battery failure

Hazard Descripion	Who/What is at risk?	Severity of impact	Likelihood of occurance	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurance	Risk (post)
4.1.2 Aircraft Battery Failure	A	5	3	15	Battery to be handled by trained staff. Battery to be used within the limits set out by the manufacturer and inspected pre and post flight. Battery telemetry monitored frequently in flight. Fire equipment present to mitigate the effect of a potential fire	5	1	5

The hazard of having an aircraft battery failure is a risk that could impact everyone. The severity of such an event is likely to be very high due to this meaning there would be a loss of control to the aircraft and the aircraft is likely to crash. While this type of event is not common it is possible. This hazard if left without mitigations scores 15 which is a *High Risk* event and therefore mitigations need to be in place.

Mitigations:

- Battery is to be handled at all times by a trained person
- Battery to be used within the limits set out by the manufacturer
- Battery to be inspected pre and post flight
- Battery telemetry monitored frequently in flight
- Emergency procedures are in place to limit the effects of a loss of aircraft. This emergency procedure can be found in *Appendix E*.
- Emergency equipment on standby

Risk:

Following these mitigations the severity of the event is still critical however the likelihood of such an event now occurring is reduced to 1. The risk factor has now decreased to a 5 which is now *Low Risk*.

30.1.3 6.1.3 Transmitter (battery) failure

Hazard Descripion	Who/What is at risk?	Severity of impact	Likelihood of occurance	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurance	Risk (post)
4.1.3 Transmitter (Battery) failure	A	5	3	15	If the battery in the transmitter fails the aircraft will enter its failsafe mode and will return to home	2	3	6

The hazard of having a transmitter battery failure is a risk that could impact everyone. The severity of such an event is likely to be very high due to this meaning there would be a loss of control to the aircraft and the aircraft is likely to crash. While this type of event is not common, it is possible. This hazard if left without mitigations scores 15 which is a *High Risk* event and therefore mitigations need to be in place.

Mitigations:

- Remote Pilot sets aircraft up that in the event of a transmitter failure or failure of the battery in the transmitter then the control link will be lost to the aircraft. The Remote Pilot has set up the aircraft that if this were to happen the aircraft would enter its failsafe RTH mode and would return to the last take off point and will shut itself down.

Risk:

Following these mitigations the severity of the event has now been reduced to a 2 as there would be little effect of the UAV returning to the home point. The likelihood of such an event now occurring is still 3. The risk factor has now decreased to a 5 which is now low risk.

30.1.4 6.1.4 Loss or interference with the control frequency

Hazard Description	Who/What is at risk?	Severity of impact	Likelihood of occurrence	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurrence	Risk (post)
4.1.4 Loss or Interference with the control frequency N/A at this time	A	4	3	12	Site assessment completed to look for potential sources of interference. Pilot can select between 2.4Ghz and 5.8GHz frequency to rectify. If no contact the aircraft enters failsafe mode and activates the Failsafe RTH procedure	2	3	6

The hazard of having a loss or interference with the control frequency is a risk that could impact everyone. The severity of such an event is likely to be high due to this meaning there would be difficulty in the controlling of the aircraft safely. While this type of event is not common it is possible. This hazard if left without mitigations scores 12 which is a *High Risk* event and therefore mitigations need to be in place.

Mitigations:

- Site assessment undertaken to point out potential sources of interference
- If the pilot notices interference they can select between 2.4 GHz frequency and 5.8Ghz frequency to try and alleviate the issue
- If control link is lost the aircraft is programmed to enter its Failsafe mode which is the Failsafe RTH procedure.

Risk:

Following these mitigations the severity of the event has now been reduced to a 2 as there would be little effect of the UAV returning to the home point. The likelihood of such an event now occurring is now 3. The risk factor has now decreased to a 6 which is now *Low Risk*.

30.1.5 6.1.5 Ground Control Station Fire

Hazard Descripion	Who/What is at risk?	Severity of impact	Likelihood of occurance	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurance	Risk (post)
4.1.5 Ground Control	Pilot	3	3	9	A mobile device is the ground station. Regular inspection of the device for any signs or significant damage or overheating should be conducted before each flight. If a fire occurs, remove the device and set aside and use the emergency equipment present to deal with the fire.	2	2	4

The hazard of having a ground station fire would directly affect the Remote Pilot. The severity of such an event is likely to be high due to this meaning there would be a fire. While this type of event is not common it is possible. This hazard if left without mitigations scores 9 which is a *Medium Risk* event and therefore mitigations need to be in place.

Mitigations:

- Device inspected for damage and overheating prior to attaching to the transmitter.
- Emergency fire equipment on standby

Risk:

Following these mitigations the severity of the event has now been reduced to a 2. The likelihood of such an event now occurring is now 2. The risk factor has now decreased to a 4 which is now *Low Risk*.

4.3.3 6.1.6 Pilot Incapacitation

Hazard Description	Who/What is at risk?	Severity of impact	Likelihood of occurrence	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurrence	Risk (post)
4.1.6 Pilot Incapacitation	A	5	2	10	The Ground Crew observer is briefed on how to activate the return to home function of the aircraft if the pilot can communicate that they are about to be incapacitated. They pilot, if possible can activate the RTH function by switching off the transmitter.	2	2	4

The hazard of having a pilot incapacitated could impact everyone. The severity of such an event is likely to be high due to this meaning there would be a lack of control of the aircraft. This type of event rarely occurs. This hazard if left without mitigations scores 10 which is a *Medium Risk* event and therefore mitigations need to be in place.

Mitigations:

- If the pilot feels that they are about to be incapacitated they can return the aircraft to landing point or they can activate the failsafe RTH procedure themselves by switching off the transmitter.
- The ground observer if present will be briefed about this emergency scenario *(Appendix E)* and will know how to activate the failsafe RTH procedure.

Risk:

Following these mitigations the severity of the event has now been reduced to a 2 as there would be little effect of the UAV returning to the home point. The likelihood of such an event now occurring is now 2. The risk factor has now decreased to a 4 which is now *Low Risk*.

30.1.6 6.1.7 Aircraft Incursion

Hazard Description	Who/What is at risk?	Severity of impact	Likelihood of occurrence	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurrence	Risk (post)
4.1.7 Aircraft Incursion	A	4	4	16	Pilot to consistently scan the airspace while flying. During the planning phase of flight is to make a note of any local airfields or AAIA. Emergency procedures for an air incusion have been created and briefed to the GCO.	2	2	4

The hazard of having an aircraft/airspace incursion is likely to impact everyone. The severity of such an event is likely to be high due to this meaning there could potentially be a loss of the aircraft and damage or loss to another aircraft. This type of event has occurred and is likely to occur again. This hazard if left without mitigations scores 16 which is a *High Risk* event and therefore mitigations need to be in place.

Mitigations:

- During the flight planning phase a note is made of any local airfield and airports, Heli lanes, low flying areas and any areas of intense aerial activity. Their hours of operation are noted. If possible the flight will be conducted outside of these hours. If not possible then the Remote Pilot and the observer will be notified of the increased likelihood of an aircraft incursion taking place.
- The Remote Pilot and observer will be briefed about the potential for an increase in likelihood of an airspace incursion and using the information provided in the flight planning form, the Remote Pilot should be aware of the likely direction that an aircraft may appear from and what types of aircraft to expect. Both to scan the sky frequently and listen out for aircraft.
- Emergency procedures have been created, practiced and briefed and the Remote Pilot will follow out the Aircraft/Airspace incursion emergency procedure *Appendix E*.

Risk:

Following these mitigations the severity of the event has now been reduced to a 2 as there would be little effect of the UAV avoiding a collision with the aircraft. The likelihood of such an event now occurring has reduce to a 2. The risk factor has now decreased to 4 which is now *Low Risk*.

30.1.7 6.1.8 GROUND INCURSION

Hazard Description	Who/What is at risk?	Severity of impact	Likelihood of occurrence	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurrence	Risk (post)
4.1.8 Ground Incursion	S, P	4	4	16	Pilot to consistently scan the ground while flying and a GCO to do the same if present. During the planning phase of flight is to make a note of public access areas. Emergency procedures for a ground incursion have been created, practiced and also briefed to the GCO.	2	2	4

The hazard of having a ground incursion is likely to impact the public and spectators. The severity of such an event is likely to be high due to this meaning there could potentially be a collision between the aircraft and people. This type of event has occurred and is likely to occur again. This hazard if left without mitigations scores 16 which is a *High Risk* event and therefore mitigations need to be in place.

Mitigations:

- During the flight planning phase and the site assessment a note is made of the likely access points for the general public to appear from. If practical signs will be placed around the area to inform people that SUA ops are in progress.
- The Remote Pilot and observer will be briefed about the potential for an increase in likelihood of a ground incursion and using the information provided in the site assessment form, the Remote Pilot and observer should be aware of the likely direction that a person may appear from.
- Remote Pilot and Ground Observer to visually scan the ground area frequently
- Emergency procedures have been created, practiced and briefed and the Remote Pilot and Observer will follow the ground incursion emergency procedure *Appendix E*.

Risk:

Following these mitigations the severity of the event has now been reduced to a 2 as there would be little effect of the UAV avoiding a collision a person. The likelihood of such an event now occurring is reduced to a 2. The risk factor has now decreased to a 4 which is now *Low Risk*.

30.1.8 6.1.9 Fly Away

Hazard Description	Who/What is at risk?	Severity of impact	Likelihood of occurrence	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurrence	Risk (post)
4.1.9 Fly away	A	5	3	15	PIC to ensure that sufficient sattelite connection is made and RTH point is recorded. Set Fly away emergency procedure excecuted.	2	2	4

The hazard of having a fly away is likely to impact everyone. The severity of such an event is likely to be very high due to this meaning there could potentially be a collision between the aircraft and or people due to a loss of control. This type of event is not likely to occur but it is possible. This hazard if left without mitigations scores 15 which is a *High Risk* event and therefore mitigations need to be in place.

Mitigations:

- Remote Pilot to ensure sufficient satellite numbers are connected to the aircraft prior to take off and that the RTH is set.
- Space Weather and Interference have been checked prior to flight.
- Emergency procedures have been created, practiced and briefed and the Remote Pilot and Observer will follow the fly away emergency procedure *Appendix E*.

Risk:

Following these mitigations the severity of the event has now been reduced to a 2. The likelihood of such an event now occurring is also reduced to a 2. The risk factor has now decreased to a 4 which is now *Low Risk*.

30.2 6.2 Fire

30.2.1 6.2.1 Fire on the ground

Who/What is at risk?	Severity of impact	Likelihood of occurance	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurance	Risk (post)
A	4	3	12	Emergency equipment (powder extingusher) present while flying. Follow emergency procedure for a fire and inform relevant authorities	2	2	4

The hazard of having a ground fire is likely impact everyone. The severity of such an event is likely to be very high due to this meaning there could potentially be damage to equipment and or person. This type of event is not likely to occur but it is possible. This hazard if left without mitigations scores 12 which is a *Medium Risk* event and therefore mitigations need to be in place.

Mitigations:

- Emergency procedures followed for this event
- Emergency Equipment (powder extinguisher) present while flying
- Local emergency services number acquired on flight planning form
-

Risk:

Following these mitigations the severity of the event has now been reduced to a 2. The likelihood of such an event now occurring is also reduced to a 2. The risk factor has now decreased to a 4 which is now *Low Risk*.

30.2.2 6.2.2 Fire in the Air

Hazard Descripion	Who/What is at risk?	Severity of impact	Likelihood of occurance	Risk (pre)	Mitigations	Severity of impact	Likelihood of occurance	Risk (post)
4.2.2 Fire in the Air	A	4	3	12	Follow emergency procedure for a fire (positioning the aircraft to a safe landing away from as many people as possible) and inform relevant authorities Emergency equipment (powder extingusher) for use when the aircraft lands.	2	3	6

The hazard of having a fire in the air is likely impact everyone. The severity of such an event is likely to be very high due to this meaning there could potentially be damage to equipment and or person with an aircraft crash. This type of event is not likely to occur but it is possible. This hazard if left without mitigations scores 12 which is a *Medium Risk* event and therefore mitigations need to be in place.

Mitigations:

- Emergency procedures followed for this event
- Emergency Equipment (powder extinguisher) present while flying

Risk:

Following these mitigations the severity of the event has now been reduced to a 2. The likelihood of such an event now occurring is also reduced to a 2. The risk factor has now decreased to a 4 which is now *Low Risk*.

7 Appendix G – Aircraft Systems

31.1.1 7.1 DJI Phantom 4 Pro

Item	
Operator	Anthony David Cliffe
Manufacturer	DJI
Distributer	DJI
Airframe Make	DJI PHANTOM
Airframe Model	4 PRO
Serial Number	**OAXDDBROA20286**
Type	QUADCOPTER

31.1.2 7.2 Aircraft Specification

Item	
Span/Diameter	0.35m
MTOM/Kg	1388g
Engine Type	Electric Motor
Number of Engines	4
Engine Size/Type	Electric Brushless Motors
Battery Type	Intelligent Flight LiPo 45
Capacity	5780 mAh
Voltage	15.2V
Kv	0.015Kv
Propeller Size	24x 7.6 x 4.1 cm

31.1.3 7.3 Control System and Communication Specification

Item	
Flight Controller	Phantom 4 Pro Remote Controller
GPS Unit	GPS/GLONASS
Controller Type	Handheld
Receiver	Unknown
Ground Station Type	Samsung Galaxy S7
Control Frequency	2.400-2.483 GHz & 5.725-5.825 GHz
Telemetry Link	DJI LIGHTBRIDGE
Telemetry Frequency	2.400-2.483 GHz & 5.725-5.825 GHz
Payload Link	2.400-2.483 GHz & 5.725-5.825 GHz
Payload Datalink Frequency	DJI LIGHTBRIDGE

31.1.4 7.4 Manufacturers full specification

Specifications	
Aircraft	
Weight (Battery & Propellers Included)	1388 g
Diagonal Size (Excluding Propellers)	350 mm
Max Ascent Speed	Sport mode: 19.7ft/s(6 m/s); GPS mode: 16.4ft/s(5 m/s)
Max Descent Speed	Sport mode: 13.1ft/s(4 m/s); GPS mode: 9.8ft/s (3 m/s)
Max Speed	45 mph (72 kph) (S-mode); 36mph (58 kph) (A-mode); 31 mph (50 kph) (P-mode)
Max Tilt Angle	42° (Sport mode); 35° (Attitude mode); 25° (GPS mode)
Max Angular Speed	250°/s (Sport mode); 150°/s (Attitude mode)
Max Service Ceiling Above Sea Level	19685 ft (6000 m)
Max Flight Time	Approx. 30 minutes
Operating Temperature Range	32° to 104° F (0° to 40° C)
Satellite Systems	GPS/GLONASS
GPS Hover Accuracy Range	Vertical: ±0.1 m (With Vision Positioning); ±0.5 m (With GPS Positioning) Horizontal: ±0.3 m (With Vision Positioning); ±1.5 m (With GPS Positioning)
Gimbal	
Stabilization	3-axis (pitch, roll, yaw)
Controllable Range	Pitch: - 90° to + 30°
Max Controllable Angular Speed	Pitch: 90°/s
Angular Control Accuracy	±0.01°
Vision System	
Velocity Range	≤31 mph (50 kph) at 6.6 ft (2 m) above ground
Altitude Range	0 - 33 feet (0 - 10 m)
Operating Range	0 - 33 feet (0 - 10 m)
Obstacle Sensory Range	2 - 98 ft (0.7 - 30 m)
FOV	60°(Horizontal), ±27°(Vertical)
Measuring Frequency	10 Hz
Operating Environment	Surface with clear pattern and adequate lighting (lux > 15)
Infrared Sensing System	
Obstacle Sensory Range	0.6 - 23 ft (0.2 - 7 m)
FOV	70°(Horizontal), ±10°(Vertical)
Measuring Frequency	10 Hz
Operating Environment	Surface with diffuse reflection material, and reflectivity > 8% (such as wall, trees, humans, etc.)

Camera	
Sensor	1" CMOS; Effective pixels: 20 M
Lens	FOV (Field of View) 84°, 8.8 mm (35 mm format equivalent: 24 mm), f/2.8 - f/11, auto focus at 1 m - ∞
ISO Range	Video: 100 – 3200 (Auto); 100 - 6400 (Manual) Photo:100 - 3200 (Auto);100 - 12800(Manual)
Mechanical Shutter	8 - 1/2000 s
Electronic Shutter	1/2000 - 1/8000 s
Image Size	3:2 Aspect Ratio: 5472×3648 4:3 Aspect Ratio: 4864×3648 16:9 Aspect Ratio: 5472×3078
PIV Image Size	4096×2160 (4096×2160 24/25/30/48/50p) 3840×2160 (3840×2160 24/25/30/48/50/60p) 2720×1530 (2720×1530 24/25/30/48/50/60p) 1920×1080 (1920×1080 24/25/30/48/50/60/120p) 1280×720 (1280×720 24/25/30/48/50/60/120p)
Still Photography Modes	Single shot Burst shooting: 3/5/7/10/14 frames Auto Exposure Bracketing (AEB): 3/5 Bracketed frames at 0.7EV Bias Interval: 2/3/5/7/10/15/30/60 s
Video Recording Modes	H.265 • C4K: 4096×2160 24/25/30p @100Mbps • 4K: 3840×2160 24/25/30p @100Mbps • 2.7K: 2720×1530 24/25/30p @65Mbps 2720×1530 48/50/60p @80Mbps • FHD: 1920×1080 24/25/30p @50Mbps 1920×1080 48/50/60p @65Mbps 1920×1080 120p @100Mbps • HD: 1280×720 24/25/30p @25Mbps 1280×720 48/50/60p @35Mbps 1280×720 120p @60Mbps H.264 • C4K: 4096×2160 24/25/30/48/50/60p @100Mbps • 4K: 3840×2160 24/25/30/48/50/60p @100Mbps • 2.7K: 2720×1530 24/25/30p @80Mbps 2720×1530 48/50/60p @100Mbps • FHD: 1920×1080 24/25/30p @60Mbps 1920×1080 48/50/60p @80Mbps 1920×1080 120p @100Mbps • HD: 1280×720 24/25/30p @30Mbps 1280×720 48/50/60p @45Mbps 1280×720 120p @80Mbps
Max. Bitrate Of Video	100 Mbps
Supported File Systems	FAT32 (≤ 32 GB); exFAT (> 32 GB)
Photo	JPEG, DNG (RAW), JPEG + DNG
Video	MP4/MOV (AVC/H.264; HEVC/H.265)
Supported SD Cards	Micro SD, Max Capacity: 128GB. Write speed ≥15MB/s, class 10 or UHS-1 rating required
Operating Temperature Range	32° to 104° F (0° to 40° C)

Remote Controller	
Operating Frequency	2.400 - 2.483 GHz and 5.725 - 5.825 GHz
Max Transmission Distance	2.400 - 2.483 GHz (Unobstructed, free of interference) FCC: 4.3 mi (7 km); CE: 2.2 mi (3.5 km); SRRC: 2.5 mi (4 km) 5.725 - 5.825 GHz (Unobstructed, free of interference) FCC: 4.3 mi (7 km); CE: 1.2 mi (2 km); SRRC: 2.5 mi (4 km)
Operating Temperature	32° to 104° F (0° to 40° C)
Battery	6000 mAh LiPo 2S
Transmitter Power (EIRP)	2.400 - 2.483 GHz FCC: 26 dBm; CE: 17 dBm; SRRC: 20 dBm 5.725 - 5.825 GHz FCC: 28 dBm; CE: 14 dBm; SRRC: 20 dBm
Operating Voltage	1.2 A @7.4 V
Video Output Port	GL300E: HDMI, USB GL300F: USB
Mobile Device Holder	GL300E: Built-in Display device (5.5 inch screen, 1920×1080, 1000 cd/m^2, Android system, 4G RAM+16G ROM) GL300F: Tablets and smartphones
Charger	
Voltage	17.4 V
Rated Power	100 W
Intelligent Flight Battery (PH4-5870mAh-15.2V)	
Capacity	5870 mAh
Voltage	15.2 V
Battery Type	LiPo 4S
Energy	89.2 Wh
Net Weight	468 g
Operating Temperature	14° to 104° F (-10° to 40° C)
Max. Charging Power	100 W

8. Appendix H – Applicable Articles of the ANO

For anyone who wishes to work for Anthony David Cliffe, they need to be aware of the governing Laws affecting drones. All flights will operate to the following articles referenced in CAP393 – the Air Navigation Order, as per Article 23:

These are as follows:

Articles 2, 91, 92, 94, 95, 239, 241 and 257 (except 257(2)(a)) apply to or in relation to an aircraft to which this article applies, then also article 265 applies in relation to those articles.

- Articles (94) and article (95) are reprinted below
- Please pay special attention to article (241) which concerns the endangering safety of any person or property
- Standard permissions may be granted by the CAA.
- These are found as *Appendix A* – Copy of Anthony David Cliffe PfCO

32.1.1 8.1 94 – Small Unmanned Aircraft (SUA)

94 (1) A person must not cause or permit any article or animal (whether or not attached to a parachute) to be dropped from a small unmanned aircraft so as to endanger persons or property.

(2) The remote pilot of a small unmanned aircraft may only fly the aircraft if reasonably satisfied that the flight can safely be made.

(3) The remote pilot of a small unmanned aircraft must maintain direct, unaided visual contact with the aircraft sufficient to monitor its flight path in relation to other aircraft, persons, vehicles, vessels and structures for the purpose of avoiding collisions.

(4) If a small unmanned aircraft has a mass of more than 7 kg excluding its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight, the SUA operator must not cause or permit the aircraft to be flown, and the remote pilot in charge of the aircraft must not fly it -

(a) in Class A, C, D or E airspace unless the permission of the appropriate air traffic control unit has been obtained; or

(b) within an aerodrome traffic zone during the notified hours of watch of the air traffic control unit (if any) at that aerodrome unless the permission of any such air traffic control unit has been obtained

(4A) Paragraph (4) does not apply to any flight within the flight restriction zone of a protected aerodrome (within the meaning given in article 94B).

(5) The SUA operator must not cause or permit a small unmanned aircraft to be flown for the purposes of commercial operations, and the remote pilot of a small unmanned aircraft must not fly it for the purposes of commercial operations, except in accordance with a permission granted by the CAA.

32.1.2 8.2 95– Small Unmanned Surveillance Aircraft (SUSA)

94A (1) The SUA operator must not cause or permit a small unmanned aircraft to be flown at a height of more than 400 feet above the surface, and the remote pilot of a small unmanned aircraft must not fly it at a height of more than 400 feet above the surface, unless the permission of the CAA has been obtained.

(2) This article does not apply to any flight within the flight restriction zone of a protected aerodrome (within the meaning given in article 94B).

32.1.3 SMALL UNMANNED AIRCRAFT: RESTRICTIONS ON FLIGHTS THAT ARE OVER OR NEAR AERODROMES

94B (1) This article applies to a flight by a small unmanned aircraft within the flight restriction zone of a protected aerodrome.

(2) The "flight restriction zone" of a protected aerodrome consists of the following two zones -

(a) the "Inner Zone", which is the area within, and including, the boundary of the aerodrome;

(b) the "Outer Zone", which is the area between -

(i) the boundary of the aerodrome; and

(ii) a line that is 1 km from the boundary of the aerodrome (the "1 km line")

(3) In the circumstances set out in an entry in column 1 of the following table -

(a) the SUA operator must not cause or permit the small unmanned aircraft to be flown

in the Inner Zone or the Outer Zone; and

(b) the remote pilot of a small unmanned aircraft must not fly it in the Inner Zone or the Outer Zone if the flight breaches a flight restriction set out in the entry in column 3 of the table which relates to that zone in those circumstances.

Circumstances	**Zone**	**Flight Restriction(s)**
There is an air traffic control unit or a flight information service unit (or both) at the protected aerodrome, and the flight takes place during the notified hours of watch of the air traffic control unit or flight information service unit.	Inner Zone or Outer Zone	A flight at any height is prohibited unless the permission of the air traffic control unit or flight information service unit has been obtained.
(a) There is neither an air traffic control unit nor a flight information service unit at the protected aerodrome; or (b) There is either an air traffic control unit or a flight information service at the protected aerodrome, and the flight takes place outside the notified hours of watch of the air traffic control unit or flight information service unit; or (c) There are both an air traffic control unit and a flight information service unit at the protected aerodrome, and the flight takes place outside the notified hours of watch of the air traffic control unit and outside the notified hours of watch of the flight information service unit.	Inner Zone	(1) A flight at a height up to and including 400 feet above the surface is prohibited unless the permission of the operator of the aerodrome has been obtained. (2) A flight at a height of more than 400 feet above the surface is prohibited unless both (a) the permission of the operator of the aerodrome has been obtained; and (b) the permission of the CAA has been obtained.
	Outer Zone	A flight at a height of more than 400 feet above the surface is prohibited unless the permission of the CAA has been obtained.

(4) The 1 km line is to be drawn so that the area which is bounded by it includes every location that is 1 km from the boundary of the aerodrome, measured in any direction from any point on the boundary.

(5) In this article, “protected aerodrome” means -

(a) an EASA certified aerodrome;

(b) a Government aerodrome;

(c) a national licensed aerodrome; or

(d) an aerodrome that is prescribed or of a prescribed description.

9 Appendix I – Third Party PLI Details

Moonrock
Drone Insurance

1 Norfolk Court, Norfolk Road,
Rickmansworth, Hertfordshire
WD3 1LA
Tel: 01923 712441
Fax: 01923 777548
Email: info@moonrockinsurance.com
Web: www.moonrockinsurance.com

CERTIFICATE OF LIABILITY INSURANCE

We, the undersigned Insurance Brokers, hereby certify that the following described insurance is in force at this date, underwritten by Hiscox Underwriting Limited:

Name of Insured:	ANTHONY DAVID CLIFFE
Business	The piloting of any **drone** for commercial purposes and ancillary business activities in connection with the piloting of any **drone**
Period of Insurance	From 00.01 on 10 August 2018 To: 23.59 on 09 August 2019
Limit of Indemnity:	Public Liability $1,000,000
Territorial Limits:	Worldwide excluding USA and Canada
Policy Number:	9483450

I write to confirm the Moonrock insurance policy is underwritten by Hiscox insurance and meets the minimum requirements of EC 785/2004 for third party liability including war and terrorism risks.
We certify that to the best of our belief as Insurers of or Insurance Brokers to the Permission holder/Exemption holder or applicant the above particulars, insofar as they relate to the insurance policies held, are correct.

The policy is subject to the insuring agreements, exclusions, conditions and declarations contained therein. The above is accurate at the date of signature.

Should the above mentioned contract of insurance be cancelled, assigned or changed during the above Policy period in such manner as to affect this document, no obligation to inform the holder of this document is accepted by the undersigned or by the Insurers.

Signed:

Dominic Trigg
Director on behalf of Moonrock Insurance
Dated: 04 August 2018

10 APPENDIX J – QUALIFICATION

UAVAIR

UK CAA NQE Approval Number:
1007/832

ConsortiQ Ltd t/a UAVAir
Forum 3
Solent Business Park
Whiteley
Fareham
PO15 7FH

Certificate of Recommendation for issue of a CAA Standard Permission

This Certificate of Recommendation confirms that the named individual has been assessed as competent in the three critical elements that comprise acceptable evidence of SUA/SUSA Pilot Competency, for the issue of a UK CAA Standard Permission in the category stated below, as set out in CAP 722 Appendix E28 (Privileges of an NQE) and in accordance with the terms of Approval granted to NQE: 1007/832.

Weight Category	UAV Type DJI Phantom 4			
0-7 Kg	Multi Rotor	Yes	Fixed Wing	
7-20 Kg	Multi Rotor		Fixed Wing	

Mark with an 'X' the appropriate category/ type

Students Name: Anthony Cliffe

Accountable Manager/ Nominated Personnel signature: CJanes

Accountable Manager/ Nominated Personnel name: ***Christopher Janes***

Date: 08/08/2017

UAVAIR

ConsortiQ Ltd t/a UAVAir
Forum 3
Solent Business Park
Whiteley
Fareham
PO15 7FH

UK CAA NQE Approval Number:
1007/832

Certificate of Practical Flight Assessment

This Certificate of Practical Flight Assessment confirms that the named individual has been assessed as competent to operate a SUA/SUSA in the category stated below, as set out in CAP 722 Appendix E28 (Privileges of an NQE) and in accordance with the terms of Approval granted to NQE: 1007/832.

Weight Category	UAV Type DJI Phantom 4			
0-7 Kg	Multi Rotor	Yes	Fixed Wing	
7-20 Kg	Multi Rotor		Fixed Wing	

Mark with an 'X' the appropriate category/ type

Students Name: Anthony Cliffe

Accountable Manager/ Nominated Personnel signature: CJanes

Accountable Manager/ Nominated Personnel name: ***Christopher Janes***

Date: 01/05/2017

[UAVAIR]

UK CAA NQE Approval Number:
1007/832

ConsortiQ Ltd t/a UAVAir
Forum 3
Solent Business Park
Whiteley
Fareham
PO15 7FH

Certificate of Competence in Remote Pilot Theoretical Knowledge/ General Airmanship Syllabus

This Certificate of Recommendation confirms that the named individual has been assessed as competent in the Remote Pilot Theoretical Knowledge/ General Airmanship Syllabus elements as set out in CAP 722 Appendix E29 (Obligations of the Holder) and in accordance with the terms of Approval granted to NQE: 1007/832.

Students Name: Anthony Cliffe

Accountable Manager/ Nominated Personnel signature: CJanes

Accountable Manager/ Nominated Personnel name: ***Christopher Janes***

Date: 30/04/2017

END OF OPERATIONS MANUAL

APPENDIX R: BETA TEST INFORMATION

TESTER	DEVICE	ISSUES
A	Samsung Galaxy S7	App worked well but struggled with the zoom feature (using two fingers to zoom would sometimes click on the number and open rather than zoom).
B	Standard LJMU library PC	Slow and jittery on explorer, crashed on HD. Chrome worked well with a small bit of lag in HD but fine in SD.
C	Toshiba i5 laptop	Crash on explorer but worked fine in SD and HD in chrome. No lag issues. Preferred navigating with a mouse rather than trackpad
D	Iveno Laptop	Slow on both browsers, difficultly navigating with the trackpad
E	Iphone X	No issues
F	MacBook Air	Better user interface on Chrome but worked ok on Safari. SD and HD versions were quick.

Appendix S: An example of a paper copy field guide

6035OUTDOR Evolution of Glacial, Fluvial and Karst Landscapes

Glacial Sediments and Landforms at Thurstaston,

Wirral Peninsula, North West England.

Field Assignment: Discuss the origins of the depositional sequence exposed on the Wirral coast at Thurstaston

Field Visit: Fri 16 March 2018

50% module weighting, 3000 words, Submission via Canvas Link (Turnitin), Fri 11 May 2018, 4pm. See Assessment Criteria in Appendix 1.

Glacial Sediments and Landforms at Thurstaston.

The purpose of the fieldwork is to investigate the origins of the depositional sequence exposed on the Wirral coast and give students some experience of examining, describing and interpreting glacial sediments in the field. Overall the fieldtrip is to be placed in the context of interpretation of the last glacial (Devensian, Dimlington Stadial) age whilst focusing on the origin of the sedimentary sequence within Irish Sea Basin and its margins. There is an ongoing debate surrounding these sequences and in 2001 McCarroll published several articles in relation to this debate (see Journal of Quaternary Science 16.) The geographical details of the fieldwork site can be Figure 1.

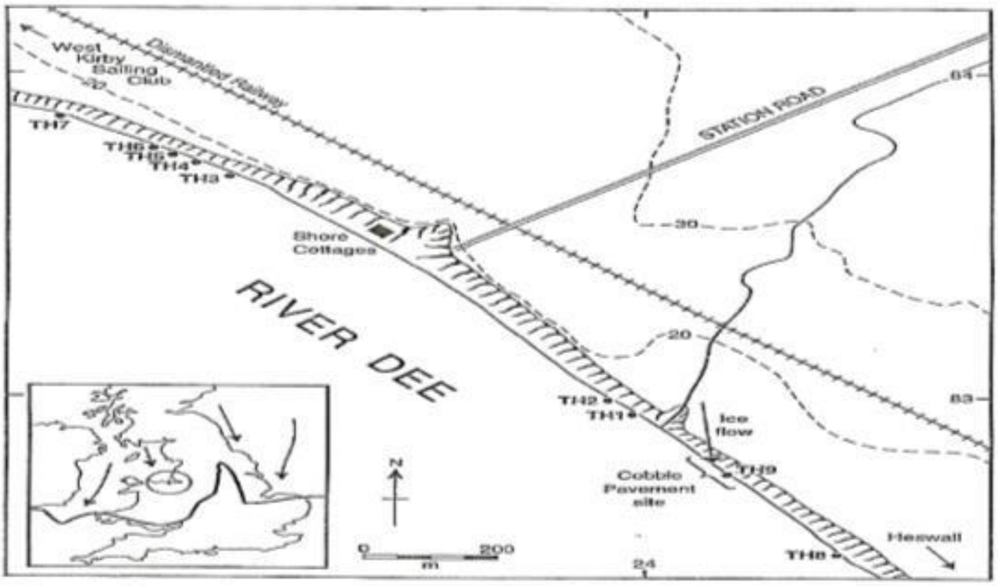


Fig. 1. Location map of Thurstaston Cliffs on the northeast bank of the Dee Estuary, Wirral Peninsula. Locations of the logged sections TH1–TH9, cobble pavements and ice flow directions from striations on clasts in the cobble pavement are marked. The location of the Thurstaston section (encircled) and its relationship to Late Devensian ice sheet movement (arrows) and maximum extent (heavy line) are shown in the inset. Figures around the margin of the map are Great Britain Ordnance Survey national grid coordinates.

Figure 1. Site locations. Source: Glasser *et al.,* 2001, p132).

Questions?

What evidence would suggest glaciomarine deposition?

What evidence would suggest terrestrial deposition?

What types of processes were operating?

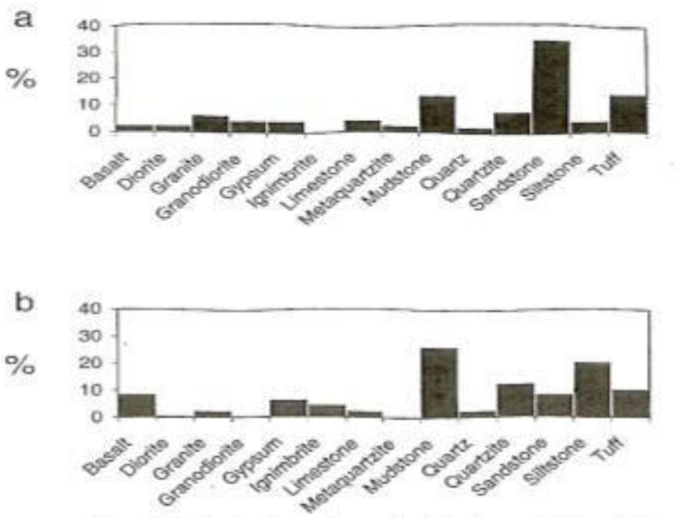
How many ice advances is there evidence for?

Background.

Ice movement during the last glacial, in the Liverpool area, was from the NNW – SSE based on striae and fabric in the Lower Boulder Clay. Shells found in glacial drift in Cheshire have been dated to 28000 years by C^{14} and organic deposits overlying these drifts in the Late Glacial dated to 12000 years (Glasser *et al.,* 2001) Hence we have time limits for this glacial period; generally thought to be c18000 years. During the deglaciation the ice sheet in the Wirral area was relatively thin and deglaciation was achieved under dynamic conditions with abundant meltwater flowing across the area (Glasser and Hambrey, 1998). In the past three divisions have been recognised: Upper Boulder Clay (UBC), Lower Boulder Clay (LBC) and middle sands and gravels (MSG): these divisions are not always clearly differentiated in the field.

i. Lower Boulder Clay: unstratified, seams and lenses of bedded sand are common. Many erratics, partially cemented by calcium carbonate in places; these clays are hard and therefore often form a steep section to the base of the cliff; markedly jointed and pebbles are striated and occasionally faceted.
ii. Bedded sands and gravels: the level is very irregular where it succeeds the LBC.
iii. The Upper Boulder Clay: brown clay, scattered erratics, horizontal fissility in places; sand seams are somewhat less common.

Erratics: It is not possible to distinguish between the three divisions: Local Triassic sandstone and siltstone predominate; lavas, ashes and ignimbrites from the Borrowdale Volcanic Series; granites; haematite – impregnated limestone from West and South Cumbria; flint; gypsum. Marine shells are comminuted in LBC, but sometimes whole in the UBC. The reddish, relatively sandy matrix suggests the source materials include New Red Sandstone. Figure 2 illustrates the results of the clast lithological analyses.



Clast lithological analyses in the lower (clast-rich) diamicton (a) immediately above and (b) immediately below the cobble pavement. Note the similarity in the lithological assemblages. Sample size is 250 clasts in both cases.

Figure 2. Clast Lithology. (Source Glasser *et al.,* 2001, p139).

Texture: UBC – clay and silt always over 65%, usually 75%; LBC contains more sand, clay never over 61% and usually about 50%.

Fabric: In the tills cobble pavements and striations on upper surfaces of the cobbles: generally from NWN, see figure 3.

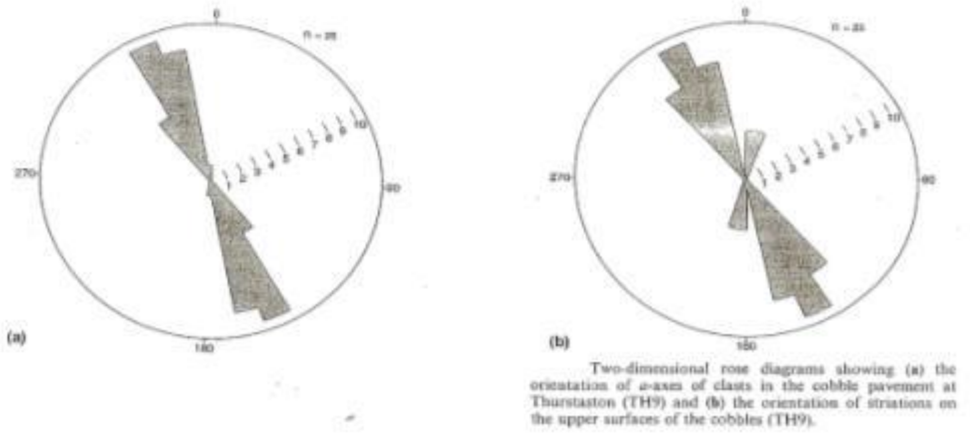


Figure 3. Till fabric analysis results. (Source Glasser *et al.,* 2001, p139)

Stratigraphy and location of lithofacies: Often the stratigraphic relationships are difficult to determine because of mass movements. Two diamictons; gravel, sand, mud, laminates; cobble pavements and deformation structures are all evident. Figure 4 details the stratigraphic logs.

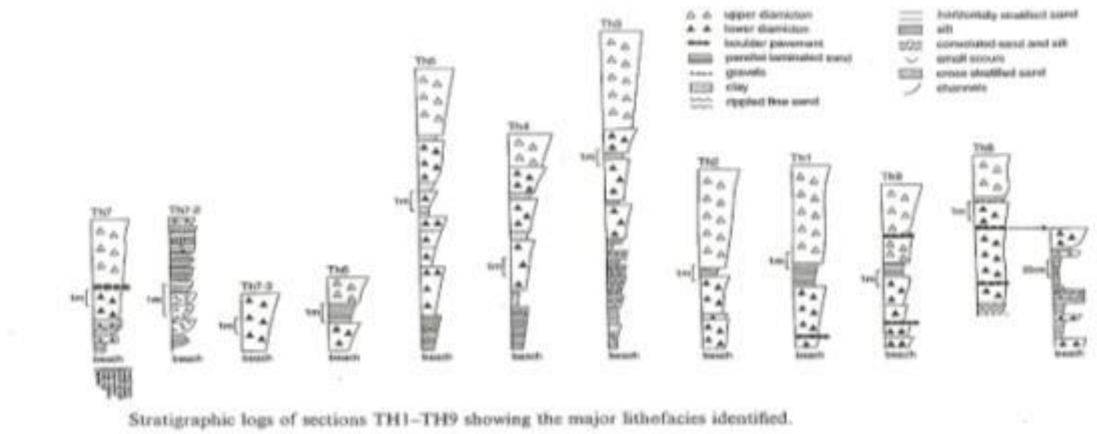


Figure 4. Stratigraphic logs of TH1 – TH9 showing major lithofacies identified. (Source Glasser *et al* 2001, p133)

Interpretation: Table 1 details some of previous interpretations.

Table 3: Summary of theories: Origins of the sequence exposed on the Wirral coast (adapted from Jones, 1990).

Research	Conclusions
Slater (1929).	Describes a situation involves two ice advances explaining the upper and lower deposits.
Brenchley (1968).	Describes a single ice advance where the middle certain gravels are due to glaciofluvial processes resulting from the ice retreat in the UBC as a product of glaciolacustrine deposition.

Lee (1979).	Lee observed windblown loess sediments between two layers of till. This observation prompted the conclusion that for the windblown sediment to be deposited there needed to be an absence of ice. Hence the conclusion that the lower till is a result of outwash sand and gravels; the medial till as a result of win deposited sediments; and the upper till a result of the second ice advance. Lee's (1979) observations have not been recognised since and therefore it is being suggested that the windblown sediments were a result of an ice raft.
Pits (1983).	Describes a situation where the lower sediments were due to processes below and in front of the glacier. The overlying till was not consolidated and sheer planes and faults were a result of rapid loading of saturated succession of limited mass permeability which suggested a flow till.
Eyles and McCabe (1989).	Used the glacial sediments at Thurstaston to form part of their model for the sediments in the Irish Sea basin. The paper argued that the deposits at Thurstaston where deposited during a catastrophic ice retreat which resulted in the Irish Sea Basin becoming a large ice carving bay.
Jones, (1990).	Jones interpreted the UBC as a melt out till.
Glasser, *et al.,* (2001).	One ice advance; deformation tills, subglacial origin of the glaciofluvial sediments, deformation structures (folds and decollement planes) and boulder pavements were all documented. No positive indications of glaciomarine sedimentation; no evidence that the sediments at Thurstaston represent ice-contact morainal bank or that rapid ice sheet recession was dominant by glaciomarine sedimentation in a glacio-isostatically depressed basin as has previously been suggested by Eyles and McCabe (1989).

The key facies identified at Thurstaston can be seen in Table 2.

Table 2. Summary table of the key facies identified at Thurstaston. (Source: Glasser *et al.,* 2001, p140*).*

Facies	Relative abundance	Interpretation
Clast-rich, sandy (lower) diamicton	*****	Deformation till
Clast-poor, sandy (upper) diamicton	****	Deformation till
Gravel	**	Subglacial fluvial (channel deposits)
Sand	***	Subglacial fluvial
Mud	*	Subglacial mud
Laminite	*	Subglacial lake

It is clear that a great deal of controversy about the origins of these sediments over the last century exists. The aim for you today is to undertake your own investigations in the field and review the appropriate literature and formulate your own opinions supported by academic research. The following pages provide suggestions of how you should approach the fieldwork and record the findings of your investigations.

A Virtual Model of the Thurstaston field site developed using a UAV and Google Earth

Tony Cliffe, PhD student, has developed this model to help with your understanding and interpretation of the past and present geomorphic processes at this location

Link: https://sketchfab.com/models/542c6e51b05a4df19476da4d936e1fd9

You are advised to visit this link (which includes using Google Earth and 9 annotations/external links to articles and short videos/ animations. You can spend as long as you wish using the model, before and after your fieldwork, but we recommend that to just get a feel for the resource you should spend at least 20 mins on first visit. It works best when opened in the Google Chrome browser.

Clast Shape.

This is the overall shape of a particle. This requires the measurement of the three orthogonal axes; the a-, b- and c- axes. The a- axis is the longest axis of the particle, the b- axis is the intermediate axis, and the c- axis is the shortest.

Measurements of these axes must be orthogonal i.e. at right angles to each other. Clasts are chosen with an a- axis of between 20 and 100mm. To be representative samples must normally comprise of 50 clasts. Figure 5 details the orthogonal axes.

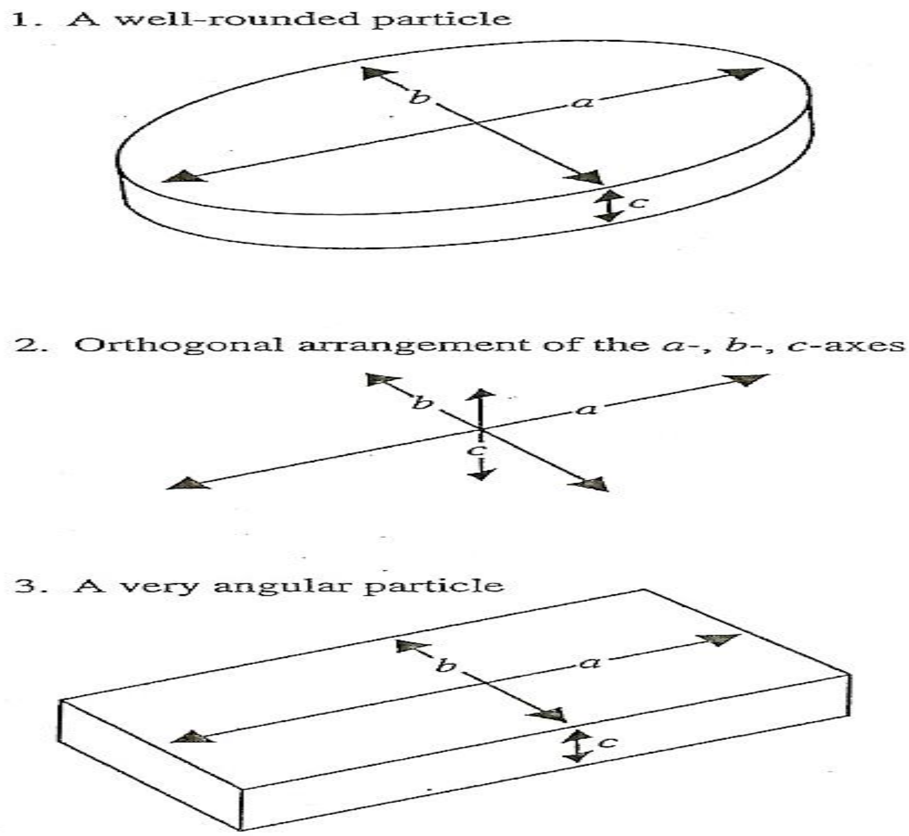


Figure 5. How to measure the three orthogonal axes (a-, b-, c-axes). (Source Hubbard and Glasser, 2005; p233).

Compaction is another important point to be noted and Table 3 provides the description and terminology for assessing compaction of sediments. For more details see Hubbard and Glasser (2005).

Table 3. A scheme for assessing the compaction of sediments in the field. (Source Hubbard and Glasser, 2005; p232).

Description	Terminolog
Loose	Unconsolida
Crumbles easily between fingers	Very friable
Rubbing with fingers frees numerous grains; gentle blow with geological hammer disintegrates sample	Friable
Grains can be separated from sample with a steel probe; breaks easily when hit with a geological hammer	Hard
Grains are difficult to separate with a steel probe; difficult to break with a geological hammer	Very hard
Sharp hammer blow required to break sample	Extremely h

Clast Roundness.

The roundness of a particle is defined by small scale changes in the surface of the particle roundness see Figure 6 and Table 4. It is obvious that during field investigations that subjectivity can be an issue and observer variance must be avoided. The scale requires a visual assessment ranging from very angular to well rounded and a histogram is a useful tool for displaying your findings.

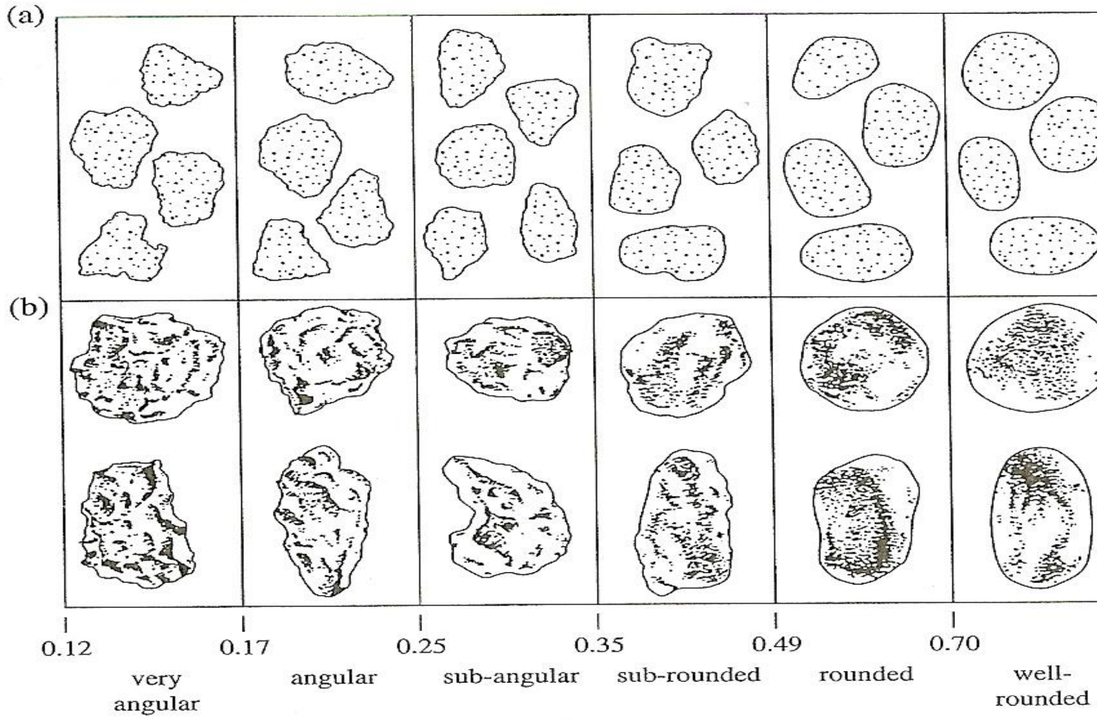


Figure 6. Visual images for the determination of roundness of grains or clasts: (a) 2D outlines; (b) 3D images. (Source: Hubbard and Glasser, 2005; p235).

Table 4. Clast roundness grades. (Source: Hubbard and Glasser, 2005; p236).

Grade term	Abbreviation	Class interval	Geometric mea
Very angular	VA	0.12–0.17	0.14
Angular	A	0.17–0.25	0.21
Sub-angular	SA	0.25–0.35	0.30
Sub-rounded	SR	0.35–0.49	0.41
Rounded	R	0.49–0.70	0.59
Well-rounded	WR	0.70–1.00	0.84

Clast axes and planes.

Measurements can be easily taken on a flat surface and tills often exhibit polished faceted on the upper and lower surfaces parallel to the glacier bed or shearing planes. Figure 7 provides a definition of clast planes and axes.

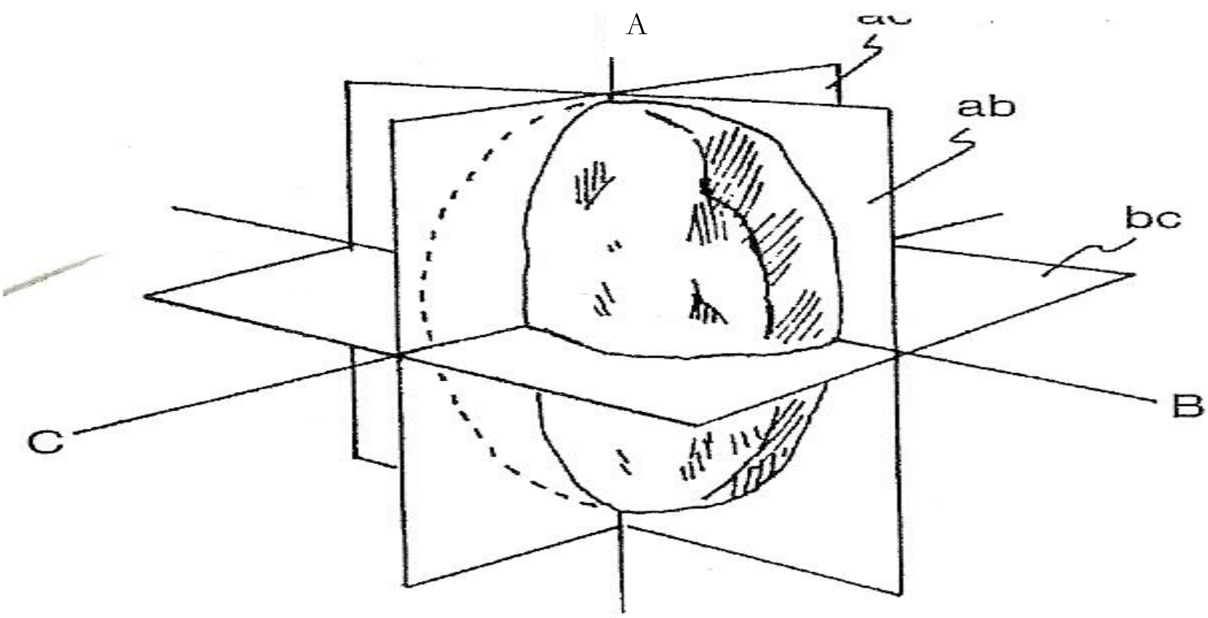


Figure 7: Definition of clasts and axes. Note that each axis is at right angles (normal) to a plane: the c-axis, for example, is normal to the a-b plane. This means that the orientation of a plane can be specified by measuring the azimuth and dip of its normal. (Source: Evans and Benn, 2004; p98).

Sampling.

A subset of the total lithofacial population is chosen for field sampling. In relation to the a-axis, clasts should be selected where the a-axis is significantly longer than the b-axis, axes of similar length will not be a useful indicators of the orientating forces and processes at work within the till fabric. Ratios commonly used are a:b >1.5:1; however it is important to note that when making links to other studies comparable methods need to be used.

Azimuth and dip.

The angle between the vertical projection of a line of interest onto a horizontal surface and true north or magnetic north measured in a horizontal plane, typically measured clockwise from north. Usually recorded in degrees with respect to the geographic or magnetic north pole and quoted in degrees from 0 to 359. The dip is the measurement of the inclination of a plane from horizontal measured perpendicular to strike. It can also be described as the angle between a planar feature, e.g. a sedimentary bed or a fault, and a horizontal plane or the angle being measured in a direction perpendicular to the strike of the plane. For axis measurements place a linear object such as a pencil or ruler parallel to the axis as a guiding tool, and use the compass-clinometer to measure the gradient of the clast relative to the horizontal (dip) and the orientation (azimuth) the dip is towards, see Figure 8.

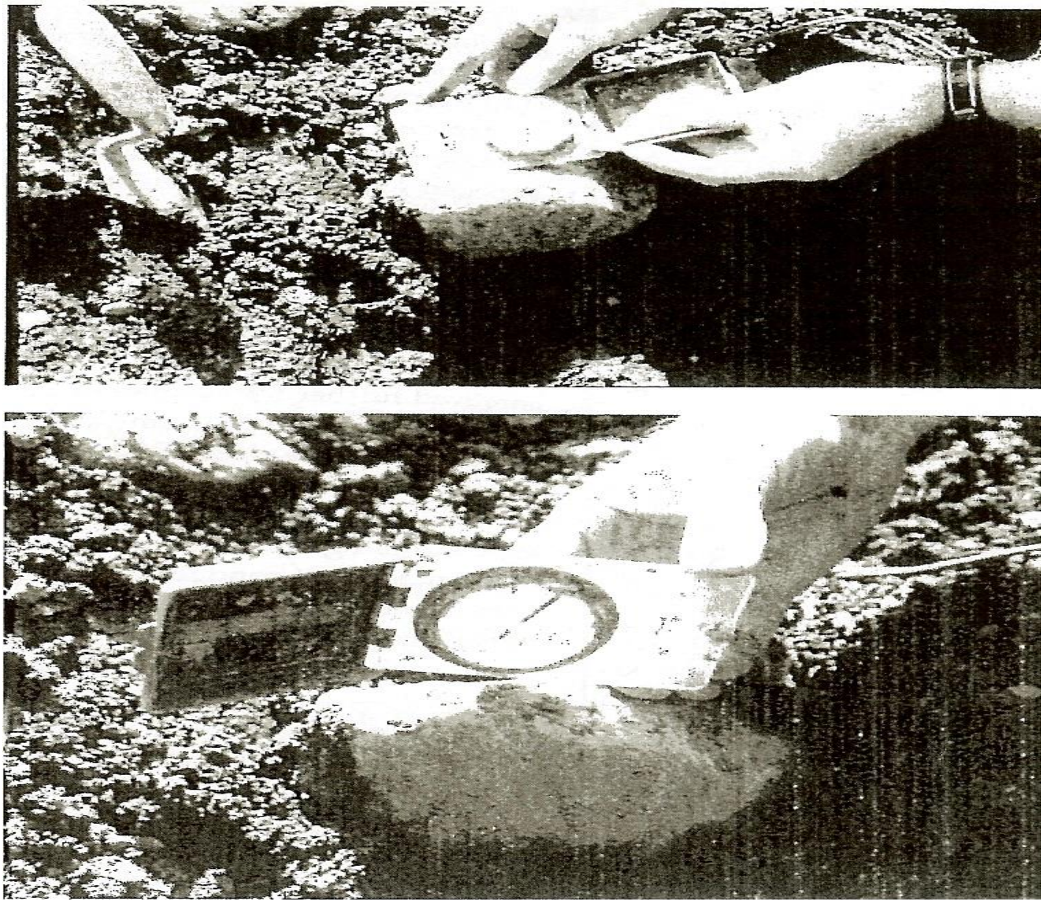


Figure 8. Measurement of azimuth (top) and dip (bottom) of clast a-axes using a compass-clinometer. (Source: Evans and Benn, 2004; p100).

Compass clinometers.

The Silva Type 15TD-CL is a very handy instrument for measuring angles of inclinations (gradients). Measure an inclination in the following way:

1. Open the cover fully.
2. Turn the dial until the cardinal points “W” is at the index pointer.
3. Hold the compass at arm’s length and at eye level, so that the clinometers needle is vertical and follows the variation scale in the base of the housing. The “N” on the dial should point upwards.
4. Align the longer side of the compass with the gradient to be measured.
5. Now read off the angle of inclination or gradient as indicated by the needle on the variation scale.

Interpretation diagrams.

The following diagrams (Figures 9 – 13) may be useful during your field investigations.

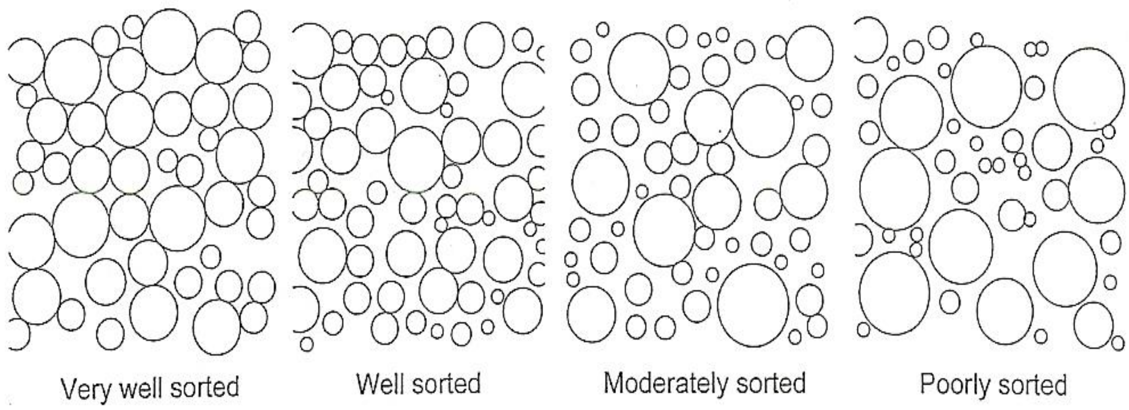


Figure 9. Clast sorting chart.

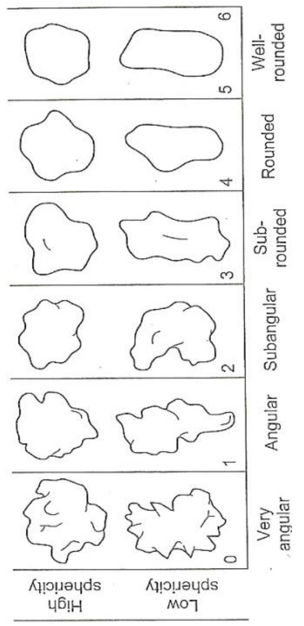


Figure 10. Roundness index.

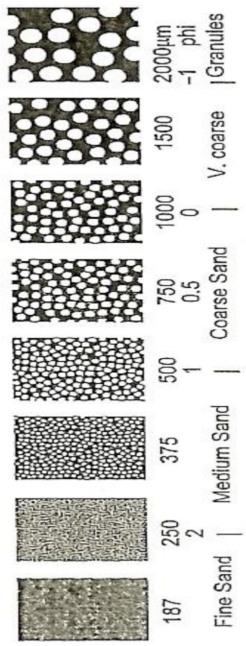


Figure 10. Grain size scale.

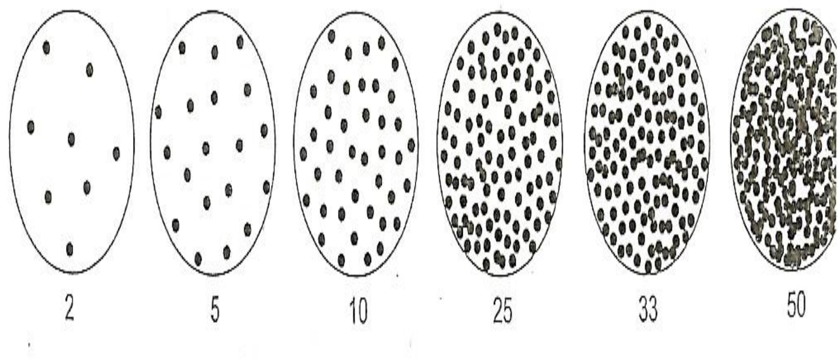


Figure 12. Percentage of area.

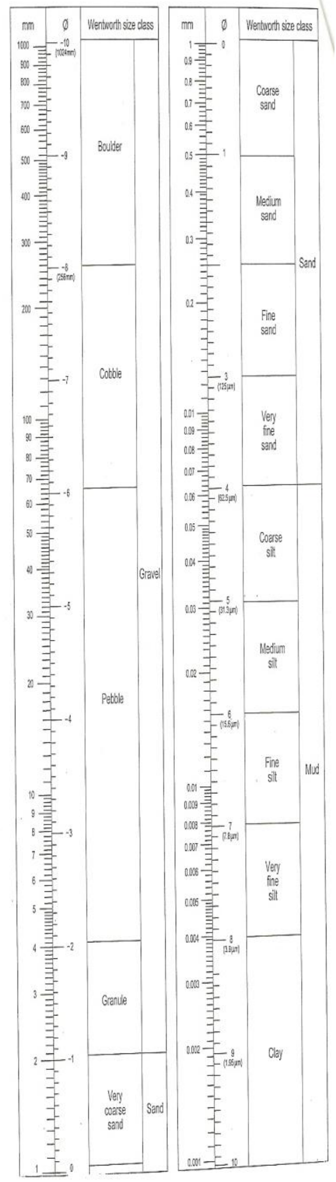


Figure 13. Wentworth size class.

Fabric Analysis Rose Diagram.

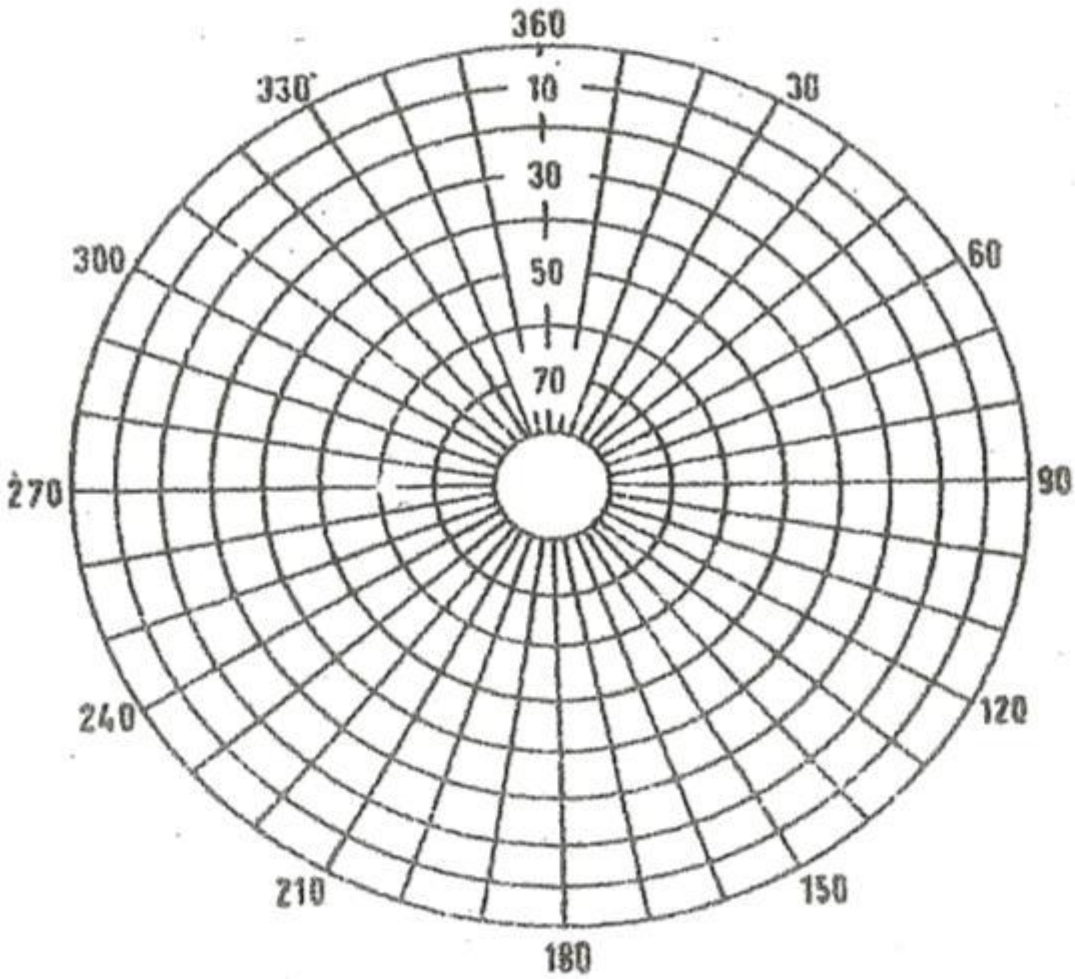
Record your fabric point analysis results on this rose diagram.

Location:

Site:

Grid Ref:

Date:



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Appendix 1: Field Report assessment criteria

Assessment Element	Suggested/approx No. of words	Weighting %	Your mark
Structure, spelling, style, grammar Use sub-headings; paragraphs; spell check		15	
Short Review of key literature sources Focus on those concerned with glacial deposition around the Irish Sea – see suggested references. You don't need to be too concerned to get up-to-date references as there may not be any	630	15	
Method Methodology (discuss techniques used by other researchers); and Methods (describe what you actually did, use diagrams to reduce the word count)	420	10	
Results, Analysis and Discussion (including table (s) of data for glacial sediments survey; photos; measurements); Summary flow chart of how the depositional sequence has been established through time (include diagrams, photos, use the model – see below)	1050	25	
Use of Thurstaston 3-D model and virtual field guide) e.g. evidence may be that you include screenshot (s) of the model as you used it	210	5	

Evaluation of Thurstaston 3-D model and virtual field guide How has this helped your learning and to complete this report? Please discuss two positive points and two aspects which you think could be developed/improved from the model?	210	5	
Conclusion	420	10	
Use of literature sources (correct referencing and citation)		15	
TOTAL		100	

Table 1: Assessment Criteria for Coursework: Thurstaston Glacial Sediments Interpretation Project (50%, 3000 words).

% score	Description of the work
70+ Class I Excellent	The assignment is very well structured, uses sub-headings to break up the topic, is concisely written and adheres to the word limit. Presentation is of a very high quality.. There are virtually no grammatical or spelling errors. The assignment includes at least 15 relevant illustrations (which will include scanned diagrams/images from published texts with the source properly acknowledged, digital photos, your own computer drawn diagrams, maps, or images collected from other web based resources such as Wikimedia commons which may have been adapted or annotated by you). At least 15 literature sources are cited throughout and referenced alphabetically at the end in Harvard style, 10 of which **will be peer reviewed journal papers**. Information used is discussed and critically analysed, and description is used sparingly. There is a balance between published books and journal references (15) and a maximum of 3 internet citations, so around 15-20 citations in all. The assignment would be of great interest to and will inspire outdoor enthusiasts about this subject.
60-69 Class II.i	The assignment is well structured, uses sub-headings to break up the topic, is quite concisely written and adheres to the word limit (+/- 10% of max words). Presentation is of a good quality.

Very Good	There are few grammatical or spelling errors. The assignment includes at least 10-12 relevant illustrations (which will include scanned diagrams/images from published texts with the source properly acknowledged, digital photos, your own computer drawn diagrams, maps, or images collected from other web based resources such as Wikimedia commons which may have been adapted or annotated by you). At least 8 literature sources are cited throughout and referenced alphabetically at the end in Harvard style, 6 of which **will be peer reviewed journal papers**. Some of the information used is discussed and critically analysed, and some is description. There is a balance between published books and journal references (8) and a maximum of 3 internet citations, so around 13-15 citations in all. The assignment would be of interest to and will inspire outdoor enthusiasts about this subject.
50-59 Class II.ii Good	The assignment is quite well structured, may use sub-headings to break up the topic, is fairly concisely written and adheres to the word limit (+/- 20% of max words). Presentation is of a reasonable quality. There are some grammatical or spelling errors. The assignment includes at least 6 relevant illustrations (which will include scanned diagrams/images from published texts with the source properly acknowledged, digital photos, your own computer drawn diagrams, maps, or images collected from other web based resources such as Wikimedia commons). At least 6 literature sources are cited throughout and referenced alphabetically at the end, usually but not always, in Harvard style, 5 of which **will be peer reviewed journal papers**. Parts of the information used is discussed and critically analysed, but most is description. There is a balance between published books and journal references (8) and a maximum of 3 internet citations so around 10-12 citations in all. The assignment would be of some interest to and may inspire outdoor enthusiasts about this subject.
40-49 Class III Fair	The assignment is not very well structured, with few or no sub-headings to break up the topic, is not concisely written and may not adhere to the word limit (+/- 30% of words). Presentation is of a fair quality. There are a number of grammatical or spelling errors, with sentences often not complete. The assignment includes at least 4 illustrations (which may include scanned diagrams/images from published texts with the source sometimes acknowledged, digital photos, your own computer drawn diagrams, maps, or images collected from other web based resources such as Wikimedia commons). At least 4 literature sources are cited throughout and referenced at the end, usually but not always, in Harvard style and not alphabetically, 1 of which **may be a peer reviewed journal paper**. Little of the information used is discussed or critically analysed, almost all is description. There is a poor balance between published books and journal references (1-2) and internet

	citations (3 max), so around 3-6 citations in all. The assignment would be of little interest to and may have difficulty inspiring outdoor enthusiasts about this subject.
30-39 High Fail	The assignment is poorly structured, with few or no sub-headings to break up the topic, is not concisely written and does not adhere to the word limit (500-600 words in total). Presentation is of a poor quality. There are lots of grammatical or spelling errors, with many sentences not complete. The assignment includes 2-3 illustrations (which may include scanned diagrams/images from published texts with the source not properly acknowledged, or images collected from web based resources and not from peer reviewed texts or journals) which do not have captions. 1-2 literature sources are cited throughout and referenced at the end, usually but not always, in Harvard style and not alphabetically, none of which **is a peer reviewed journal paper**. None of the information used is discussed or critically analysed, all is description. There is a poor balance between published books and journal references (maybe 1) with a preponderance of internet citations (4+). The assignment would be of no interest to and may have difficulty inspiring outdoor enthusiasts about this subject. There may some evidence for **plagiarism or collusion.**
< 30 Low Fail	The assignment is completely un-structured, and it is totally disorganised. It is written with poor style and is well below the word limit (probably around 500 words or less). Presentation is of very poor quality and no diagrams or illustrations are included. There are numerous grammatical and spelling errors. Sentence construction is poor, with may incomplete sentences and few paragraphs. No literature sources are cited in the text and no references are included at the end. Information used is only descriptive. There is little evidence for the use of the Internet to gain recent relevant information. There are no text books or journal papers cites or referenced so there is little evidence for research beyond that provided in Bb. The assignment is not interesting or inspiring. The assignment would be of no interest to and would not inspire outdoor enthusiasts about this subject in any way. There is strong evidence for **plagiarism or collusion.**

You will receive e-feedback using this template below which is designed to help you improve your work in future.

Clast Fabric Analysis: Data Recording Sheet

Clast No.	Orientation (direction/dip direction with compass bearing)	Dip (use clinometer in compass)	Rock type/comments Sandstone or not ?

PAPER

A review of the benefits and drawbacks to virtual field guides in today's Geoscience higher education environment

Anthony David Cliffe

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