The Impact of an Adaptive Learning Environment on Students' Classroom Related and Learning Related Emotions

By

Oran Zane Devilly

A thesis submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy in Computer Science

Supervisors

Dr J. E. Sinclair and Professor M. S. Joy

Department of Computer Science

University of Warwick

June 2021

Contents

List of Figures

List of Tables

Acknowledgements

Firstly, I would like to thank my supervisors, Dr Jane Sinclair and Dr Mike Joy for their unwavering advice, support, and encouragement from the initial conceptualising of the research to the completion of this thesis.

Also, a thank you to my many academic advisors especially Dr Claire Rocks and Dr Sara Kalvala for their most valued guidance and patience.

Last but by no means least, a great big thank you to my family, my wife Rina, my children, Ryan, Rhys and born during the PhD period, Sofia, for all their understanding of the time and pressure required in such an undertaking and supporting me in every way they could along the way.

Declaration

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It has been composed by myself, is my own original work unless otherwise stated, and none of the work contained in this document has been submitted as part of a degree for any other award at any other university.

Oran Zane Devilly

Signature: _____

Date: _____

Abbreviations

AEQ	Academic Emotion Questionnaire / Achievement Emotion Questionnaire, the survey tool used to measure academic emotional engagement in this study
ALE/ALS	Adaptive Learning Environment/Adaptive Learning System, learning systems design with adaptivity in mind so content and/or other material may be adapted to the user's needs
IRB	Institutional Review Board
LMS	Learning Management Systems, similar to a Virtual Learning Environment, but focus more on module management, tracking students' progress and learning objectives
MOOCs	Massive Open Online Courses, describes online courses made available usually without charge to the wider online community
GALE – GRAPPLE	Adaptive Learning Environment, the environment that students interact with when using the adaptive system.
GAT – GRAPPLE	Authoring Tool, A tool provided by GRAPPLE for authoring course content through Domain and Course models.
GRAPPLE	Generic Responsive Adaptive Personalized Learning Environment, the adaptive learning environment used to deliver adaptive course material and worksheets as part of this study

GUMF – GRAPPLE	User Modelling Framework, part of GRAPPLE, handles the User Modelling to collect and maintain information on the students' individual interactions with the ALS
GVIZ – GRAPPLE	Visualisation Tool, allows for visualisation of concepts from the GRAPPLE tool
STEM	Science, Technology, Engineering, Maths
VLE	Virtual Learning Environments, similar to Learning Management Systems, focus more on interactivity, usually a web-based technology useful for delivery of module content such as online distribution of resources, activities and management of assessments

Abstract

One-to-one tuition has often been cited as a more beneficial approach to learning in large classroom environments. However, this is rarely practical in traditional classrooms such as those observed in most universities. The standard approach of one-lecturer-to-many-students can result in bottlenecks where multiple students require support simultaneously, a common occurrence in subjects of a technical nature such as those found in STEM subjects.

Students encounter many emotions in the classroom as a result of how and when they receive support. Lecturer bottlenecks and delayed support can result in students having negative emotions. For example, weaker students may feel frustrated or even hopelessness when they fail to make progress on their own or in the case of stronger students, they may feel boredom when they are not sufficiently challenged.

This research explores the impact that an adaptive learning environment (ALE), with adaptive content and worksheets, has on academic emotional engagement. It follows a design science approach which consists of three key phases: (1) Problem identification and needs analysis, (2) Design development and implementation and (3) Evaluation. This evaluation phase can further be described as an explanatory sequential mixed methods design.

Using the ALE as opposed to traditional approaches, findings showed an overall significant increase in three aspects, namely, in overall academic emotional engagement, classroom academic emotional engagement and learning academic emotional engagement. When viewed from the perspective of separating positive and negative emotions, negative emotions were greater impacted, showing a significant

decline in negative academic emotions with a large effect size for those students who used the ALE. This was further explained and supported by the qualitative findings.

Finally, the findings help suggest how an ALE can be used in classroom environments. It also includes a discussion on possible limitations and highlighted areas for future research. These are discussed in the conclusion chapter of the thesis.

Chapter 1

1. Introduction

1.1. Background to Research

Providing high quality instruction to individual students contained in a large classroom environment remains a challenge for many instructors (Khosravi, Sadiq, & Gasevic, 2020). Depending on the nature of the content, a large classroom environment could be anywhere from 20 students and above. However the notion of one-to-one interaction with each and every student in the classroom is rarely possible (role of lecturer as tutor), due to the nature of modern day classrooms where the lecturer teaches a larger group of students, than would be expected by a traditional tutor, but is also expected to fulfil the role of a tutor and accommodate individual students needs within this large group. However, it is well accepted that one-to-one tutoring promotes greater student learning and increases student motivation compared to traditional classroom settings (Wood & Tanner, 2012). Two major issues occur in the one-to-many setting of a traditional classroom which may have one lecturer trying to teach many students. The first issue is a concept of bottlenecks, where the lecturer can only support one student at any one time. The second issue is further exacerbated by the first in that most classes, especially in the first year of university, have high levels of diversity in learners' academic ability resulting in a commonly used 'teach-to-the-middle' approach (Khosravi et al, 2020). Such an approach does not account for differing academic ability in learners, and indeed does not address the issue of challenges faced by the lecturer in attempting to provide one-to-one tutoring in a traditional classroom environment. Bloom (1984), found that one-to-one tutoring had the potential to provide learning gains for students that were two standard deviations above the conventional classroom approach as well as identifying that students of all

aptitudes had the potential to reach higher levels of learning when provided with individual support. As a result Bloom (1984) posed the challenge of findings ways in which group instruction could be conducted in a way that was similar to or as effective as one-to-one tutoring (Bloom, 1984).

Wood et al (2012), while exploring ways in which traditional classrooms could operate in a way that is as effective as one-to-one tutoring, found a number of characteristics that were common for good tutors, those being:

- Intelligence: Being intelligent in relation to not only the subject matter, but also having a clear understanding about how students learn and being able to draw appropriate information at the level of the students understanding.
- Nurturing: Building a rapport with students, empathizing with their struggles, being as non-judgmental as possible, being aware of their frustrations and motivation levels and helping students build confidence.
- Socratic: Giving as little information about the answer to a problem as possible, but instead providing direction, hints, and progressively more specific information if the student continues to struggle.
- Progressive: Able to quickly gain a clear and accurate picture of a student's understandings and misunderstandings, providing progressively more challenging work and working with the student by providing leading questions.
- Indirect: Do not judge or critique the student, but focus only on the work they are producing giving indirect praise through the work, and drawing attention to errors in their work
- Reflective: Get students to reflect on their progress and how they are doing on a regular basis.

- Encouraging: Motivate and encourage students with interesting problems, attainable challenges all of which help to build their confidence.

While this provides a fair overview of characteristics of an effective tutor, it still poses a challenge for the tutor to easily fulfil all of these roles and even more of a challenge for a lecturer in larger scale traditional classroom environments. Furthermore, (Gregori, Martínez, & Moyano-Fernández, 2018), identified that to create an effective learning environment, closeness and co-responsibility are necessary between students and tutors as well as a respect for individual student differences. Fluid communication is recommended to ensure that students do not feel alone or unattended to.

When exploring factors that lead to student dropout rates in computer science subjects, Pappas, Giannakos, & Jaccheri (2016), found that the year of study had significant impact on students' intention to complete their studies, identifying first year students as more likely to drop-out of university that those in second and third year. Effort was also a significant factor in relation to retention, where it was noted when students put in more effort, they were more likely to stick with their course.

Aldowah, Al-Samarraie, Alzahrani, & Alalwan (2020), additionally found that prior experience and academic skill were causal factors leading to dropout, although they only said that attention should be given to these aspects by decision makers, it could align to the concept of traditional classrooms tendency to 'teach-to-the-middle' (Khosravi et al., 2020) such that prior experience and academic skill were only sufficient for those who were operating at the middle or above, meaning those below the middle faced too great a challenge and decided to drop out. However, Aldowah et al. (2020) did elude to this deduction as they explored content difficultly being a

factor contributing to dropout which they found as being associated to other core factors such as academic skills, prior experience and course design.

In recent years, a possible solution has emerged that has the potential to address the one-to-one tutor issues described above within a classroom environment, this being the introduction of adaptive learning environments. Although such systems go by many names and have evolved over the years, the basic principle of such a system adapting learning content to individual user requirements remains the same. A comprehensive review by vanLehn (2011), which is still widely referenced today, found that there was a significant difference in achievement for one-to-one tutoring and traditional teacher-led large group instruction, but there was no significant difference between human one-to-one tutoring and an intelligent tutoring system. The above pattern was repeated in a more recent study by Xu, Wijekumar, Ramirez, Hu, & Irey (2019), through a meta-analysis of 19 studies related to K-12 students' performance in reading comprehension with an effect size of d = 0.6 between traditional classroom instruction and an intelligent tutoring system. This was a slightly lower than the effect size reported by vanLehn, (2011) at d=0.76 but still considered a medium to high effect size.

As a result, it is proposed here that such adaptive learning environments could bridge the gap between group classroom settings and one-to-one tutoring. Furthermore, reflecting on the background research above, such a system should also have well-designed content. From a pedagogical perspective, the system should take into consideration the wide range of previous experiences and skills that students may have on entering a course, provide clear support and feedback mechanisms to ensure that students feel that the challenges posed to them are achievable. Further, the adaptive learning environment should emulate an effective tutor as much as possible,

immediately being able to form a clear picture of the student's understanding of the topic, provide suitable material for the student pitched at their level and adapt the problems a student is expected to solve at a progressively more challenging level as the student progresses in the subject area.

Much of the current research in the area of adaptive learning environments or intelligent tutoring systems has focused unsurprisingly on the impacts of such systems on performance. However, performance is more of an end result of an intervention rather than something that gives us a clear understanding of what changes occur with students during the intervention. Exploring the literature, one critical factor identified by Young (2010) is engagement, highlighting that engaged learning and engaged learners are critical factors towards significant learning which gives an insight into how teaching and learning can be enhanced. Furthermore, Young (2010) states that empirical evidence suggest links between engagement and critical thinking, persistence, grades and dropout rates. Kahu (2011), notes that students partaking in activities for intrinsic reasons were more likely to go beyond the standard expectations of a module and learn even more than expected. This intrinsic motivation to learn, also known as deep learning, leads to additional effort which Pappas, et al (2016) identified as a key factor to retention.

Although engagement has many facets, research has shown that emotional engagement may potentially impact both behavioural and cognitive engagement as well. Kahu, Stephens, Leach, & Zepke, (2014) highlight the importance of emotions in education but note that the connection between emotions and education needs further study. Emotions have been found to be highly malleable and, as a result, a good target for educational interventions. Emotions have also been noted to influence motivation which as stated above can impact other aspects of students' learning such

as the use of learning strategies, self-regulated learning and academic success (Linnenbrink-Garcia & Pekrun, 2011; Meyer & Turner, 2007; Brdovčak, 2017).

As a result, the aim of this research is to explore the impacts of an adaptive learning environment on students' emotional engagement, specifically within a traditional classroom environment. From a review of the literature, the definitions of adaptive learning environments, traditional classroom environments and academic emotional engagement are further expanded on as well as enabling an exploration of suitable pedagogical design for all content and processes related to the adaptive learning environment. This is to ensure it operates as closely as possible to a 'good' tutor as described above.

Academic emotions have been selected as a measure, as more research is needed in this area, identified as an impactful aspect of students' learning which may link to learning approaches and intrinsic motivation. Likewise, further understanding of how adaptive learning environments impact students' learning is beneficial to the design of content for such systems and provide a better understanding of how best to deploy such systems in classroom environments.

1.2. Problems Identified

The core problems identified above which an adaptive learning environment could potentially address are as follows:

- Traditional group classroom environments resulting in bottlenecks where one lecturer is unable to provide sufficient support for each individual student of varied abilities (Khosravi et al., 2020 ; Wood & Tanner, 2012)

- One-to-one tutoring, being a preferred approach, is not possible without intervention in a traditional group classroom environment (Bloom, 1984 ; Khosravi et al., 2020 ; vanLehn, 2011)
- The need to provide adequate ‘good tutor’ support for individual students even in group settings (Aldowah, Al-Samarraie, Alzahrani, & Alalwan, 2020 ; Wood et al, 2012)
- More research is needed beyond performance with emotional engagement being identified as a critical factor in students’ learning, promoting good learning and academic success (Kahu at al., 2014 ; Linnenbrink-Garcia et al., 2011; Meyer at el., 2007; Brdovčak, 2017)

This research will address the issues of sufficient support in traditional group-based classroom and desire for one-to-one ‘good’ tutoring in group classroom environments by deploying an adaptive learning environment on a web server for use in traditional classroom environments. For this research, the ‘traditional’ aspect of the classroom will be related to the one-to-many relationship between lecturer and students with at least 30 students in each classroom. This is a computer science based practical session, so students will be in front of a computer at all times during the class and sitting in groups of up to 5 students per table. The system itself will have complementary course material which deals with content usually found on power-point slides which reside in the learning management system of the university where the students study. This complementary material will also be adaptive to control how and when students see certain content based on their current level of knowledge. Integrated into the adaptive learning environment, adaptive worksheets will be developed which will simulate tutor scaffolding based on a student’s performance and remember the level at which students are performing for later activities. All content

in these worksheets will be adapted based on students' interaction with the complementary material through targeted hyperlinks, as well as reflections by students on their performance as they progress through their worksheet activities.

Finally, the effectiveness of the above intervention will be evaluated through the lens of academic emotional engagement which has been identified as critical to students learning, influencing student's motivation, and learning approaches. Academic emotional engagement will be explored in a multifaceted approach to get a clear picture of the impacts the adaptive learning environment has on all aspects of student's academic emotional engagement which will add to the literature on our understanding of the impacts that adaptive learning environments have beyond performance, and the most malleable aspects of academic emotional engagement when it comes to the benefits such an adaptive learning environment has to offer. To truly understand the emotional impacts, both quantitative and qualitative data will be collected, to identify cause and effect through quantitative data and understanding the reasoning, expectations and perceptions through the qualitative data. This will shed further light into some best practices for using adaptive learning environments in classroom environments to facilitate their adoption by other practitioners.

1.3. Research Questions and Objectives

Based on the abovementioned problems and a brief review of literature of key topics that will subsequently be further discussed in chapters two and three, the following research questions were derived:

- **RQ1:** What impact does an adaptive learning environment have on students' emotional engagement inside a classroom environment?

As a follow on from the main research question, which will be addressed through a review of existing literature relevant to this study specifically for the purpose of designing the adaptive course content as well as through items within the research instruments, the following questions will also be addressed:

- **RQ2:** What impact does an adaptive learning environment have on students' classroom related and learning related emotions?
- **RQ3:** How are positive and negative emotions affected by the presence of an adaptive learning environment in the classroom?
- **RQ4:** What elements expected to enhance overall engagement are impacted by the presence of an adaptive learning environment?
- **RQ5:** In what ways can adaptive learning environments be used inside a classroom environment to enhance curricular content design?

As a result, the overall aim of this research is to understand and assess the impacts on academic emotional engagement of an adaptive learning environment. The adaptive learning environment itself consists of an adaptive course that complements students' learning experiences in the classroom and the provision and use of adaptive worksheets which support students' learning as they work on in-class activities. In alignment with this aim, the following objectives must be met:

- **Objective One:** Extensive literature review to define the problem domain more clearly, focusing on academic emotional engagement, adaptive learning environments and creating engaging learning content.
- **Objective two:** Identify a suitable tool from the literature to measure academic emotional engagement for the context of this study.

- **Objective three:** Decide on the platform to use and the process for the development of adaptive learning content and adaptive worksheets as well as regular worksheets to ensure content is designed in a way to maximize students' engagement.
- **Objective four:** Design, develop and deploy an adaptive course using the platform decided on in **objective three** and develop and deploy adaptive worksheets.
- **Objective five:** Evaluate the impact of the adaptive learning environment inclusive of adaptive content and adaptive worksheets, based on the tool identified in **objective two**.
- **Objective six:** Discuss findings and contribution of the research to the relevant areas concerning adaptive learning environments and students' engagement. Limitations of the research will also be identified, and further improvements and future directions will also be included

1.4. Justification for this Research

This research explores the impact of an adaptive learning environment on students' academic emotional engagement inside the classroom and looks to understand why specific emotions are impacted as a result of the adaptive learning environment being deployed.

Adaptive learning environments have been available for quite some time so technically they are not considered something that is very new, however, they are not commonly used in classroom environments. With previous research alluding to the fact that such systems could provide a similar level of scaffolding as a human one-to-one tutor, and given that research has commonly shown one-to-one tutoring as a highly beneficial form of tutoring, it is definitely surprising that the use of adaptive

learning environments is not a more regular occurrence especially in large tutorials and laboratories where active learning takes place and additional forms of support would likely be most welcome by lecturer in charge of such learning scenarios. Understanding the impacts of adaptive learning environments in learning and within classroom environments and understanding how best to use them, may help practitioners to better implement such systems in their practice, giving them a better picture of best practices in terms of where they can impact student learning most. Furthermore, this understanding and exploration will add to the literature and further justify the use of such adaptive learning environments in classroom settings and beyond.

1.5. Research Design

The overarching research design for this study follows an education design research approach. This encompasses the systemic study of designing, developing and evaluating educational interventions (McKenney & Reeves, 2014), which are purposefully seeking a solution to an identified problem (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008). In the case of this research, it is the deployment of an adaptive learning environment, and the development of an adaptive course with adaptive worksheets. This is done with the intention of supporting the lecturer in the classroom, removing bottlenecks where many students require the attention of one lecturer at any one time and providing more individualized support to students using the adaptive learning environment. A survey is also used, which collects data on academic emotional engagement to measure the impacts the deployment of an adaptive learning environment has on the students' academic emotional state. Moreover this approach holds true to the belief that context matters and that conducting the research in a real world classroom environment is most beneficial

(Collins, Joseph, & Bielaczyc, 2004), as simply examining learning processes as isolated variables within a laboratory setting may lead to an incomplete understanding of their relevance in a naturalistic setting (McKenney & Reeves, 2014). Similar to other studies of this type, design, development and evaluation, which are research functions related to design research, are often conducted together, as a study may involve deployment and/or development of a technology as well as its evaluation in a certain context to help contribute to the body of knowledge in a domain of research (McKenney & Reeves, 2014). As a result, this approach can inform best practice in terms of designing and deploying adaptive learning content and adaptive worksheets as well as evaluating their impact on academic emotional engagement.

Design research is composed of three phases as seen in Figure 1-1 (McKenney & Reeves, 2014). Phase one includes problem identification and needs analysis, this can be achieved through processes such as literature reviews to better understand problem areas and explore potential solutions, and interviews with experts in the field to get a sense of potential problems. For this research, the problem was initially identified through practice as the module used for this research had been run a number of times before and the lecturer/researcher had taught similar modules in multiple educational institutes in the past. The initial problem was identified to be an issue with bottlenecks, where one lecturer would struggle to provide sufficient support for a classroom with many students. Regardless of the lecturer's effectiveness, students had a diverse range of questions during workshops and the lecturer would not be able to field all questions simultaneously. This was observed to have an impact on students' emotional state where they felt emotions such as frustration and hopelessness when they remained 'stuck' at a problem for a period of time, only able to make progress with lecturer's intervention. The problem was further defined and

understood through an extensive literature review into the problem domain, leading to a deeper understanding of academic emotions, impacts of tutoring systems and approaches to content development which may support general engagement. The potential solution was identified also through the exploration of the current state, use and impact of adaptive learning environments for educational purposes.

Phase two involves the design, development, and deployment of an artefact, which in this case was the adaptive learning environment. This also includes development of the adaptive course and the adaptive worksheets. Again, the how-to knowledge came from the lecturer/researcher with multiple years of experience running this module and modules similar to it, giving an in-depth understanding of the kind of scaffolding students needed on an individual level to make progress and embedding that into the adaptive course and adaptive worksheets.

Phase three involves evaluation, specifically to evaluate if the intervention has had the desired effect on students. A tool to measure academic emotional engagement was adopted from the literature that would explore emotions that most commonly occur in an academic setting as a result of students' engagement with academic activities, which in this case refers to activities in their worksheets, adaptive or otherwise.

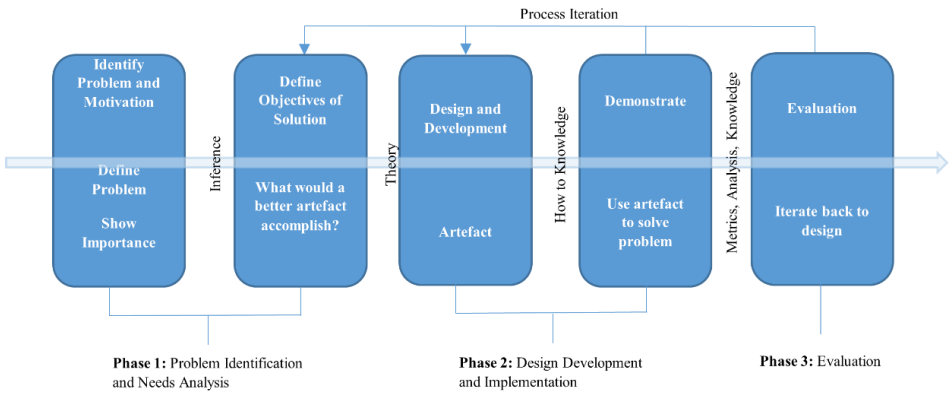

Figure 1-1: Adapted from Design Science Research Methodology Process Model (Peffers et al, 2008)

To further expand on the evaluation phase of this process, the evaluation has been further described as an explanatory sequential mixed methods design (Figure 1-2). Mixed methods is a common approach used in educational research to go beyond quantitative data and attempts to find richer meaning and to obtain a deeper understanding and insight into the quantitative data. The explanatory approach means we first collect quantitative data, analyse it, and subsequently, collect qualitative data

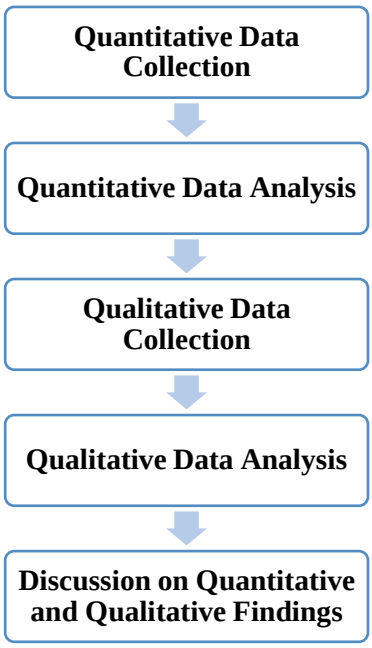

Figure 1-2 : Explanatory Sequential Mixed Methods Design Structure

and conduct data analysis on this as well. The data analysis process is then followed with a discussion on both the quantitative and qualitative results, using the qualitative data to help provide further insights into the quantitative findings.

Once the evaluation phase of the educational design science approach is complete, a decision can be made to determine if the intervention was a success, or as in many cases with such an approach, the cycle may be iterated to review the objectives or the design of the product for further iterations based on what has been learned from the first run of the intervention. In the case of this research, time is somewhat limited resulting in only one instance of data collection being possible, so

careful planning and tapping into years of contextual experiences were necessary to ensure the most effective solution for the first iteration so as obtain and measure significant impact on academic emotional engagement during the first iteration. This is further discussed in the limitations section. However, whatever is learned from this study and ideas for potential improvements are explored in the discussion and conclusion chapters to pave the way for future research in this area.

1.6. Ethical Approval and Mitigating Bias

After the study had been carefully designed, the approach settled on and the instruments for data collection selected, it was important to attain appropriate ethical approval from both institutional review boards where this study was taking place.

The whole study design was approved (annex 1) by the Institutional Review Board (IRB) from both the University of Worcester where the students were from and where the researcher was employed, and the University of Warwick where the researcher was conducting his doctoral studies. Only students who were taking part in the selected modules were able to participate which formed the bases of the inclusion and no exclusion criteria within this group were identified.

It is also worth noting that due to a very small number of female students in the groups, the participant's genders have not been revealed in this study to protect the identity of all participants.

Finally, as the researcher was also the lecturer in the classes being conducted, one could argue that students may respond more favourably to the intervention to cooperate with the lecturer. One approach to resolve such an issue is for the researcher to be constantly aware of this issue and attempt to address it at every suitable opportunity. As a result, students were informed that the study was designed to

explore the emotional impacts of the intervention and did not favour a positive or negative response to the intervention as both would be equally valid and reportable in the final study. The researcher was also aware of his role and position and to address common concerns pertaining to the design and reporting of semi-structured interviews, ensured all guiding questions related back to the conceptual framework and aligned with pre-validated instruments being used so alignment between the quantitative and qualitative data would help ensure there were no abnormalities in reporting. Likewise, once data was collected, students were made aware that regardless of the results, they would be given access to the adaptive learning environment for the remainder of the semester. This assured the students that their responses will not impact the availability and access to the adaptive learning environment. Indeed, it is the position of the researcher that the validity of the results are important regardless of being significant or not. This will allow for a data informed decision to be made on the potential use or otherwise of adaptive learning environments in classroom environments for both the research and policy makers who may view this research in the future. Seeing both sides of the story as equally important help support a non-bias view from both a positive and negative perspective.

1.7. Thesis Outline

This section will give a brief overview of each chapter and its purpose in this thesis. Chapter one sets the scene for the study overviewing the background of the research and problems identified. This lead us to our research questions and objectives, further justification of the research and the research design.

The second and third chapters of this thesis provides an overview of the literature on pertinent topics to this study. Chapter two aims to form a clear definition of three key terms for this study, namely, emotions, motivation, and engagement.

These terms have a variety of interpretations and as a result need to be clearly defined for any particular study that deals with each term. In addition, the term academic emotional engagement is defined and suitable tools for measuring this phenomenon are explored and discussed. Throughout this exploration of emotion, motivation and engagement, suitable approaches to developing engaging learning content and good pedagogical approaches to content are also identified.

Subsequently, chapter three is focused on blended learning and technology in the classroom. Blended learning refers to the use of technology with traditional teaching approaches and its development and benefits are discussed and subsequently, linked to an overview of adaptive learning environments. This also then leads to the identification of a suitable adaptive learning environment for the purpose of this research. Through this discussion, gaps in research pertaining to such systems are identified and potential reasons discussed as to why adaptive learning environments are not more widely used. This helps position this study as value adding to the greater body of literature.

Following on from the previous chapter, informed by the literature in terms of development of engaging content and appropriate pedagogical design as well as selection of an appropriate system for this study, chapter four provides an overview of the deployment of the adaptive learning environment, GRAPPLE, and the design, development, and deployment of adaptive learning content, as well as the development of adaptive worksheets which are embedded into the GRAPPLE framework.

Looking at this study from two key perspectives, the appropriate pedagogical design for the content as well as the evaluation of academic emotional engagement

needs to be carefully considered and informed by the literature. As such, chapter five provides an overview of these aspects of the conceptual framework which uses Young's (2010) principles for fostering academic engagement as a framework for designing engaging content for the course in general, as well as Pekrun et al. (2002) academic emotions questionnaire to understand, explore and measure academic emotional engagement.

Chapter six is focused on the methodological design and gives an overview on how this study was conducted. It starts with information about the sample and research protocol, followed by details relating to the collection of quantitative data through surveys and qualitative data through semi-structured interviews. The data analysis approaches are also discussed here for both the quantitative and qualitative aspects of the research.

Following the above, chapter seven looks at data analysis and findings. It is divided into two sections with the first section dealing with the analysis of the quantitative data collected from the surveys and the findings. The second section focuses on the analysis of the qualitative data collected through semi-structured interviews reporting findings and quotes from participants in a more general way, leaving interpretation informed by the literature and quantitative findings for the discussion chapter.

Subsequently, chapter eight provides a discussion of the findings. It begins with the quantitative findings and relates them back to the various research questions they were designed to answer. Here the findings are summarized, considered based on knowledge gained from the literature and linked to answers to the specific research questions that were outlined earlier in this chapter. As this study uses explanatory

mixed methods, the qualitative findings are also discussed alongside the quantitative findings in relation to the research questions and contributes towards developing a more nuanced understanding of the quantitative findings.

Chapter nine concludes the research, giving an overview of the findings and discussion, reflecting on how this would contribute to the literature and provides recommendations for future research. The chapter also outlines and discusses the limitations of the study so as to help future research and related studies identify and mitigate such limitations where possible.

1.8. Conclusion

This chapter provided a general overview of this thesis and everything that is to come in the subsequent chapters. The background research and problem identification resulted in the development of the research questions, aims and objectives. These have been derived from a combination of experience and a review of existing literature and are presented in the introduction as directions that guide the subsequent sections of this thesis. In the justification section, the need for this research was highlighted and subsequently, progressed to briefly discuss the research design. This helps to define the objectives for the operationalisation of the study, how it is intended to be executed and the ways in which the findings contribute to the knowledge and provide further directions for future research. This is then followed by a thesis outline where each chapter is succinctly described. In summary, this chapter sets the scene for why and how this research is conducted, its necessity and the possible impact it will have towards a better understanding of adaptive learning environments and students' learning and engagement.

Chapter 2

2. Engagement, Motivations and Emotions

2.1. Introduction

Over the next two chapters, a number of key areas will be unpacked which must be understood and clearly defined for this study to be conducted. This will allow for a clear conceptual framework to be formed on which the research will be based. These chapters will also help to identify and define the intervention that will take place and explore the approach and tools that will be used for the analysis of impact from the chosen intervention.

In this chapter motivation and engagement are explored as key considerations for academics looking to improve their students overall learning experience. First, motivation and engagement will be differentiated as individual concepts while uncovering their relationship with each other, specifically the role motivation has on engagement, and the importance engagement plays in persistence of action. Appreciating the malleability of emotions, the impact emotional engagement has on the student experience and the potential influence emotional aspects of engagement have on other facets of engagement, helps us to identify emotional engagement as being a prime candidate for module interventions. With emotional engagement as a lens, emotion itself is further explored, looking into the triggers for emotions and their role in the goal and decision-making process of an individual.

Having motivation, engagement and emotions clearly defined in the context of this study, emotional engagement is explored from an academic perspective helping to define a clear set of emotions. This set of emotions is based on emotions which take place most frequently in the classroom as a result of classroom-based activities, which may be measured as part of our intervention. Furthermore, it is important to

understand how best to design module content to foster academic emotional engagement and ensure the module itself is first suitably designed before considering the intervention. In this context, understanding how best to engage students also helps us construct a suitable intervention which may target academic emotional engagement as its core objective.

Finally, this chapter investigates measures of engagement, refined for our directive to explore emotional aspects of engagement, towards selecting a suitable tool and methodology to measure academic emotional engagement specifically in the context of a classroom intervention.

2.2. Engagement and Motivation

Learner engagement and motivation have been widely accepted as important influences on achievement in education (Fredricks, Filsecker, & Lawson, 2016; Hefce, 2013; Hernández, Sucar, Arroyo-figueroa, & Erro, 2013; Kahu, 2013;NSSE, 2013; Young, 2010; Ortony, Clore, & Collins, 1990). Engagement and motivation fall under the realms of emotion which is one of the most pervasive aspects of our perception of experience (Colby et al., 1989). Engagement itself is specifically appealing to researchers as there is mounting evidence that engagement is malleable and responsive to change as a result of interventions (Fredricks et al., 2016; King, McInerney, Ganotice, & Villarosa, 2015). Indeed it is believed that heightened student engagement may have positive impacts on academic achievement, student boredom, and dropouts (Fredricks, Blumenfeld, & Paris, 2004). Young (2010) points out that engaged learning and engaged learners are increasingly cited as critical factors in producing significant learning. This is reflected by Carini, Kuh, & Klein (2006) where they describe engaged students as being linked to desired outcomes and high engagement being among the better predictors of learning and personal development.

Likewise a robust relationship between students who achieve high levels of engagement in college and develop habits that increase their capacity to engage in lifelong learning has also been found (Carini et al., 2006; King et al., 2015; Lyubomirsky, King, & Diener, 2005).

2.2.1. Definition of Engagement and Motivation

Engagement can occur anywhere both inside and outside of school and even beyond the classroom. Engagement is often described as the quality of a student's connection or involvement with the endeavour of schooling (King et al., 2015). However to further focus the definition of engagement in an academic context, Ben-Eliyahu, Moore, Dorph, & Schunn (2018) consider learner-peer, learner-educator and learner-parent relationships as support mechanisms for engagement, with actual engagement emanating from learner-activity interaction in particular, supporting their definition of engagement as 'the intensity of productive involvement with an activity'. In this case, peer/family support, and care in school fall into the category of belongingness which leads to and may support engagement but are not themselves actually instigating engagement which is best to be measured at an activity level (Ben-Eliyahu et al., 2018). To further unpick engagement however, it is best to understand its relationship with motivation and clearly differentiate the two.

In organizational behaviour literature, motivation is described as the set of psychological processes that cause the initiation, direction, intensity and persistence of behaviour. Locke (1996) notes that the study of this human condition is 'a very difficult undertaking' as he describes motivation as something which exists internally. Dornyei & Otto (1998) describes motivation as 'a dynamically changing cumulative arousal in a person that initiates, directs, coordinates, amplifies, terminates, and evaluates the cognitive and motor processes whereby initial wishes and desires are

selected, proprieties, operationalize and (successfully or unsuccessfully) acted out'. Indeed to better frame motivation and understand its place around engagement, it is best to consider motivation as a antecedent of engagement, with motivation instigating engagement (Ben-Eliyahu et al., 2018).

2.2.2. Differentiating Engagement and Motivation

Often found in the literature on the topics of engagement and motivation, the words 'engagement' and 'motivation' are used interchangeably which makes them difficult to distinguish from each other. Some would say in terms of a learning task, a motivated student would look towards a reward or an objective for completing a task, whereas an engaged student would see the task itself as rewarding. This could be viewed as the difference between instrumental and intrinsic motivation. With instrumental motivation, the task itself is just a means to an end with the actual motivating factor being considered external, such as grades, qualifications or extrinsic reward. With intrinsic motivation, the focus is on the pleasure and interest in learning and learning activities (Kahu, 2011). To further refine this definition, Ben-Eliyahu et al., (2018) described this desire to learn and development as mastery-goal-orientation, while having an external focus such as the desire to look smart or impress others with your grades is considered performance-goal-orientation.

To clarify based on these definitions, motivation refers more to the question of 'why' a student wants to engage with a task, either for intrinsic or extrinsic reasons whereas engagement refers to 'what' in terms of what they are doing, feeling, and thinking and how that contributes to their continued active engagement on a task or activity. As a result, both active learning and motivation are required for engagement to occur (Barkley, 2009), the student must 'want' (motivation) to do the task to begin to actively participate (engagement) with it. It is at this point that we can explore what

is happening with the student while they are engaging with the task. It could be expected that a student who has already shown up for class will have some form of motivation based on the fact that they are actually there and working on an activity. However, understanding their engagement, and exploring how the elements of engagement on an activity can be enhanced would be most beneficial in a classroom context and for classroom interventions.

In would seem then that understanding engagement comes from understanding the motivation for one to engage, where in an ideal situation motivation is intrinsic. This is visualized well in the self-determination continuum (Ryan & Deci, 2000) where the motivation to engage is divided into amotivation, extrinsic motivation and intrinsic motivation, going from the least desired type of motivation to the most desired. Although not strictly a sequential process, it can map out how one might move from an amotivation state to an intrinsically motivated state by shifting their value of a behavioural goal or regulation from being something that is externally imposed on them to something that is personally important.

It could also be assumed that a learner doing a task or activity for extrinsic reasons would be less likely to expand too much further on their understanding of the subject matter and simply do what is expected of them to reach their extrinsic goal, resulting in sustained active participation being more of a challenge. Adversely, a logical link can be made that a learner who is intrinsically motivated, and so engaged in the activity itself, is more likely to enjoy the activity, explore the content in more depth, go beyond standard expectations and maintain active participation on the activity (Kahu, 2011). This concept of easier sustained activity on task now moves us into the realm of engagement, where the desire to start the task was based on their motivation objectives but staying on task and the depth in which the context of the

task is explored leads towards the definition of engagement. Indeed, the concept of a student 'enjoying' a task not only helps us start to explore the definition of engagement but also starts to uncover the facets of emotional engagement (joy, interest, absence of boredom), as we start to unpick the multidimensional nature of engagement. To further expand on this, we need to consider how we might enhance general engagement, then narrow down into the facets of engagement to understand what aspects of engagement may be more easily influenced by classroom interventions.

2.2.3. Unpacking Engagement

As Young (2010) highlights the importance of engaged learning and engaged learners as critical factors of significant learning, it is noted that academic engagement integrates theories of learning and motivation into a useful model that gives us insight into ways teaching and learning may be enhanced. Empirical evidence suggests that engagement is related to critical thinking, persistence, grades, and dropout rates (Young, 2010). Deci & Ryan (1985) identify fundamental needs of motivation and performance as being competence, autonomy, and relatedness. Literature on motivation generally establishes that a person's need for a feeling of competence or self-efficacy has an impact on performance (Locke, 1996; Deci & Ryan, 1985; Kahu, 2011) but without engagement this ability to perform may not actually translate into actual performance (Young, 2010). In terms of autonomy, Moore (1980) notes that learners differ in their ability to be autonomous and self-directed and care must be taken not to give a learner more autonomy than they are capable of exercising. Krischner et al. (2006) conclude in their study that minimally guided instruction is less effective and less efficient unless learners have sufficiently high prior knowledge to provide self-guidance. Relatedness, fulfilled through assistance from the

instructors, dialogue with fellow students and access to disciplinary experts allowing learners to feel respected and cared for (Young, 2010), results in learners feeling more willing to engage in behaviours that are valued by significant others to whom they feel connected with.

The demand / control / support model (Karasek, 1979) has been used for over 25 years by researchers investigating the psychological aspects of the work environment and their effects on the well-being of employees (Young, 2010). These elements have been found to have an influence on engagement on tasks which may be positive or negative depending on how each element is addressed. In the context of learning, demand relates to psychological stressors often seen as the challenge and complexity of tasks, time pressure, workload or ambiguity. Control concerns the learners control over their learning process (which tasks they do, or how they do those tasks). Support is a social dimension which looks at the social relationship in the learning environment and the support structures in place. These elements may also have relationships with each other such as a highly demanding workload that the learner has control over in terms of how and when they work can increase engagement in that task. The same situation yet in a very controlled environment, in terms of how and when work is done, can lead to burnout and lack of engagement (Young, 2010). Young (2010) refers to these situations as the former being high demand / high control and the latter being high demand / low control. Young (2010) also notes that in the high demand / low control scenario that high support can lead to a rise in engagement. This then relates to the idea of 'good stress' which can lead to higher motivation and active learning behaviours.

Young (2010) refers to engagement as a multifaceted phenomenon which guides the targeted engagement of their study. This perception of engagement as

being more than a single dimension is shared by many researchers and has become somewhat mainstream in the literature on engagement (Fredricks et al., 2016; Kahu, 2013). Bryson and Hand (2007), appreciating the complexity of engagement, called for the multifaceted approach toward understanding and improving learner engagement. Fredricks et al. (2004) take this multifaceted approach into consideration and defines engagement as being made up of three key dimensions:

- Behavioural – Commonly defined in three ways, the first being positive conduct, the second in terms of involvement in learning and academic tasks in areas such as effort, persistence, concentration, attention etc. and the third being participation in school related activities such as athletics or school governance.
- Emotional – Referring to students' affective reactions in the classroom including interest, boredom, happiness, sadness, anxiety etc. Some define it as a feeling of belonging, feelings towards school, teachers, work etc., which have been seen to overlap more with motivational research.
- Cognitive – Conceptualised as investment in learning which may also involve self-regulation and being strategic. Some also explore psychological investment in learning, a desire to go beyond the requirements and a preference for challenge. This, too, has also been seen to overlap with motivational research.

2.2.4. Importance of Emotional Engagement in Education

Interestingly, out of the three engagement dimensions, one seems to have an impact not only on the other two, but also on motivation itself, that being emotional engagement. Kahu, Stephens, Leach, & Zepke, (2014) point out that the importance of emotions in education is no longer in dispute based on increased research and

evidence in this area but notes that the connection between emotions and education needs further study. Indeed Askham (2008) notes that the experience of learning has an emotional intensity to it which is often overlooked. Understanding where engagement and emotional engagement fits in relation to various influences helps form this complex picture of learning, which is visualised well by Kahu (2013) in the conceptual framework of engagement, antecedents and consequences (Figure 2-1).

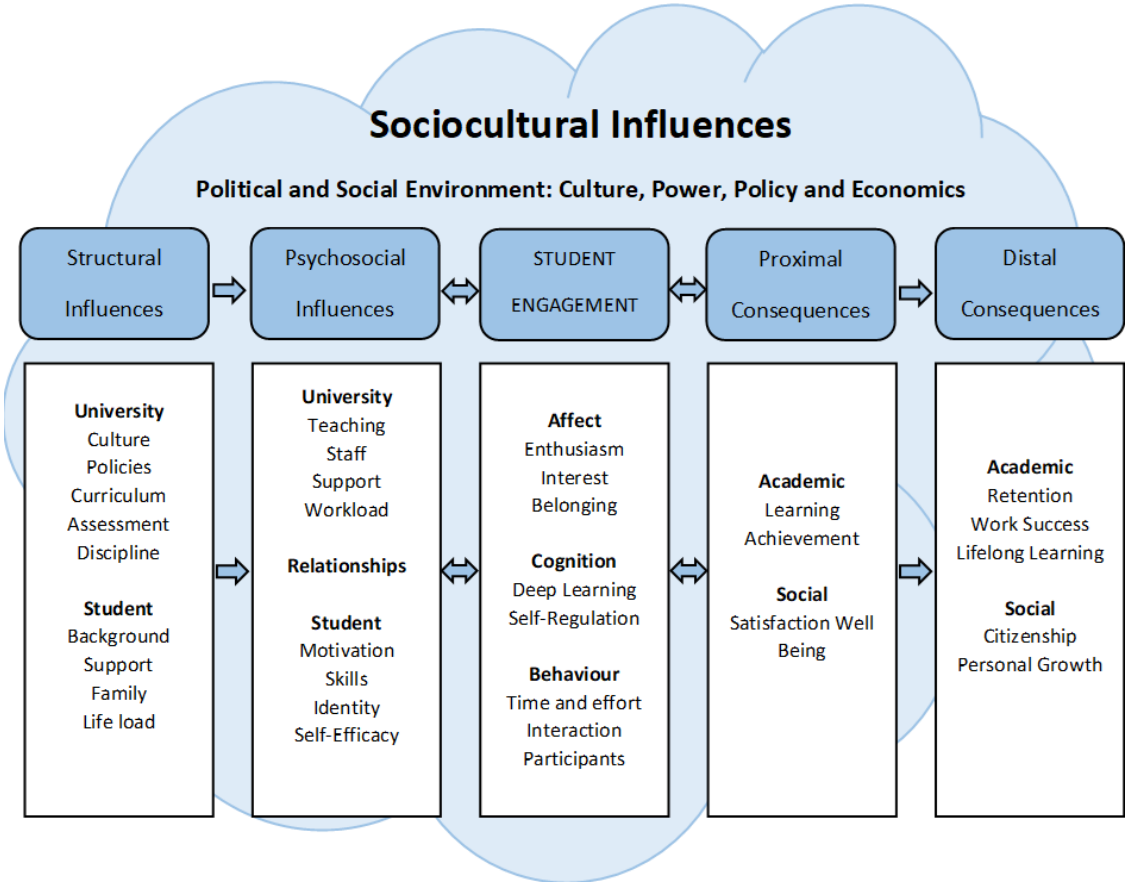

Figure 2-1 : Conceptual Framework of Engagement, Kahu (2013)

Although emotional engagement itself can be seen from two different lenses, that of being related to positive and negative reactions to teachers, classmates, academic activities or school (Fredricks et al., 2016) to that of examining primary emotions such as joy, pride, anger and anxiety (Pekrun, Goetz, Titz, & Perry, 2002), regardless of which definition is used, the impact on behavioural and cognitive

elements is still evident. As noted previously, motivation has an impact on behaviours such as effort, persistence and concentration, all stated as aspects of behavioural engagement. Research has also shown that emotions actually impact motivation, the use of learning strategies, self-regulated learning and academic success (Linnenbrink-Garcia & Pekrun, 2011; Meyer & Turner, 2007; Brdovčak, 2017) as well as the desire to go beyond the requirements (Kahu, 2011), which are stated as aspects of cognitive engagement. Indeed as can be identified from Figure 2-1, relationships are seen as psychosocial influences to student engagement with the definition of emotions around feelings such as interest and enthusiasm forming the bases for student engagement in the affective dimension. This aligns well with the notion explored earlier that intrinsic motivation leads to enjoyment on task (emotional engagement) which can impact elements such as the depth of learning (cognitive engagement) and the time and persistence on task (behavioural engagement).

Indeed this notion seen in Figure 2-1 of support having a psychosocial influence on engagement aligns to Young's (2010) second principle of fostering academic engagement which identifies support as a key factor. Young (2010) concludes that to enhance performance through classroom interventions, instructors need to pay particular attention to a learner's level of engagement. By combining self-determination theory (Deci & Ryan, 1985) and demand/control/support (Karasek, 1979) to explore secondary data, Young's (2010) five principles for fostering academic engagement emerged based on research findings, those being:

1. Empowering students: Research suggests that student autonomy or control over their learning has greater impact on their overall engagement (Karasek, 1979, Pekrun, 2016). Opportunity for self-direction enhances their intrinsic motivation.

2. Providing support resources: Where students are provided with support to help them achieve their learning goals be it physical, psychological, social or organizational. It was also found that minimally guided instruction is less effective than instruction that included instructor's guidance and feedback.
3. Creating demanding learning tasks: Challenging tasks that require substantial but reasonable time and effort to complete.
4. Beware of role overload: Ensuring students are not overly cognitively taxed or feeling under time pressure. Research showed that role overload had an impact on engagement and performance.
5. Utilize multiple targets of engagement: Ensuring the instructor has an understanding of the diversity of their students in terms of interests, experiences, backgrounds, and expectations as well as commitment to their classes and designs learning tasks accordingly to engage learners in different ways on different levels.

2.2.5. Focus on Emotional Engagement

Emotions have been noted as an integral part of education (Brdovčak, 2017) which helps to align the focus of this research on this specific aspect of engagement with a model for fostering academic engagement (Young, 2010) that can be used to guide the development of material and the module structure of the intervention for this study. To explore emotions further however, an understanding of the meaning of emotion will be developed through literature on the topic to come to a suitable definition which will help inform a more narrowed exploration of emotion in an academic context which will be used to develop the conceptual framework of this study.

2.3. Understanding Human Emotions

Ortony et al (1990) describes emotion as one of the most central and pervasive aspects of human experience and notes that while emotions may have profound positive effects, they can also cause disruptions in judgement and performance. Pekrun (2016) points out that emotions are functionally important to students' motivation, academic success and personal development but notes that educational research around emotions has been largely neglected and that few studies have examined students' emotions as they occur in an academic setting.

2.3.1. Importance and Influence of Emotions

It has been argued that emotions evolved for their adaptive value in dealing with fundamental life-tasks such as facing an immediate danger, experiencing an irrevocable loss or progressing towards the realisation of a goal (Johnson-Laird & Oatley, 1989). Positive emotions can lead to the attainment or expected attainment of a goal while negative emotions can lead to the loss or expected loss of a goal (Stein & Levine, 1989), while plans, goals and knowledge representation themselves can actually elicit emotions based on expectations (Colby et al., 1989).

Emotions are linked closely to goals and goal attainment at their very core. In the endeavour to define emotions, their origins and what actually invokes them, many authors agree that emotions are triggered by events, objects or agents, that are of intrinsic or extrinsic relevance to the concerns of the organism experiencing them (Cabanac, 2002; Ortony et al., 1990), which may result in a disruption of behaviour where action is taken if needed to generate new goals or plans (Cabanac, 2002; Scherer, 2005).

As a result, emotions are important determiners of motives. Organisms take into consideration the potential emotional outcomes of the decisions that they are planning to make, before they take action, based on the concept that pleasurable or positive results are the desired outcomes of their decisions and the results of those decisions are considered useful (Cabanac, 2002). Emotions such as happiness, sadness, anger, fear and disgust are expected to occur with the achievement of a sub-goal, loss of a goal, frustration of a goal (or plan), conflict with goals and perceptions that something is toxic to the organism (Johnson-Laird & Oatley, 1989). All of these points suggest that emotions are an important part of the decision-making process relating to a meaningful event to help inform plans, goals, decisions and action in relation to desired outcome.

In an academic context, considering that learning and achievement are of fundamental importance for students' educational careers, it would be expected that a range of emotions most specifically relating to achievement may manifest frequently and quite intensively in academic situations (Pekrun, 2016). As a result, we can comfortably state that emotions are important to motivation and success (Pekrun, 2016) but what does remain to be considered here is, what are emotions and how do we clearly define them?

2.3.2. Towards a Definition of Emotion

The origin of emotions have long been in debate, with two major lines of argument. The first line of argument perceives emotions as being evolutionary based on the past history of the species (Ekman & Friesen, 1975; Ekman, 1992) and the second, perceives emotions as being learned or developed through social interactions based not on the past history of the species but the past history of the individual (Ortony & Turner, 1990). While this understanding of the true origin of emotions and

what elicits them is important, it has been fuel for hot debate for decades with, as of yet, no fixed conclusion and so is beyond the scope of this research.

However, throughout the literature there has been fair agreement on the fact that various emotions do exist. Most find it fitting to define a list of emotions that describes each emotion in its most simple form, removing definitions which refer to intensity or alternate forms of the same emotion, (Ekman, 1992; Johnson-Laird & Oatley, 1989, Pekrun et al., 2002) and seeing the differentiation of emotions from other affective states or traits as very important (Scherer, 2005).

The production of a definitive list for human emotions, or at least the core, modular or basic emotions, has also been illusive to researchers (Scherer, 2005; Cabanac, 2002). In earlier research, many came to an agreement on at least 6 clearly identifiable emotions, those being; happiness, surprise, fear, sadness, anger and disgust (Ekman, 1999; Cabanac, 2002). These emotions were identified using methods such as observation of facial expressions, patterns of autonomic nervous system activity and interpretation of electroencephalogram (EEG) readings (Ekman, 1999; Ortony et al., 1990). However, even with this consensus on the existence of such emotions, the number of these basic emotions, whether we should even call them basic emotions (Ortony et al., 1990) and the words we use to describe these emotions are all still in flux.

To focus in on just one word in the latter list, ‘happiness’, Cabanac (2002) suggests that the word happiness best describes a condition that is stable and indifferent whereas the word joy refers to a dynamic, transient and pleasant experience and as such, should be used in the place of happiness. This conversation around the grammar of emotion is not a new one as the literature shows much consideration and

debate around which list of words to use to describe various emotions, but a suitable list should be agreed on in a piece of research to best serve the objectives of that research.

Scherer (2005) sees this as a drawback for the social science researcher as they must resort to everyday language concepts in both every-day and empirical investigations. Ortony & Turner (1990) realised this challenge and noted that an important part of the job for a linguist is to ensure as much explicit clarity as possible on words which are implicitly understood, and likewise the job of a psychologist is to ensure the emotion which is implicitly understood is explicitly explained and linked to the most appropriate grammar to define that emotion.

A major challenge then becomes how to define a list of emotions for a piece of research. Scherer (2005) notes that there are too many emotions to count and many believe emotions are what people say they are (Frijda, Markam, Sato, & Wiers, 1995). As such, understanding where alignment exist may be an important part of choosing the most appropriate definition of emotion for any piece of research dealing with them.

Componential theories of emotion have been noted to be gaining widespread acceptance (Scherer, 2005; Cabanac, 2002). Many researchers also agree that emotions can be formed into groups of similar emotions, where a single word such as happiness or joy may refer to a group of similar emotions (Ekman, 1999; Ortony et al., 1990; Scherer, 2005). This list of emotions should:

- Take into consideration the difference between emotions, feelings, moods and attitudes (Ekman, 1999; Scherer 2005),

- Appreciate some important characteristics of emotions such as quick onset, brief duration, having elements of appraisal (Ekman, 1999; Scherer, 2005),
- Have a behavioural impact and varied levels of intensity (Scherer, 2005),
- Have clearly categorisable positive and negative emotions (Scherer, 2005; Cabanac, 2002; Ortony et al., 1990; Ekman, 1999) and
- Used definitions should be suitable for any piece of research dealing with emotions (Scherer, 2005).

2.4. Academic Emotions and Emotional Engagement

With a general understanding of motivation and engagement and basic emotions developed over the previous two sections, we can now bring our definition into clearer focus for this research using the academic setting as a lens.

2.4.1. Definition and Impact of Academic Emotional Engagement

The first point to address is to ensure clarity in terms of the meaning of emotional engagement in the context of this research. On one hand, emotional engagement has been described as the extent of positive or negative reactions to teachers, classmates, academics or school settings, an individual's sense of belonging and identification with school or subject domains (Fredricks et al., 2016). On the other hand, and potentially just another aspect to emotional engagement, emotions can be seen as reactions to significant events and objects believe to serve as a mechanism to prepare and adapt an individual for subsequent processes of perception, cognition and action (Pekrun, 2016). While each is clearly important to the learning process of a student, the former fits well with a course level overview of engagement, where various potential factors can influence a student's engagement within their course and within their school, while the latter is useful for the exploration of specific events which may trigger emotional reactions, such as, in an academic context, tests,

assignments, in-class activities and reactions to learning in general which are of specific interest to educators exploring interventions in classroom environments (Pekrun, 2016; Kahu, Stephens, Leach, & Zepke, 2014).

There has been alignment among researchers which has led to the idea that emotions consist of multiple coordinated processes, important components of which are (Shuman & Scherer, 2014):

- Affective components that relate to emotional feelings
- Cognitive components involving emotion-specific thoughts
- Physiological components serving the preparation of action
- Motivational components comprising of behaviours impulses and wishes
- Expressive components including facial, postural and vocal expression of emotion

Pekrun et al. (2002) notes that qualitative studies have shown that students experience a rich diversity of emotions in academic settings both positive and negative. When we narrow down our definition of emotion to this scale, individual emotions brought about by reactions to learning content can be explored. Pekrun et al. (2002) defines academic emotions as those linked to learning, instruction, and achievement which are seen to influence all stages of the learning process affecting learning through attention, memory, motivation, and self-regulation.

Perhaps unsurprisingly so, student engagement has been noted to address persistent educational problems such as low achievement, high dropout rates and high rates of student boredom and alienation as well as improving students behavioural patterns such as heightened attention in class and better attendance, resulting in a

growing body of research in this area (Fredricks et al., 2016; Kahu et al., 2014; Kahu, 2011; Kuh, 2009).

As previously explored motivation and engagement can be seen as having three basic dimensions to it, behavioural, emotional and cognitive (Fredricks, Blumenfeld and Paris, 2004). Again, while each dimension is important in its own right, it would seem that the emotional aspect of engagement has the potential to impact cognitive and behavioural facets of engagement as well having significant impact on students' motivation, learning strategies, cognitive resource, self-regulation and attitude in the classroom (Pekrun et al., 2002).

Initial literature on emotion, it has been found, focused on the negative side of emotions (Kahu et al., 2014), focusing more on anxiety around test based scenarios rather than on a range of negative emotions in various contexts with even less research conducted on positive emotions (Pekrun et al., 2002).

2.4.2. Unpacking Antecedents for Academic Emotions

Pekrun (2016) refers to the work of Weiner (1985) as a piece of research which stands out amongst previous research, presenting empirical evidence for three dimensions of perception those being locus, stability and controllability. In his research, Weiner (1985) attempts to relate the structure of thought to the dynamics of feeling and action. In very simple terms, this idea touches on the behaviour trait that results in individuals assigning a cause to an event, which in turn, when related to success or failure, will influence their expectancy of success. Initial findings showed that the most commonly related causes to the successful outcome of an event were an individual's perceptions of ability, effort, task difficulty and luck.

To further understand these dimensions, Weiner (1985) categorised them into stable, unstable, internal and external dimensions, and while this classification was deemed too simplistic it helped shed some light onto how the previously mentioned dimensions may impact success expectancy. For example, based on this classification, ability was seen to be internal and stable, meaning ability was something which was under an individual's control in this sense, it was not externally controllable, however it was perceived as somewhat stable. In an academic context, this would be similar to saying that a student attempting a task has their current internal stable ability which would impact the potential outcome of that task. Difficulty for example was classified as more external and stable, where the difficulty of a task would be set by someone other than the individual attempting it and would not change. These classifications are not set in stone however, as it could be argued for example that a student's ability would change as they worked on the task with increased effort. However, a student's perception may also impact their own classification of ability. For instance, a student who consistently fails at tasks may perceive their ability to be fixed rather than malleable.

While the classifications themselves are open to perception and interpretation, they do shed some light on the thought process behind an individual's expectancy of success, and may also give us insight into ways in which this expectancy can be enhanced. For example, if a task or activity is considered to be of fixed or stable difficulty and externally controlled, a student with perceived low ability and perceiving the task as high difficulty would consider their chances of success on the task to be slim. This may result in a lack of engagement on the task, lack of confidence in attempting the task, or even avoidance of the task as it may be perceived as 'too difficult'. However, if the task itself was to be adaptive, enabling the individual to

control the task's difficulty, resulting in the difficulty still technically being externally set, but internally adaptable, this may support a student in attempting the task. In such an instance, the student may put in more work and effort into completion of the task given their heightened perception of potential success.

While this sense of goal expectancy is considered by psychologists as one of the major determinants of action (Weiner, 1985), this does not necessarily mean that an individual who perceives that engagement in a task will lead to success will actually engage with the task. In simple terms, just because I can do something, does not mean I will. The factor that takes an individual from assessment of goal expectancy to actually engaging in a task is motivation, and indeed while it is not guaranteed that an individual will attempt a task just because they believe the outcome will be a success, this goal expectancy does become a motivational factor in itself. This belief in self that a task can be done, is often referred to as self-efficacy (Pekrun et al., 2002), that leads to aspiration which leads to success, and in turn, with every success, aspiration is also noted to increase (Weiner, 1985). Interestingly, while overall expectancy of a major outcome may be difficult to change, such as a student's belief they will do well in a module that they traditionally struggled with, individual goals on tasks are easier to impact which may impact their overall expectation of success (Weiner, 1985). In this sense, if we can lead a student to more individual successes on activities in the class, leading to a higher goal expectancy in future tasks, this may eventually lead to an increase in overall expectancy on the module that they are engaging in which in turn may lead to higher overall engagement and performance. Likewise, Weiner (1985) points out that if conditions remain the same and stable, the expectancy of success, goal or overall expectancy, will remain the same as well.

The motivation to engage in a task leads us back to intrinsic and extrinsic factors which in the context of goal expectancy can be considered goal incentives (extrinsic) or properties of the goal object (intrinsic). As a result, motivation is considered by Weiner (1985) to be determined by what one can get as well as the likelihood of getting it, touching on incentives and expectancy respectively. This forms the bases for Weiner's attributional framework (1985) which explores outcome emotions based on the outcome of an event. The framework is based on the idea that feelings arise from how an event is constructed and evaluated and states that following the outcome of an event, a primitive emotion is triggered that is either positive or negative depending on the perceived success or failure of that outcome (primary appraisal of the outcome), these emotions are labelled as outcome dependent-attributional independent as they are linked to the outcome of the desired goal and not yet linked to the cause of the outcome. Additionally, a causal ascription is expected which results in a different set of emotions. Again, in most simple terms, if an individual achieves a task, and so has a successful goal outcome, they may initially feel positive emotions such as joy, after which they would be expected to consider why this task resulted in a successful outcome, which may invoke other emotions such as pride. In a further study of this framework (Weiner, 1985), it was found that one determinant of affect was the outcome of an action and that the success of achievement regardless of cause, resulted in happiness. Failure of an outcome however, again regardless of cause, resulted in feelings of sadness and frustration with casual associations and emotions coming after the event.

Table 2-1: Causal Dimensions, Weiner (1985)

Emotions	**Dimensions**		
	Locus	**Controllability**	**Causal Stability**
	Pride Self-Esteem	Anger Gratitude Guilt Pity Shame	Hopefulness Hopelessness

Finally, from this piece of work by Weiner (1985), seven dimension related emotions (Table 2-1) were identified and categorised based on the locus dimension, controllability and causal stability.

In the conclusion of this study (Weiner, 1985), it is noted that one should be careful not to assume that an action will definitely lead to an expected emotion. For example, if someone performed well in his/her exam, he/she may not exhibit the emotion of pride. However, it is easier to assume that if the emotion of pride is reported, it is due to the outcome of a specific event and based on the goal expectancy of that event. Further, it was also noted that persistence in the face of failure is enhanced when attributions for failure are changed from low ability to lack of effort. This is based on the potential perception from an individual that their ability may not be malleable (even if it is) but if they feel they 'could' complete a task but simply did not put in the effort to complete it, this is something that is more obviously malleable to the individual.

Using the work of Weiner (1985) as one of the baselines for expanding on a framework, Pekrun et al. (2002) explore more extensive literature on test anxiety, as

a more predominantly researched emotion in recent times as a result of an academic event. Such research sets a foundation for the exploration of additional emotions involved in an academic context which had largely been neglected (Pekrun, 2016; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011;Kuh, Kinzie, & Buckley, 2006; Pekrun et al., 2002). As academic achievement has long-term impacts on an individual's career prospects both academically and professionally, academic learning and achievement have become key factors in modern society resulting in individuals in an academic setting experiencing a wide variety of emotions as a result of the internal importance of learning and achievement to each individual (Pekrun et al., 2002). The potential for more research on the impacts of such a wide range of emotions experienced by students in an academic setting was noted as a significant gap in research (Pekrun et al., 2002).

2.4.3. Process of Defining Academic Achievement Emotions

Pekrun et al. (2002) goes beyond exploring emotions only in the domain of success and failure to including those which are involved in the process of studying, leading to the term 'achievement emotions', being those experienced in a school or university setting. This initial piece of work attempts to address a similar issue noted in earlier work around the definition of basic emotions (Ekman & Friesen, 1975; Ekman, 1992), and identify primary emotions which are experienced by an individual, but in this case, in an academic context. Pekrun et al. (2002) identified 5 guiding questions to explore the topic of academic / achievement emotions in more depth, those being:

1. Which emotions do students experience in academic settings when attending class, studying, and taking tests and exams? Furthermore, what are the elements of these emotional experiences and how are they structured?

2. How can we measure students' academic emotions?
3. How do these emotions affect learning, academic achievement, and students' health?
4. What are the origins of these emotions within students' personality and in their environments?
5. What can we do to foster positive academic emotions and to help students avoid negative emotions, or to cope with negative emotions in flexible ways once they emerge?

Indeed, while the study by Pekrun et al. (2002) mainly addresses the first four of these questions, and subsequent work on the topic refines and expands on these findings (Pekrun, 2016; Pekrun et al., 2011; Pekrun et al., 2002), all questions relate strongly to the direction of the research being presented in this study and form a solid foundation on which to explore the impact of an intervention which strongly relates to the fifth question proposed here around enhancing positive emotions, reducing negative emotions and/or finding ways to address situations which may result in negative emotions. Pekrun et al., (2002) highlights that it is important to address the first four proposed questions prior to designing educational applications or interventions, and proposes that an appropriate strategy for exploring emotional dimensions includes a mixed methods approach and multiple research strategies.

Before delving into the list of emotions identified in the work by Pekrun et al., (2002), some interesting observations are worth mentioning based on their qualitative work. Anxiety was unsurprisingly mentioned most often, not only in relation to exams but also in the context of being in class or studying at home, which points to the importance of educational experiences to an individual on their life goals. Achievement pressure and goal expectancy were also reported as major contributing

factors to emotional arousal. This led to a suggestion of enhancing students well-being and increasing their opportunities for success to support them in coping with excessive demands (Pekrun et al., 2002). On top of this, it was also noted that in terms of the cognitive components of academic emotions, three major cognitions contributed, namely, thoughts about the task (quantity, difficulty and relevance), thoughts about mastery and achievement as well as thoughts about the social situation within an academic setting. These components were often related to more than just one emotion and likewise sometimes it was noted that emotions themselves led to emotions, such as the feeling of shame leading to feeling hopeless. This as a result led to the conclusion that measuring individual emotions would not be as beneficial to understanding emotional engagement as measuring a range of emotions in a similar category within a specific domain, which in this case would be the domain of learning in an academic setting.

To finalize the list of emotions, Pekrun et al., (2002) attempted to select a limited range of emotions based on their importance in an academic setting which could be assumed to effect students learning, achievement and health, the following criteria was used to select these emotions:

a) The scales should represent those categories of primary human emotions that play a role in academic settings.
b) Only emotions frequently reported by students in qualitative studies should be selected.
c) Positive and negative emotions should be included as well as activating and deactivating emotions.

2.4.4. Identifying Academic Achievement Emotions

Generally two approaches have been used in the literature to identify academic emotions, namely, discrete emotion approach, showing individual emotions as a distinct phenomena, and dimensional emotion approach which views a small number of affective dimensions as sufficient to describe human emotion. Pekrun, (2016) however, proposes that the two are not mutually exclusive instead highlighting that discrete emotions are lower-level factors and affective dimensions as higher order factors.

Related to this criteria, both positive and negative emotions are addressed which appear in much of the literature on emotion (Cabanac, 2002; Colby et al., 1989; Ekman, 1992; E. Kahu et al., 2014b; Pekrun, 2016; Scherer, 2005). This is considered the valence dimension of emotions. In their cognitive-motivational model, Pekrun et al., (2002) suggest that a second dimension of emotion is no less important, this being activation. This second dimension thus leads to four groups for emotions to be categorised in. The first two are considered the most straight-forward with positive activating emotions being noted to enhance enjoyment of learning and academic motivation, negative deactivating which are seen to be detrimental to learning and motivation.

The other two groups of emotions are somewhat more complex, with positive deactivating emotions (e.g. relief) although considered initially a positive emotion, may actually deactivate motivation to continue on a task (example: a student does enough to pass, becomes relieved and stops working towards a better grade). Negative activating emotions on the other hand, considered as negative emotions such as anger and shame, while initially will decrease enjoyment and indeed perhaps reduce intrinsic motivation, may act as extrinsic motivators further on, in that a student may

attempt to cope with the negative events that caused them. For example, anger may be seen as an emotion that motivates an individual to want to overcome an obstacle, whereas shame may be a feeling that is best avoided by investing more effort and so increasing academic motivation. (Pekrun et al., 2002)

While it is important to understand the groupings of the 2 emotional dimensions mentioned here, it is noted in their findings (Pekrun et al., 2002) that while negative deactivating emotions may have longer term motivation impacts, in an immediate setting such as working on a task or activity in the classroom, such emotions point to an individual lacking enjoyment in their activity and would be expected to have detrimental effects on intrinsic motivation. As this study is looking at emotions in a classroom environment, at a single point in time, such emotions are viewed as detrimental to a student's motivational engagement on the current task, but acknowledgement is given to the complexity of this group of emotions.

With the groups for emotions established, emotions that fit naturally into these four groups needed to be identified. Based on the criteria for selection of emotions mentioned above, the following clusters of emotions were identified (Pekrun et al., 2011, 2002)

- Positive Activating: Enjoyment, joy, hope, pride
- Positive Deactivating: Relief, relaxation, contentment
- Negative Activating: Anger, frustration, anxiety and shame
- Negative Deactivating: Boredom, sadness, disappointment, hopelessness

It was also noted by Pekrun et al., (2002) that correlations between clusters were relatively low and within clusters correlations were considered relatively high.

As a result of this work and their studies leading up to it, Pekrun et al., (2002) devised the Academic Emotion Questionnaire (AEQ) with a long and a short version.

The long version uses scales per emotion, and the short version is item based and considered suitable for a single course over a shorter time where the measure of transient emotions is desired (Pekrun et al., 2002). As well as this initial review of the AEQ, Pekrun et al., (2011) did further testing on the later version of the tool which showed high levels of reliability and validity on the items and scales.

2.4.5. Dimensions and Appraisal of Academic Achievement Emotions

Pekrun et al. (2006), (Pekrun, Elliot & Maier, 2006) expands this grouping by adapting a control value theory based on expectancy value theories of emotions, transactional approaches, and attributional theories and models of performance effects of emotions. This leads to emotions being grouped further in this Three-Dimensional Taxonomy of Achievement Emotions (Pekrun, 2006) around what the emotions are focused on, being either Activity or Outcome focused.

Activity focused emotions are those which are brought about by engagement with learning such as enjoyment (Positive Activating) or boredom (Negative Deactivating), whereas outcome related emotions such as joy, hope and pride (Positive Activating) or anxiety, shame (Negative Deactivating) are related to the success or failure outcomes of academic activities. This view of emotions and their dimensions is highlighted Table 2-1

Table 2-2 : Three-Dimensional Taxonomy of Achievement Emotions

(Pekrun et al., 2006 ; Perkrun, 2016)

	Positive		**Negative**	
Object Focus	**Activating**	**Deactivating**	**Activating**	**Deactivating**
Activity Focus	Enjoyment	Relaxation	Anger	Boredom
			Frustration	
Outcome Focus	Joy	Contentment	Anxiety	Sadness
	Hope	Relief	Shame	Disappointment
	Pride			Hopelessness
	Gratitude			

Pekrun (2016) also noted that the classroom instruction and social environments themselves have a role to play in achievement related expectancy which have been found to play a significant role in students' emotions based on a somewhat limited amount of research in this area. This included lack of structure and clarity in classroom instruction as well as excessive task demands which were found to increase overall student anxiety. Studies also found that teacher-centred instruction which lead to teacher-controlled environments, were also found to be detrimental to students' positive emotions, as opposed to cognitive quality of instruction, support for students, autonomy at learning and task control which correlated positively with students enjoyment of learning.

Finally, to elaborate the work of Weiner (1985), appraisal comes into clearer focus here as an antecedent to emotion. Pekrun (2006) notes that the appraisal of a situation by an individual leads to emotions. This makes it an important consideration for educational interventions intended to foster positive emotional development for

its potential to mediate the impact of situational factors. Here Pekrun (2006) breaks down appraisal into two dimensions:

1. Subjective Control over Achievement Activities: Expectations that persistence at study will lead to success.
2. Subjective Values of Activities and Outcomes: Perceived internal importance of success.

This implies that the appraisal of control and value are important for the instigation of achievement emotions. As a result, control and value are positive factors when one is in control of an action and outcome and the belief is that one's own actions will produce some positive outcomes or prevent / reduce negative outcomes. This can be further broken down into situational outcome expectancies and action outcome expectancies (Pekrun, 2006):

- Situational Outcome Expectancies: The situation itself will produce positive outcomes without the need for self-action or result in negative outcomes if no action is taken.
- Action Outcome Expectancies: One's own actions will produce some positive outcomes or prevent / reduce negative outcomes. This has a further aspect of action control where one believes that he or she is able to produce the action in the first place. If there is a perceived lack of action control, then the expectation would be that negative outcomes cannot be prevented.

When situational-outcome, action-control and action-outcome expectances are combined, the overall appraisal results in a total outcome expectancy. Aligned with this research, when a student engages in an activity, also known as an achievement situation, then effort is needed for this activity to result in a successful

outcome. As a result, situational-outcome expectancies should be low (as the student will have to do something for the activity to be completed) and action-control would have to be high for the student to engage as they have to have some feeling that they can do the task, likewise action-outcome should also be high in that they believe if they do engage in the task, they will be able to achieve a positive outcome. In contrast, if control is low or they lack belief that they can do the activity or task, this may lead to disengagement.

Furthermore, the concept of prospective and retrospective appraisal is also considered, where causal expectancies explore potential causes and their future effects (prospective) and causal attributions explore the potential causes of a given effect (retrospective). This highlights the emotional process of learning to be an ongoing one, where students enter a learning situation with prospective appraisal of themselves and as a result will have certain emotions in place based on their past experiences. Indeed Pekrun (2006) notes that the results of recurring activities (e.g. always performing poorly in programming activities) may mean appraisal need not be conscious or need to take place at all leading to habitualised achievement emotions. However, appraisal may take place again if the situation changes and the student feels that they are performing differently from their habitualised expectations, which is important when considering an intervention to reduce negative emotion (Zeidner, 1998).

2.5. Measures of Engagement and Emotions

The measure of emotions has been a consideration for researchers in the social and behavioural sciences for a very long time, with a dramatic increase in related research over the past two decades (Fredricks, 2015; Scherer, 2005). However, measuring emotions in a comprehensive and meaningful way has remained a

challenge (Scherer, 2005). A key issue touched on earlier in this review is the fact that engagement and emotions are often defined in differing ways among researchers (Fredricks et al., 2016). Part of the reason behind this is that research on engagement has grown out of a variety of different theoretical traditions with authors using motivational theories such as self-determination, self-regulation, flow, goal theory and expectancy value (Fredricks et al., 2016). The question of what emotion is, rarely results in the same answer from scientists and laymen alike. Indeed some just believe that emotions are what an individual say they are (Frijda et al., 1995). There is in fact much truth to this statement, as humans are often very aware of what they are feeling, as Ortony et al. (1990) points out, a person who is afraid, ordinarily knows that he/she is afraid and is also aware that their fear has been invoked by some sort of threat which can allow for individuals to accurately reflect on how they are feeling . To add to this, scholars also differ in whether engagement itself should be measured at the school level, classroom level, during moment to moment task engagement or over more long-term engagement (Fredricks, 2015). Indeed, all of these levels are potentially important and may help unlock different aspects of the puzzle that is student engagement. However, as we discussed earlier in this chapter, these factors may be more related to motivation to engage but not aspects of the measure of engagement itself.

2.5.1. Challenges in Measuring Emotional Engagement

Should we refine our lens even just to emotional engagement, we will find that there are far too many emotions to count, and the list and debate about which emotions should be measured continues (Fredricks, 2015; Frijda et al., 1995; Scherer, 2005). However, alignment in terms of engagement itself being multifaceted between behaviour, affective, cognitive and psychological has started to emerge. Furthermore,

self-reporting instruments have emerged as being a common measure of engagement especially in the dimensions of cognitive and affective emotion as these aspects of engagement are not directly observable and need to be inferred through behaviour (Fredricks, 2015). Likewise, in terms of emotional engagement, scholars have generally agreed that they can be split into at least two additional dimensions, those being positive and negative (Fredricks, 2015; Pekrun, 2016; Pekrun et al., 2002; Scherer, 2005). Scherer (2005) points out the ideal approach to truly measure emotions would be to measure the appraisal process, the response patterns in various nervous systems, the motivational changes produced by the appraisal results, the patterns of facial and vocal expression, body movements and the nature of the subjects experienced feelings, such an approach would be far too complex and invasive for most types of research where reliable results can be obtained by a self-report.

Also of note is that much of the earlier research had combined measures of all aspects of engagement into one scale, making it hard to disentangle each dimension while others focused more on just the behavioural element. This resulted in less research on the other specific dimensions (Fredricks, 2015). Indeed, increasingly research is finding that while there are multiple dimensions in engagement, each dimension seems to have impacts on different aspects of the student experience. For example, it was found that only behavioural engagement had an impact on school dropouts (Archambault, Janosz, Morizot, & Pagani, 2009). Likewise Manwaring et al. (2017) noted that different dimensions of engagement were influenced by different elements of a student's learning experience with self-efficacy, online activities, peer interaction activities, and active learning activities with lecturers having significant positive impacts on cognitive engagement, and student interest and initial interest,

feeling of choice, and content interactive activities having impacts on their emotional engagement.

Engagement by itself is a very broad term, with multiple dimensions, each of which have differing definitions and their own broad measures. Unsurprisingly, Fredricks (2015) points out that researchers are using the term engagement too broadly, and suggests that researchers need to be clearer about how they define engagement and at which level they are measuring it as well as the 'value add' that studying engagement would have. Fredricks (2015) also points out that beyond self-report instruments, multiple methods of assessment should be used, where possible, in measuring engagement (such as qualitative and quantitative methods).

2.5.2. Exploring Tools for Measuring Engagement

Perhaps not unexpectedly so, there are a large number of self-report instruments emerging that attempt to measure engagement, each measuring various aspects of engagement underpinned by varied definitions. Fredricks & McColskey (2012) explored these issues in some depth through a systemic review of the literature and some 1,314 citations to identify named instruments that measure student engagement resulting in a list of 156 different instruments. This list was whittled down through exclusion criteria which included (1) developed and used only with college age samples, (2) used only with special education populations, (3) measured constructs beyond engagement, (4) based on items from a larger national data set. Reliability and validity were also taken into consideration to ensure a suitable set of instruments were explored. The results can be seen in Table 2-3 below, with a further comment made here about the focus of the engagement dimensions being measured, those generally being either cognitive, emotional, or behavioural. For emotional engagement, further clarification is offered in terms of how the term 'emotional' was

interpreted by the instrument, which is often either perceptions of school, family, peers and teachers or emotional feelings relating to affective engagement.

Table 2-3 : Measures of Engagement, sampled from Fredricks & McCloskey (2012)

Name of Measure	Subscales	Engagement Focus
Attitudes Toward Mathematics Survey (ATM)	Self-Regulation (12 items) Deep cognitive strategy use (9 items) Shallow Cognitive Strategy use (5 items) Persistence (9 items)	A module level instrument that focuses on cognitive elements of engagement
Engagement vs Disaffection with Learning (EvsD)	Behavioural Engagement (5 items) Behavioural disaffection (5 items) Emotional Engagement (5 items) Emotional disaffection (7 items)	A program/institutional level tool that focuses on behavioural elements such as working hard, participation and listening. Also looks at emotional elements related to feeling good, interest, fun, enjoyment, boredom, anxiety, frustration, and anger
High School Survey of Student Engagement (HSSSE)	Cognitive/intellectual/academic engagement (65 items) Social/behavioural/participatory engagement (17 items) Emotional Engagement (39 items)	A program/institutional level instrument, looking at various dimensions of engagement. In terms of emotional engagement, the focus is more-so on feelings towards school, teachers, peers and class-based motivation and interaction.
Identification with School Questionnaires (ISQ)	Belongingness (9 items) Value of school (7 items)	A program/institutional level tool that touches on elements of emotional engagement related to feelings towards school and teachers.

Motivated Strategy of Learning Use Questionnaire (MSLQ)	Self-Regulation (9 items) Cognitive Strategy use (13 items)	A program/institutional level tool that explores items related to self-efficacy, motivation, test-based anxiety, cognitive strategy use and self-regulation.
Motivation and Engagement Scale (MES)	Self-Belief (4 items) Learning focus (4 items) Valuing School (4 items) Persistence (4 items) Study Management (4 items) Disengagement (4 items) Self-sabotage (4 items) Failure Avoidance (4 items) Anxiety (4 items) Uncertain Control (4 items)	Items grouped under themes from the motivation and engagement wheel. In terms of engagement, the focus is on persistence, planning and task management relating more to cognitive elements of engagement.
Research Assessment Package for Schools (RAPS)	Ongoing Engagement (5 items) Reaction to challenge (6 items)	A program/institutional level instrument which covered elements of cognitive, behavioural, and emotional elements explored. With emotional elements, the focus is on perceptions of school, self in school, teachers, peers and family.
School Engagement Measure (SEM)-MacArthur	Behavioural Engagement (5 items) Emotional Engagement (6 items) Cognitive Engagement (8 items)	A program/institutional level instrument which touches on behavioural, cognitive, and emotional engagement, with emotional engagement mainly focused on perceptions of school and self in school.

School Engagement Scale / Questionnaire (SEQ)	School Engagement Scale (4 items and 3 subareas)	A program/institutional level tool exploring students' perceptions of the school and their course.
School Success Profile (SSP)	School Engagement (3 items) Trouble Avoidance (11 items)	A program/institutional level tool, exploring perceptions of the school, their interactions with parents, peers, and teachers.
Student Engagement Instrument (SEI)	Affective Engagement: teacher-student relationship (9 items) Affective Engagement: Peer support for learning (6 items) Affective Engagement: Family support for learning (4 items) Cognitive engagement: control and relevance of schoolwork (9 items) Cognitive engagement: future aspirations and goals (5 items)	A program/institutional level tool exploring students' cognitive engagement and affective engagement in terms of their perceptions towards support in relation to family, peers, and teachers.

Another popular tool related to student engagement which was not mentioned in the above table is the national survey for student engagement (NSSE). This instrument focuses on Academic Challenge, Learning with Peers, Experiences with Faculty and Campus Environments (NSSE, 2015). Again, this is a course level tool attempting to judge students' engagement from a course level and taking the emotional engagement elements along the lines of perceptions towards school, peers, family and teachers.

The right most column in Table 2-3 has been explored in relation to Graham's (2004) definition of interventions which will be explored more later in this chapter. This see's an intervention as at either an activity level, a course/module level, a

program level or an institute level. As can be seen above, most of the tools available through Fredricks and McCloskey's (2012) review were operating at a program or institute level, whereas, for the instructor, the most useful information is to look at the impacts at either an activity or module level (Graham, 2004).

With this in mind, a suitable tool for measuring engagement at an activity level would take into consideration emotions that happen around that activity, in the classroom and, as part of the process, try to mitigate impacts for external factors outside of the classroom. While mitigating external impacts can be handled somewhat through the methodology using a control and treatment group approach, the tool to collect the data must be able to quickly collect information on student's emotional engagement before and after the session for each group. Likewise, this tool should take into consideration a range of emotions both positive and negative which students may feel while engaging with an activity.

2.5.3. When and What to Measure for Emotional Engagement

These requirements align nicely to the set of emotions and their definitions outlined by Pekrun (2006) in the Three-Dimensional Taxonomy of Achievement Emotions which was touched on earlier in this chapter. It breaks down emotions into a number of key areas from the more commonly explored positive and negative emotions that could be experienced in an academic setting, to activating and deactivating emotions which, beyond the more intuitive positive activating and negative deactivating emotions (in simple terms, good emotions which are good for engagement and bad emotions which are bad for engagement), may help explain how certain positive emotions may have negative impacts and how some negative emotions may have positive impacts in the long term.

These sets of emotions are called positive deactivating (relief, relaxation) and negative activating (anger, anxiety, shame). The set of emotions explored by Pekrun (2006, 2016) can be viewed from the perspective of outcome emotions as well, where emotions such as hope and anxiety are considered prospective emotions which happen prior to engaging in an activity, to retrospective emotions such as pride, shame, relief and disappointment which occur after an activity has been completed usually relating to the success or failure of that activity.

The last major consideration before delving into the intervention would be to consider how and when these emotions take place, what influences them and where they occur in the process of delivering learning content so as to construct the intervention in the best possible way. The work of Weiner (1985) and Pekrun (2006) and Pekrun et al. (2006) exposed some key areas around when emotions occur and what instigates them. Existing literature suggest that achievement emotions can be influenced at any point in the learning process.

Figure 2-2 highlights this well showing the linkage between antecedents, emotions, and effects. It also further highlights the importance of the design of learning and social environments to not only ensure the content is of high quality, but also establish value, support, and expectations in students prior to them engaging in the activities.

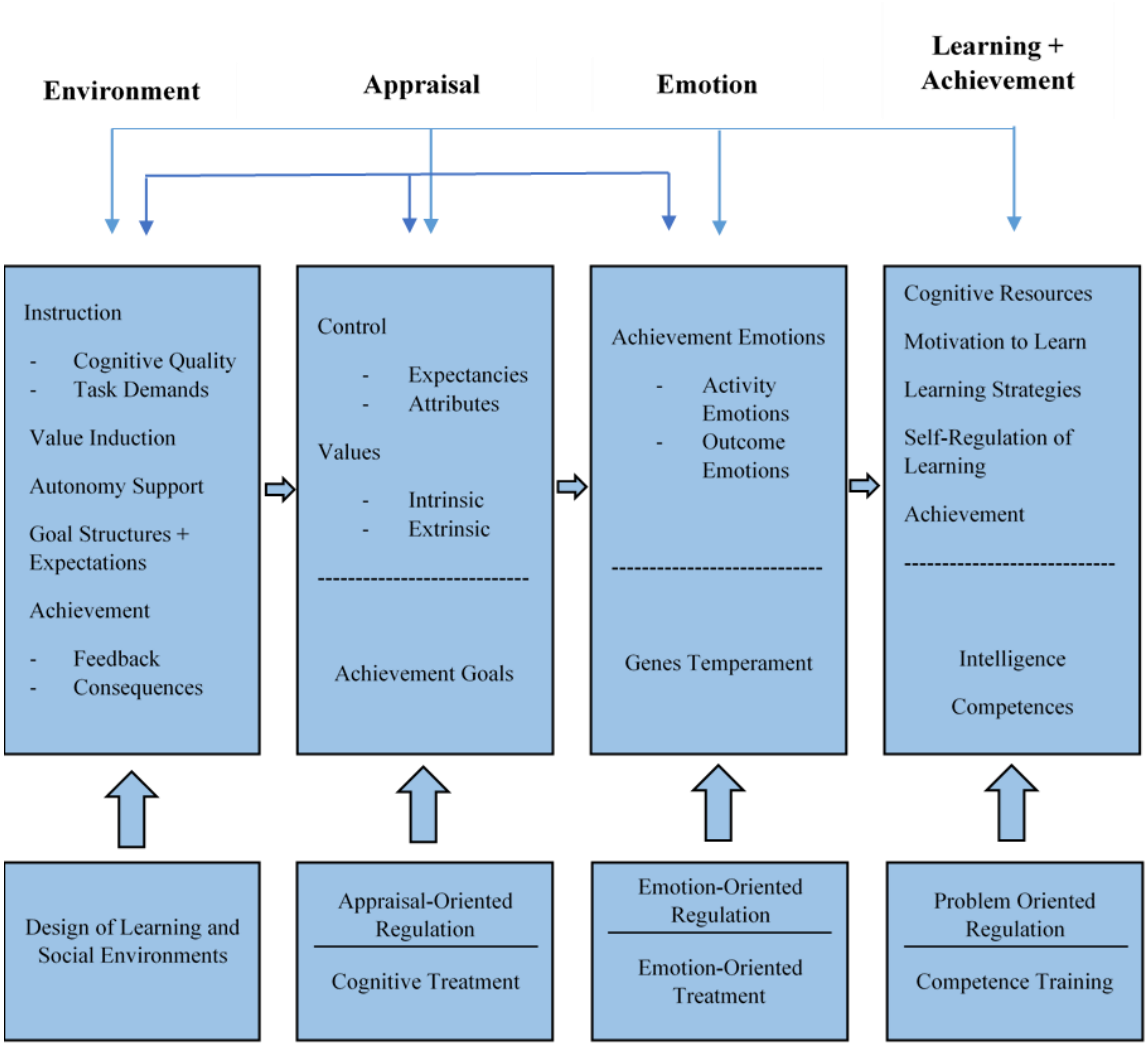

Figure 2-2 : The control-value theory of achievement emotions: Reciprocal linkages between antecedents, emotions, and effects (Pekrun, 2006).

This design can help them establish their appraisal of control and value which should influence their emotional state while they work on activities. This in turn may also have the potential to impact on their motivation to learn, learning strategies and overall achievement.

2.6. Conclusion

This chapter has unpacked the meaning of a number of key terms important to this research, while appreciating how they interact and how we can better differentiate them allowing us to focus on core facets important to this study. Engagement and

motivation have been addressed as complementary yet unique phenomenon, with motivation serving as an antecedent of engagement and engagement being the active and continued participation in an activity. Additionally, an appreciation for the natural complexity of engagement and the various aspects which make up engagement has been developed. This research accepts that engagement is made up of multiple dimensions such as emotional, behavioural, and cognitive as well as the individual dimensions being faceted in themselves. Indeed, the dimension of emotional engagement can be broken down into positive and negative emotions, further layered into activating and deactivating emotions as well as being activity and outcome focused. Furthermore, emotions have a number of characteristics with a particularly important one, being considered carefully in the design of this research, relating to an emotion being an instant reaction to an event which helps an individual determine their next course of action. In the case of this research, the event is academic in nature, a classroom activity intervention, and as such a tool is needed to quickly grasp the students' emotional state at the start and end of a session to explore the impacts that the intervention has had on their academic emotions.

Although the measure of emotions may be done through a number of methods, a suitable tool, agreed on by a number of authors in the literature presented in this chapter, is a self-reporting instrument. Even compared to more intrusive methods of gathering data on emotions, self-reporting instruments yield similar and reliable results. Given the nature of this research being a classroom intervention done in a natural classroom setting, such a non-intrusive and easy to administer instrument is ideal.

As with most educational research, the literature presented in this chapter also supported the idea of using a mixed methods approach or multiple methods of analysis

to really understand the phenomenon being explored. This approach ensures that we go beyond the quantitative answers appertaining to if a certain emotion has been altered by the intervention to being able to understand more clearly as to why this is the case through more qualitative measures.

The AEQ has also been identified as a suitable tool to measure academic emotions. Firstly, it measures academic emotions in the context in which this study wishes to explore them, which is related to emotions which happen inside the classroom and are malleable to intervention. Secondly, the tool has been designed to be customisable with individual items and scales showing similar levels of validity and it has been recommended to be adjusted to best suit the research being conducted. In the case of this research, to avoid disrupting the flow of natural classes, to ensure responses are considered and increase participant rate, a short form of the questions, specifically related to the emotional aspects of affective engagement, has been selected. Finally, the tool has been validated by the authors in a number of circumstances a number of times helping to support its claims of validity and addresses emotional engagement from all dimensions touched on above.

So, with academic emotional engagement defined and a potential measure in place, the focus must now turn to the intervention which will be discussed in the next chapter. Taking from insights gained in this chapter, consideration is made for what Pekrun et al. (2002) identified as their fifth guiding question to explore the topic of academic / achievement emotions, that being 'what can be done to foster positive academic emotions and to help students avoid negative emotions, or to cope with negative emotions in flexible ways once they emerge?' In addition, while deciding on and designing the intervention itself, Young's (2010) five principles of fostering engagement are continuously adhered to. To address these issues, the research moves

in the direction of technology-based interventions, specifically in the area of adaptive learning systems as a way to not only make content available to students as and when they want or need it, but also to allow for layered support and guidance tailored to the users' needs, be made available to them outside of what is already offered by the lecturer.

As a result, the following chapter explores blended learning technology, its uses, impacts and evolution. After which adaptive learning systems are unpacked and explored with a suitable system then selected for the remainder of the study.

Chapter 3

3. Blended Learning and Technology in the Classroom

3.1. Introduction

As technology becomes more and more pervasive in all aspects of the human experience, it is perhaps unsurprising that the use of technology has taken a key role in the landscape of modern classroom environments. For almost two decades, researchers have begun to explore the impact that the use of technology has on the student experience. As far back as the start of the century, Young, (2002) described the use of technology, as part of the educational process, as the single greatest unrecognized trend in higher education. A statement which was indeed not unfounded with a noted increase of computer-mediated instructional elements incorporated into traditional face-to-face learning experiences (Graham, 2004; Manwaring et al., 2017) and technology having been recognized as integrated into classroom teaching in meaningful and transformative ways not long after (Boling, 2008; Sawang, O'Connor, & Ali, 2017). As this study focuses on a technology-based intervention, technology enhanced learning is further explored to define how technology has an impact on students' learning, the role of the lecturer within technology based interventions and how both lecturer and technology can work together for a better student experience. As we further uncover the benefits of technology in learning and identify areas for improvement, the potential impact of an adaptive learning environment on engagement and more specifically emotional engagement emerges.

3.2. Defining Blended Learning

An area of specific interest to educators was whether or not technology could completely replace them with online only learning facilitated by Massive Open Online Courses (MOOCs) or would the role of the educator still be an important element of

student learning. As a result, a number of different pedagogical models have come under investigation and compared against each other, those being:

- Courses delivered online only with no face-to-face instructor interaction.
- Traditional approaches and tools such as textbooks and lectures.
- Approaches which blend technology and various forms of face-to-face interaction.

The pedagogical approach of using technology and face-to-face interaction in the classroom has led to the commonly used term of blended learning, which can be defined as the 'thoughtful integration of classroom face-to-face learning experiences with online learning experiences' (Garrison & Kanuka, 2004). Graham (2004) defined it in three potential ways, namely, combining instructional modalities, combining instructional methods and combining online and face-to-face instruction. Graham (2004) later noted that the first two definitions were too broad and could encompass just about all learning, finally concluding that the third definition of combining online and face-to-face instruction was more descriptive of this convergence of traditional face-to-face teaching with a blending of any modern-day technology, thus aligning closely to the previously mentioned definition by Garrison & Kanuka (2004). It should be noted that while online can serve as a platform to access technology and is commonly used to access MOOCs and Learning Management Systems (LMS), technology is not only available online and the use of virtual reality devices, microcomputers or other technologies in the classroom which can function offline as well as online or may only function offline, can also be considered as a blend of technology and face-to-face instruction, this aligns to a later definition by (Graham, 2009) stating blended learning as a combination of face-to-face instruction with technology-mediated-instruction.

3.2.1. Importance of Blended Learning

As with any intervention, it is important to understand why the intervention is important, how best to apply that intervention for maximum impact and then to explore this impact in terms of what effects the intervention has and if they are significant enough to justify the intervention in the first place.

Addressing the question of why blended learning is important, Graham (2004) explored both the impacts technology has in learning spaces as well as the reasons instructors adapted to blended learning as part of their own pedagogical practices. In learning spaces, it was noted that the impact technology has had on learning in distributed learning environments, such as communication technology leading to similar fidelity as face-to-face communications which also lead to facilitation of human interaction. At an even higher level, the learning space itself can be altered, moving it to a virtual space through virtual and augment reality systems. Technology has also become more widespread and available to all users making it an obvious consideration for educators. Graham (2004) also explored the reason why educators decided to adopt blended learning in their own practice and found six common reasons as listed below:

1. Pedagogical Practice: Seeing blended learning as the best of both words and leading to a more effective pedagogical practice.
2. Increased Access / Flexibility: Online platforms allowing for both distance learning which would otherwise be challenging and provides enhanced access for local student.
3. Social Interaction: Affordances offered by technology such as active forums and communication tools.

4. Personal Agency: Giving the learner control over how and when they engage with the content.
5. Cost Effectiveness: Blended learning provides the ability to reach large audience all over the globe in a very short period of time.
6. Ease of Revision: Changing, uploading, or revising resources on a learning management system instantly changes for all participants in the course.

However, it was reported that the three most important reasons shared by educators were, improving their pedagogical practice, increased access/flexibility and increased cost effectiveness (Graham, 2004).

With pedagogical reasons at the forefront of why blended learning has gained so much popularity, Laurillard (2002) notes that technology-based tools must be accompanied by appropriate pedagogy in order to be effective. Therefore how the technology is used and for what purpose will clearly have an impact on how effective it is (Burbules & Callister, 2001; Lavin, Korte, & Davies, 2011a). Indeed Graham (2004) supports this argument stating that the future is not about 'if' technology blends, but 'how' it blends, seeing it as not just the effective use of technology in the classroom, but the application of best practices for its use.

3.2.2. Application Levels of Blended Learning

The use of technology and blended learning can be explored from numerous different levels, for example, Graham (2004) notes that such interventions can be deployed at various levels within an institution:

- Activity Level: The learning activity itself contains a mix between face-to-face and computer mediated elements.

- Course/Module Level: The module has a blended learning strategy which ensures the combination of blended learning and computer mediated elements throughout the whole module lifecycle. This can either be blended across the module or have time elements dedicated to face-to-face and blended.
- Program Level: Where an entire degree program has blended learning as part of the pedagogical approach for that degree, potentially allowing students to choose a selection of modules in which they decide to complete as online or face to face.
- Institutional level: When the university determines a blended learning approach for all programs, this becomes a strategic direction for the whole university that determines their teaching ethos.

In terms of blended learning which is in the control of the instructor / learning designer, activity level and module level blended learning approaches are most common. This is what Graham (2009) refers to as the instructor stakeholders, with the program and institutional level aimed at the administrator stakeholders.

3.2.3. Impacts of Blended Learning Interventions

It would be difficult to assess however if a study includes appropriate pedagogical approaches without a more in-depth look into the design of the intervention and potentially the learning materials and activities, so while this is important and will be addressed in this study and indeed should receive appropriate attention in any study designing a teaching intervention, it will be assumed that the literature reviewed here has taken this important factor into consideration. With this in mind, the next step is to consider what impacts the use of technology has on student

learning, and which approaches have been found to have more positive implications between traditional, online only, and blended learning.

Perhaps one of the earliest interventions in terms of blended learning occurred with the introduction of learning management systems such as Blackboard or Moodle as an online source to access all learning materials related to a module. These systems complemented presentation technology such as Power-Point, meaning local students had better access to all learning material designed with a focus on module specifics without having to take hand-written notes or use textbooks. Learning management systems also opened up the option of distance learning (Graham, 2004) in modules that may have previously not considered it. Indeed the format of traditional textbook and lecture while appropriate for some students has been seen as suboptimal for others and has been considered a potential issue for student retention (Stockwell, Cennamo, & Jiang, 2015). With recognition of this and in light of the rapid emergence of learning technologies (Graham, 2004) alternative methodologies using technology were considered a potential solution (Reich, 2015; Stockwell et al., 2015).

In a study on learning approaches with and without the use of technology, Stockwell et al. (2015) explore a number of different potential approaches to teaching a class of science students taking an undergraduate biochemistry course at Columbia University. The study examined:

- Video versus textbook pre-class assignments.
- Instructor demonstrated problems versus students solving problems in class.

This resulted in students being randomized into four arms, 1) textbook preparation for lecturer driven activity, 2) video preparation for lecturer driven activity, 3) textbook preparation for problem solving in class or 4) video preparation

for problem solving in class. In terms of measures, the study looks at impacts on attendance, satisfaction, and performance. As attendance in the study was voluntary, students were able to leave the study at any time, however it was noticed that attendance was significantly higher for those students who received a video pre-class assignment versus a text-book pre-class assignment ($p=0.04$, Pearson's Chi-Squared Test), consistent with their hypothesis that video would be a more engaging way to present new and complex material to students and stimulate students to learn more about a topic by attending class. To further explore this hypothesis, students' satisfaction with preparation material was also measured, showing students who received video assignment material were significantly more satisfied with this material than students who received text-book assignment material ($p=0.0001$, Mann-Whitney test). Finally, in terms of performance, each arm mentioned previously showed a progressive increase, with arm 1 (textbook preparation for lecture driven activity) showing the lowest median exam scores (61/100) to arm 4 showing the highest median score (80/100).

These results showed that the most significant intervention was indeed a fully blended approach where students use technology (in this case video assignment) prior to class and engage in active learning and problem solving with the lecturer acting as a facilitator when they are in class. This also aligns with the pedagogical approach of 'flipped learning' or 'flipped classrooms' where the traditional classroom is 'flipped' and instruction is provided to students at home while active learning and problem solving takes place in the classroom rather than instruction being delivered in class and problem solving activities being given as part of a student's 'homework'. This has been a much-explored pedagogical approach (Mazur & Somers, 1999; Baker, 2000; Mori, 2018). While Stockwell et al. (2015), note a limitation of this study as

just being on one particular group of students on one particular course, other studies (Kaw, Besterfield, & Eison, 2005) have shown similar results in similar work where the effectiveness of four instructional modalities on a STEM course were compared, namely, 1) traditional lecture, 2) blended web enhanced lectures, 3) web-based self-study and 4) flipped (web-based self-study and classroom discussion). Interestingly, the second approach of blending technology as part of the learning process of a lecture was found to have the highest impact on student performance and satisfaction, which leads to some other very important questions, should we favour online only instruction or blended learning and what role should the lecturer play?

There is some consensus relating to the idea that the inclusion of face-to-face interactions between instructor and students are an important factor in blended learning and that makes it a more effective approach than that of online only courses. Roblyer (2004) points out that while many educators agree that technology enhances the classroom and enables learners to be more actively involved in their own learning, as well as improving engagement, satisfaction and performance, most still believe that technology alone does not replace the need for a structured, content-driven learning process grounded in theory. Waddoups & Howell (2002) share this reasoning stating that online only learning and distant education suffers from making large amounts of learning material available online for learners to engage with and absorb independently. This again highlights the importance of the educator as a facilitator of learning, as described by Graham (2004), blended learning is more teacher-directed (facilitated), includes person-to-person interaction in a live synchronous high fidelity environment, while distance learning is self-paced, requires self-motivation, is asynchronous and potentially lower fidelity. While an ideal learner would have ideal approaches to learning that involve learning with as much independence as required

by an online only course, this is very often not the case. This may shine a light on findings that online courses are often plagued with low completion rates leading researchers to believe that online only learning may not be the most effective strategy for teaching and learning (Reich, 2015; Stockwell et al., 2015). Indeed while exploring impacts on engagement for blended learning, Manwaring et al. (2017) found that cognitive engagement was impacted by face-to-face interactions. This evidence gives more weight to the statement by Moore (1980) that a student should not be given more autonomy in learning than they are capable of exercising. In this case it would seem that the structure, guidance and scaffolding provided by the educator ensures students stay on track with their learning. However, technology can be used to complement this learning path and enhance the overall experience (Stockwell et al., 2015) which further highlights the importance of blended learning as a more suitable pedagogical approach.

In terms of impact, much research on pedagogical interventions focuses on the impact on performance as an indicator of the impact of the intervention. However, while performance is an important outcome, it is also important to understand elements which may have been impacted to lead the students towards better learning and increased module performance. This brings us back to our consideration of motivation and engagement which was touched on by Stockwell et al. (2015) drawing on the assumption that video assignments were more engaging to students which allowed them to invest more energy into the videos as compared to the less preferred textbook assignments, which in turn motivated them to attend more classes (interest coming from engagement leading to motivation resulting in better attendance). However, in this study and many others, engagement itself was not measured. Indeed, Manwaring et al. (2017) points out that despite an increase in research related to

blended learning, very little empirical research has focused exclusively on students engagement in blended learning experiences (Halverson, Graham, Spring, Drysdale, & Henrie, 2014). In their study, Manwaring et al. (2017) investigated understanding of student engagement in blended learning through a longitudinal semester long blended learning course, specifically focused on emotional engagement and cognitive elements of engagement. The study investigated two specific research questions:

> "1. What impact do instructional design decisions, student characteristics, and student perceptions have on student emotional and cognitive engagement in blended learning classrooms? What is the impact of the modality of the instruction (online or face-to-face) on these influences?
>
> 2. How are emotional and cognitive engagement related longitudinally throughout a semester long blended learning class? Does higher emotional engagement at the beginning of the course proceed and lead to greater cognitive engagement later in the course?"

Their findings showed that while emotional and cognitive engagement are correlated, they were uniquely influenced by different aspects of individual students and classroom characteristics. In general, the finding showed that self-efficacy, online activities, peer interaction activities, and active learning activities with lecturers, all had significant positive impacts on cognitive engagement, while students' interests and initial interest, choice, and interactive activities all had impacts on emotional engagement. An important link here between cognitive and emotional engagement was self-efficacy which inspired interest, with self-efficacy impacting cognitive engagement and interest inspiring emotional engagement. Furthermore, interest has been found to impact enjoyment which is a key factor for emotional engagement

(Pekrun, 2006). It was also found in this study that a high grade point average (GPA) negatively impacted cognitive engagement, and computer-self-efficacy had a negative impact on emotional engagement.

Although not fully explored in the study, these findings do offer interesting insights into the nature of learners. In terms of GPA, it may link to the research earlier explore by Karasek (1979) and Young (2010) that found appropriately challenging tasks with high control were more engaging to a learner, meaning that those with a high GPA may have lacked challenge related to the learning content, and as such were not experiencing the 'good' stress of a difficult activity. This would align with the findings in the study (Manwaring et al., 2017) which showed that the second most important factor to a student in terms of enhancing their emotional engagement, was their perception of an activity as being important to them, and additionally the feeling of 'choice' was also a factor that impacted emotional engagement. Likewise, computer-self-efficacy having an impact on emotional engagement could have been as a result of a lack of novelty in using a technology that students were already familiar with, as Lavin et al. (2011) found, that just the use of Power-Point alone without significant changes to content showed an increase in students' perceptions of the organisation of the classroom, communication and lecturer interaction. However, in a more modern setting this technology will no longer have this novel effect. In this regard, and aligned with suggestions throughout the literature (Burbules & Callister, 2001; Laurillard, 2002; Lavin et al., 2011b), technology alone may have an initial impact, but as it becomes more common place, such as the use of learning management systems and Power-Point, it is not 'if' technology is used that will engage students, but 'how' it is used (Lavin et al., 2011b).

Related to this point, it is worth noting that the design of the learning material was not explored in much depth in the study. Also, the range of emotions explored, while taking some reference from the work of Pekrun (2006) and Pekrun & Linnenbrink-Garcia (2012), was somewhat limited. These were potentially due to the instrument attempting to collect numerous aspects of the student experience (cognitive, emotional, self-efficacy, subject interest and computer self-efficacy) in a very condensed tool set.

However, the conclusion of the study raised some interesting points in relation to the findings. Firstly, aligned with other research in this area, pointing out the importance of appropriate pedagogy, instructional design in terms of how content and technology is used and merged and the application of best practices (Burbules & Callister, 2001; Graham, 2004; Laurillard, 2002; Lavin et al., 2011), Manwaring et al. (2017) found that the pedagogical decisions an educator makes appears to have a stronger impact on students' engagement than the individual characteristics of the learner or location of the learning activity. This emphasises the need for a structured instructor led approach to guide the students along their learning path. Further, it was recommended that future research should explore additional techniques that can be used to enhance students' perception of control, value, interest and that flexibility in instructional activities that facilitate choice and autonomy as well as interactions with peers and instructors should be considered (Manwaring et al., 2017)

3.2.4. How Blended Learning Occurs

This leads to a deeper question of how should blending occur. Graham (2009) address this by presenting three categories of blends, namely, enabling, enhancing and transforming blends:

- Enabling Blends: The core focus here is on access and convenience using information and communication technologies to provide equivalent learning experiences to a face-to-face approach.
- Enhancing Blends: This style of blending often includes supplemental online resources or online activities, allowing for incremental changes to the pedagogy.
- Transforming Blends: Allow for more significant pedagogical changes that facilitates active learning and construction of knowledge.

In simple terms, this model moves from the most basic usage of technology which does not have major implications to the learning experience or pedagogical design, to a much more involved use of technology which has the potential to transform the learning experience and has been carefully designed to ensure that technology is embedded as part of the learning process. Graham (2009) notes that while Enabling Blends are part of an introductory level to technology in the classroom, it is hoped that Enhancing Blends are the first step to Transforming Blends, alluding to the fact that the expected ideal form of blending is when technology is carefully embedded into the design of learning content to enhance the overall learning experience.

This perspective of layering technology usage from least impactful to most impactful from a pedagogical design perspective is shared by (Puentedura, 2006) where the terms transformation and enhancement are used as broader categories which are divided into smaller subcategories. The principle is the same, with enhancements offering an initial layer of technology usage and transformation being the ultimate goal to true blended learning. The subcategories of substitution and augmentation are

housed under enhancement, with modification and redefinition housed under transformation.

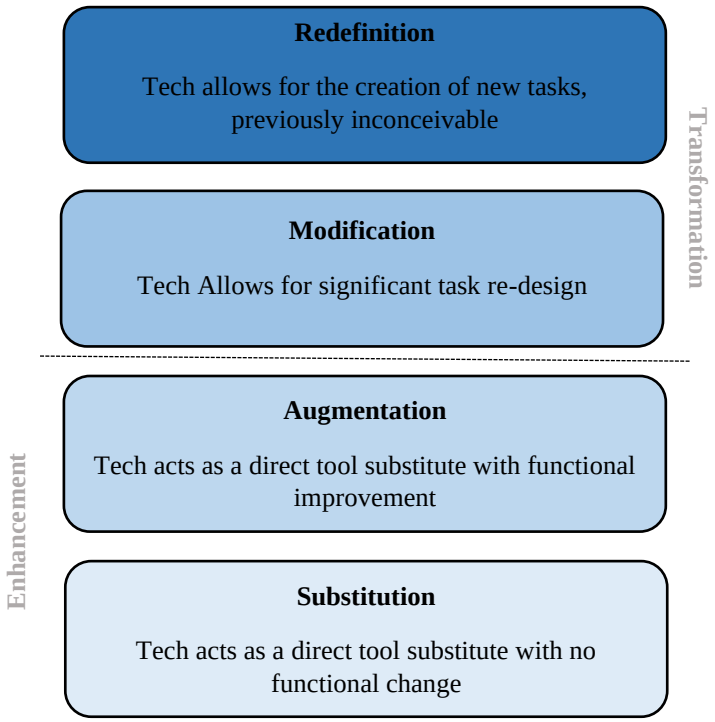

Figure 3-1 : The SMAR model, Puentedura (2006)

Puentedura (2006) uses the example of a typewriter used for writing reports to highlight the differences between these various layers of technology usage. At the substitution level, a technology equivalent to the typewriter is used, this being a word processor, but features of the word processor are not really used to enhance productivity. At the augmentation level, basic functions such as spell checker and cut and paste functions are used to optimise the process. While it enhances the process and takes some advantage of the technological affordances, the nature of the task will not have improved significantly. At the modification level complementing technology could be used such as using Excel, a Microsoft Office application, to store important and relevant data that can be quickly modified and updated between reports, fed into report templates, and potentially the use of e-mail to allow for the document to be quickly distributed. Finally at the redefinition level, consideration is given for the existence of the report in the first place, the structure of the task is brought into

question in terms of its objectives. For example, if it is simply there to share information, alternative approaches to sharing information such as working groups or content management software may be more effective solutions and remove the need for a report completely as well as allowing for live, up-to-date information to be constantly available and shared.

3.2.5. Summary

This section explored various potential impacts of technology in learning environments. Starting with the level in which the technology intervention takes place, it was found that the most advantageous exploration of an intervention for an educator would most probably be at the activity or module level, as this is where intended impacts, directly on learners within a class, could be explored. In terms of the technology, it has been found that technology can enhance motivation, engagement, and performance for a number of reasons, but drilling down into activity specifics, to truly enhance engagement, and considering principles behind engaged learning, students should have choice, challenge and a variety of learning material available to them based on their needs. Considering this and the various layering of technology usage in classrooms (Puentedura, 2006), such an intervention would have to happen at the modification layer at the very least, allowing for a significant task redesign to allow the content to shape itself to be most suitable for individual learners. This is aligned with this study in relation to the use of an adaptive learning environment which can understand the user and adapt the content to them either making it more challenging for high performing students or providing more nuanced instruction through additional explanations, images or even video for those who are struggling. As we have previously explored the importance of emotional engagement, initial interest, suitable challenge, choice, interesting content, and interactive activities

were all noted to have an impact on this aspect of engagement. Leaning on these elements, it is hoped that the ability of the adaptive learning environment to shape tasks and give students choice over how and when they interact with tasks as well as allowing them to adjust the difficulty to their needs, giving them a sense of achievement in self completed tasks, would help promote emotional engagement even further. As a result, the following section provides an overview of adaptive learning environments and their potential to impact learning experiences in the areas explored in this section.

3.3. Adaptive Learning Environments

The use of general electronic learning systems have received increasing attention in recent times for their ability to personalize learning environments in response to students' learning needs (Park, Joo, Cornillie, van der Maas, & Van den Noortgate, 2019). From a technological standpoint, learners are best supported when they are engaged in active, meaningful exercises via technology tools that provide cognitive support (Schmid et al., 2014). Ottenbreit-Leftwich et al (2012) noted that many educators find technology to be an important professional competency and highlighted that the appropriate use of technology by educators can have positive academic benefits which indeed aligns with much of the literature on technology enhanced learning and blending learning as previously explored. In these examples, the general use of technology was the main focus, potentially using existing virtual learning environments (VLE) or MOOCs in a more effective way to benefit the learners. Such systems are a one size fits all approach to learning where all users are given the same content and it is up to them as to how they engage with it. While this does give learners more control over their learning and promotes autonomy, these

technologies alone do not facilitate choice or control and generally go no further than offering easily accessible material in a structured manner.

Adaptive learning environments go a step further by attempting to understand the learner as they interact with the system and adapt to their needs. Such adaptive learning environments can take the learner's individual characteristics into account such as their background information and knowledge level (Park et al., 2019). In many ways this guides the learner through the use of the content that is available, allowing for content to be tailored to the user's needs in a more meaningful way as they interact with the environment and as such making more or less content available depending on their interests or ability to progress through the activities provided. For adaption like this to happen at an individual level, a model of the learner is required, known as the user model. With information gathered from the learner through their interaction with content, a user model can develop that allows additional content to be tailored to the needs of each individual user. This content exists in the domain model, and an adaption model selects content based on methods or rules which decide which learning object is presented to a learner and when (Karampiperis & Sampson, 2009).

While there is a growing body of research on the outcomes that result from adaptive educational environments, investigations are still currently in their early stages (Dziuban, Moskal, Johnson, & Evans, 2017). This section will outline the general structure of adaptive educational environments, explore a potential system for use in this research and outline the impacts such systems may have in alignment with this study.

3.3.1. User Model

The user model allows for content to be delivered to the learner that is suitable for them based on their own personal abilities, represented by attributes and values within the system (Tadlaoui, Chikh, & Bouamrane, 2013). The user model is a vital component in understanding the learner and their learning needs so must be kept up-to-date at all times with information such as user knowledge, interests, preferences, goals and objectives, action history, type, style and other relevant useful properties for adaptation (De Bra et al, 2010).

Peña-Ayala et al (2012) describes the user model as a mental representation of several sorts of attributes about a given learner which may reveal properties of the individual and qualify personal traits. De Bra et al (2013) highlighted the need for a rich representation of the learner as one of the main issues in an adaptive learning environment.

Kobsa (1993) and more recently Martins et al (2008) explored two different techniques for implementing the user model, namely, Knowledge Based and Behavioural based. The knowledge-based approach gathers data about learners through questionnaires, whereas the behavioural approach gathers data through the monitoring of users during their activities.

User models usually consist of two types of properties, those being domain dependent and domain independent. In this case, domain refers to a learning domain such a programming, therefore domain independent properties usually consist of items such as name, password and identity but some models can include user groups and preferences. Domain-dependent properties have properties such as entities and objects

or concepts which are linked to the domain being addressed by the adaptive tool. (De Bra et al, 2010)

There are many aspects related to understanding a learner that have been identified through research, each with potential to play an important role in the learning experience, engagement and learners motivation to learn. Elements such as emotion, or affective state, knowledge models, tutorial situation, overlay model, perturbation model and stereotyping have been explored and found to have impacts on the overall understanding of the learner and their integration with adaptive learning environments. (Hernández et al., 2013; Ortony et al., 1990; McCrae & John, 1992). Other areas such as prediction of learner's domain knowledge (Peña-Ayala, 2013) and using data mining (Holzhüter, et al, 2013) to form links between learners and tasks have also shown promising results.

3.3.2. Domain Model

Content should be delivered and tailored to individual learner needs (Hamada et al, 2013). The domain model describes how the conceptual representation of the application domain is structured (De Bra et al, 2010). Relationships between concepts and how they are connected to content presentation are defined through the use of such a model. A concept is considered to be an abstract information item in the application domain within a hierarchy of other concepts and sub-concepts with descriptors of how they all fit together (De Bra et al, 2010). Such relationships between concepts represented by the domain model structure can be found in most adaptive learning systems. There are also links between the user model and the domain model mapping user's domain specific characteristics into the domain knowledge space (De Bra et al, 2010).

3.3.3. Adaption Model

Adaption takes place in the form of content, presentation of content and navigation through content based on the user's level of knowledge, goals, objectives among others (De Bra et al, 2010). The main goal of the adaption model is to interpret how concept relationships from the domain model direct users through concepts and content suitable to their individual needs.

The adaption model is often made up of rules via one of two approaches, direct definition or semi-automated approaches, where rules are either; created by expert users, or selected automatically by the system respectively (Karampiperis & Sampson, 2009). Direct definition can suffer inconsistency problems due to two or more rules conflicting, or insufficiency issues due to a lack of appropriately defined rules for a given situation (Wu & De Bra, 2001). Such issues can be addressed using adaption patterns and semi-automated decision based mechanisms, but this can lead to machine-learning problems. (Karampiperis & Sampson, 2009). Adaption models can also follow the forward reasoning or backward reasoning approaches. The former relates to an event leading to a conditional action that may update the user model and be immediately available when needed, while the latter refers to trying to deduce user model values from events that have happened through lower-level stored information about the user (De Bra et al, 2010). Information calculated forward often relates to user knowledge updates when selecting content while information calculated backward can be related to the system choosing which content to present to the user based on its suitability for that individual.

3.3.4. Grapple

De Bra et al. (2013) remarked that attempting to create a truly personalized learning experience using all of the most recently established adaptive methods and

techniques would be a near-impossible task. As such, any adaptive learning environment being created should have modularity and extensibility at its core allowing it to evolve to the needs of the system within the context where it has been deployed.

GRAPPLE is an example of such an adaptive learning environment that addresses all the key components of an adaptive system as discussed above. It is an adaptive learning environment that provides support for the learning process together with adaptive guidance and personalized learning material. It is composed of a cluster of five key components, namely, the learning management system, the user modelling framework, an authoring tool, an adaptive learning environment and a visualization tool (LMS, GUMF, GAT, GALE and GVIZ respectively) which communicate via an event bus (De Bra et al., 2013).

The adaptive functionality in grapple is delivered through GRAPPLE Adaptive Learning Environment (GALE) which is usable as a stand-alone learning management system or within the larger GRAPPLE framework. (De Bra et al, 2010). GALE comes with predefined presentation and adaption templates allowing for easy adaptation to an existing curriculum and allowing authors to create their own look and feel for their applications. To ensure the fastest response time and greater performance, GALE has all the information needed to perform adaption readily available. In the larger GRAPPLE framework, most adaption can still take place in GALE but also in other parts of the greater framework via communication on the GRAPPLE Event Bus (De Bra et al., 2013).

GALE contains a user model with domain dependent and domain independent variables capable of communicating with GUMF should that component be in place.

It has a domain model to form a set of relationships between concepts. A mostly unrestrictive adaption model is also present which allows for both backward and forward reasoning and works through events to update a user model, providing a means for updates to the user model to adapt hypermedia for individual users requirements (De Bra et al., 2013).

As such, GALE forms a common core for most of the other components of the GRAPPLE framework, where components can easily be added as and when they are required. This is due to the fact that GALE was built with modularity in mind (De Bra et al, 2010). As such GALE can be used as it is, in a standalone form, enhanced through modules as part of the greater GRAPPLE framework or extended through the use of Java working natively on Tomcat Apache.

3.3.5. Impact and Use of Adaptive Tools

With the key components of adaptive learning environments explored and an example of such a system defined, attention is now turned to the potential impacts the use of such a system may have in students' learning. VanLehn (2011) did an exploration of the effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems within education. The study explored the 2 sigma problem (Bloom, 1984) which suggests when compared to no tutoring, answer-based tutoring, intelligent tutoring systems, and human tutoring had an effect size of d=0.31, d=1.0, d=2.0 respectively. In reference to adult human tutors the comparison was made on one-to-one tutoring by an adult subject matter specialist, this being seen as one of the most effective method of instruction. VanLehn (2011) identified nine potential hypotheses as to why human tutoring should yield the expected effect sizes. However, through the research, it was deduced that only two of the hypotheses held any ground, namely, the abilities for a human tutor to provide timely feedback when and how the

learner needs, and the ability to provide scaffolding such as guided prompting to push the learner along the correct line of thinking rather than providing them with a direct answer.

However, the study, which was based on a review of existing literature in the field, found the effect size of human one to one tutoring to be much lower: d=0.79 and the effect size for intelligent tutoring systems to be nearly as effective as human tutoring: d=0.76. Although an intelligent tutoring system could provide some level of feedback and scaffolding, it was assumed that a human tutor could do this to a higher level. This study found that decreases in granularity yielded higher effectiveness (d=0.31 to 0.75 based on answer-based to step-based techniques in computer-based tutors). However, an interaction plateau was also identified, where further prompting and interaction would result in a negligible increase in effectiveness. This perhaps points to the idea that an adaptive learning environment can provide enough feedback and scaffolding for a learner to learn effectively and that with the additional support a human tutor might be able to provide, the end benefits based on this interaction plateau would be negligible. It was also found that the results of Bloom's (1984) 2 sigma problem may have reflected more on the effectiveness of a learning approach called mastery learning than on a clear comparison between computer-based tutoring and human tutoring.

Somewhat lacking from this study however was motivation and engagement, which were deemed as 'complicated' and although identified in the nine hypothesis, were not really explored as potential benefits of a human tutor. VanLehn (2011) did note in conclusion that human tutors may have impacts on learners' motivation, engagement, and efficiency, but this could not be deduced from this study. The activities, on most of the papers reviewed, replaced human tutoring in a single area

only, in most cases on homework assignments, and did not deploy the tutoring systems in classroom environments. While the human tutor may indeed be able to contribute towards higher motivation and engagement, it could also be argued that in terms of competence, autonomy and relatedness (Deci & Ryan, 1985), the adaptive learning environment could enhance autonomy through tailored tasks based on user ability, in turn giving them a higher sense of competence and self-efficacy, which are all areas which could enhance engagement for the learner.

De Bra et al (2013) believes adaptive learning environments are mostly intended for individual self-paced learners, perhaps leading to the suggestion that such systems replacing the tutor is not the best course of action. Similarly, Moores (1980) stated that too much autonomy for a learner who has yet to acquire the required knowledge to exercise it may result in adverse effects on engagement and further justify the need for a tutor to complement any technology based intervention. This idea is further supported by Stockwell et al. (2015) as they believe the structure, guidance and scaffolding provided by the instructor ensures students stay on track with their learning, and that technology should be more of a complement to the overall learning experience. De Bra et al (2013) aligns with this idea stating that such systems may be useful as study material or as an accompaniment to regular courses with lecturers and labs. Martins et al (2008) defines it well, identifying that the role of the tutor is to guide learners all of whom learn in different ways, something which could likely be assisted by an adaptive learning environment through tailored content for individual learners and supported by the tutor.

Aligned with the previous section, it would seem that the potential for adaptive systems to provide scaffolding, support, choice and various forms of content is clearly apparent, and aligns with the objective of this study which is to explore the impacts

that adaptive learning systems may have on students' academic emotional engagement within a classroom environment where the lecturer is part of the learning environment.

3.4. Conclusion

The literature reviewed in the preceding two chapters relate to engagement, motivation, and emotions as well as blended learning and technology in the classroom, respectively, completes the first two objectives of this study, and begins to address the third. Thus**, objective one** of this study, which was to conduct an extensive literature review to define the problem and to focus on academic emotional engagement, adaptive learning environments and creating engaging learning content, was achieved by differentiated motivation from engagement, exploring emotions and emotional engagement and understanding the influence emotional engagement can have on other facets of engagement, as well as the potential for emotional engagement to be enhanced through technology based interventions, more specifically using adaptive learning environments. Furthermore, through our exploration of emotional engagement, approaches to foster academic emotional engagement have been identified which may inform the content design and adaptive course structure to ensure the quality of content created enhances the overall impact of the intervention.

Subsequently, objective two has been completed with an exploration of various tools used to measure engagement, extracting elements used to measure emotional engagement and the key focus areas for these measures, and finally deciding on a suitable tool to measure engagement in the context of a classroom intervention targeting the impacts of an activity based intervention on student's emotional engagement.

Finally, **objective three** is addressed with an initial outline of adaptive learning environments as part of this review, but the reasoning for selecting a specific system is outlined in the next chapter.

Chapter 4

4. Deployment of Adaptive Learning Environment and Adaptive Content Development

4.1. Introduction

The tool chosen for the adaptive learning environment for this study was Grapple which was discussed in the literature review chapter. The key requirements for the choice of this system were strictly based on the requirements of the study. The system had to be quick in terms of setting up, flexible enough to adapt to an existing curriculum and open source to allow for modifications to the existing framework where the requirements of this study were beyond what Grapple had to offer and were more specific to this particular application. It was also important that it was easy to access, usable, and integrated seamlessly with any LMS which in the case of this study was Blackboard. The adaptive learning environment selected is used as a proof of concept related to the research question and not an evaluation on the effectiveness of this particular tool. Grapple meets all of the key requirements of an adaptive learning environment and as such is deemed suitable for this study. The selection of this tool after an initial review of adaptive learning environments through the literature helps us complete **objective three** of this study which was identified in chapter one.

As discussed in the previous chapter, Grapple comes equipped with an authoring tool and adaptive learning environment. The authoring tool known as GAT which stands for Grapple Authoring Tool, allows the users to form both a domain model and a course model for the course that they intend to deliver while GALE which stands for Grapple Adaptive Learning Environment comes with predefined presentation and adaption templates which not only allows for an existing curriculum to be easily mapped onto existing templates, but gives a clear overview of the setup

required to get adaptive content on the adaptive learning environment for students to interact with.

Behind the scenes, GALE also contains a user model which has domain independent and dependent variables to store key information about each user and to ensure content is specifically targeted to the users based on their interactions with the system and its content. The domain and course models, which are editable through GAT, are stored within GALE and are used to show available concepts, link content through adaptive logic and organise how and when content is delivered to an individual based on the user model and course model logic.

This research required Grapple on two levels, a learning content level, and an activity level. In terms of the first level and the interaction with learning content, GALE and GAT were well suited to allow for adaptive learning content to be delivered to the students through adapting hyperlinks for individual user requirements with links being made available or not depending on users completing pre-requisite sections.

A further addition to this, which was achieved through scripting inside the framework, was to create adaptive content, so the language used to describe a concept and the details in which a concept was described would be dependent on what the student had already read.

Finally, the study required not only the adaption of content through hyperlinks and the structure of the content itself, but also the adaption of worksheets which was not natively a part of Grapple. To achieve this requirement, an additional variable was added to the user model which tracked the students' current level of progression in their adaptive worksheets. The worksheets use a similar approach in terms of the

content in that the structure of content and its wording would change depending on what students had read in the main content section. In addition, students could reflect on their own learning and comfort level in doing a task with the worksheet adapting accordingly to either increase or decrease the challenge and add or removing additional scaffolding to align to the student's own abilities.

This section will go into more detail on the use of GALE to create the adaptive course which was used in the study and detail the scripting for modifications required to have more adaptive content in the course section of the system and adaptive worksheets for the laboratory activities that were conducted.

4.2. Adaptive Learning Environment Setup

As a course on GALE is a servlet and GALE is accessed from the outside as any other web server (Mazzetti et al., 2010), the main technology required was a server running the various software required to run GALE and GAT. In the case of this study, the server selected was a Windows 12 R2 server with the following specifications:

Table 4-1 : Server Specifications for running GALE

Package:	Windows 100
Processor:	Dual Core Xeon 2.4Ghz
Memory:	4GB EEC Memory
Storage Drive(s):	1 x 500GB SATA Hard Drive

For the adaptive learning environment to operate correctly the following software was required to be installed on the server. The list of software requirements (Table 4-2) was deemed most compatible with the current version of Grapple in use

and was not necessarily the most up to date version of the software at the time of implementation.

Table 4-2 : GALE Installation Software Requirements

Software	Source
JDK 6	https://www.oracle.com/java/
Maven 2	https://maven.apache.org/
Tomcat 6	http://tomcat.apache.org/
MySQL 5.1	https://www.mysql.com/

Once all software is installed on the server, a MySQL databased is required to be setup, which is achieved by going into the MySQL command line, and typing '**CREATE DATABASE galedb;**'. With the database created, all paths for the application should be established which in the case of this study was achieved by adding all commands to a batch file (Figure 4-1) to allow the path setup to be done quickly on whichever computer the adaptive learning environment was being deployed on.

```
set "PACKAGE_HOME=C:\gale"
rem java
set "JAVA_HOME=%PACKAGE_HOME%\jdk"
set "path=%JAVA_HOME%\bin;%PATH%"
rem tomcat
set "CATALINA_HOME=%PACKAGE_HOME%\tomcat"
set "path=%CATALINA_HOME%\bin;%PATH%"
rem maven
set "MAVEN2_HOME=%PACKAGE_HOME%\maven"
set "path=%MAVEN2_HOME%\bin;%PATH%"
rem mysql
set "MYSQL_HOME=%PACKAGE_HOME%\mysql"
set "path=%MYSQL_HOME%\bin;%PATH%"
```

Figure 4-1 : Sample batch file for establishing paths required to run GALE

At this point the start-up batch file supplied with GALE can be run from the tomcat/bin directory and the server starts up with a template course available and access to GALE and GAT to start developing an adaptive course on.

4.3. Developing the Domain Model

The domain model allows us to map out the concepts for the module that will be delivered through the adaptive learning environment. In this case, the module to be taught is a first-year programming module which covers the fundamentals of programming with concepts such as variables, loops, conditional statements and basic data structures up as far as the basics of object-oriented programming, covering concepts such as objects, inheritance, and polymorphism.

To ensure that the content was appropriate and adaptable for any programming course of this nature, both the domain and course models were designed, in a mostly generic way, to allow them to be applied easily and with minimal changes to other programming modules. This ensured that the models themselves could easily map to any version of a programming module in just about any programming language of choice. As can be seen in Figure 4-2, each node in a domain model represents a concept to be taught.

Each node is linked by it's conceptual relationships to other nodes in the model. At this point, we are not concerned so much about the flow of content which would be handled in more depth by the course model, but more on the conceptual connections of concepts and their groupings.

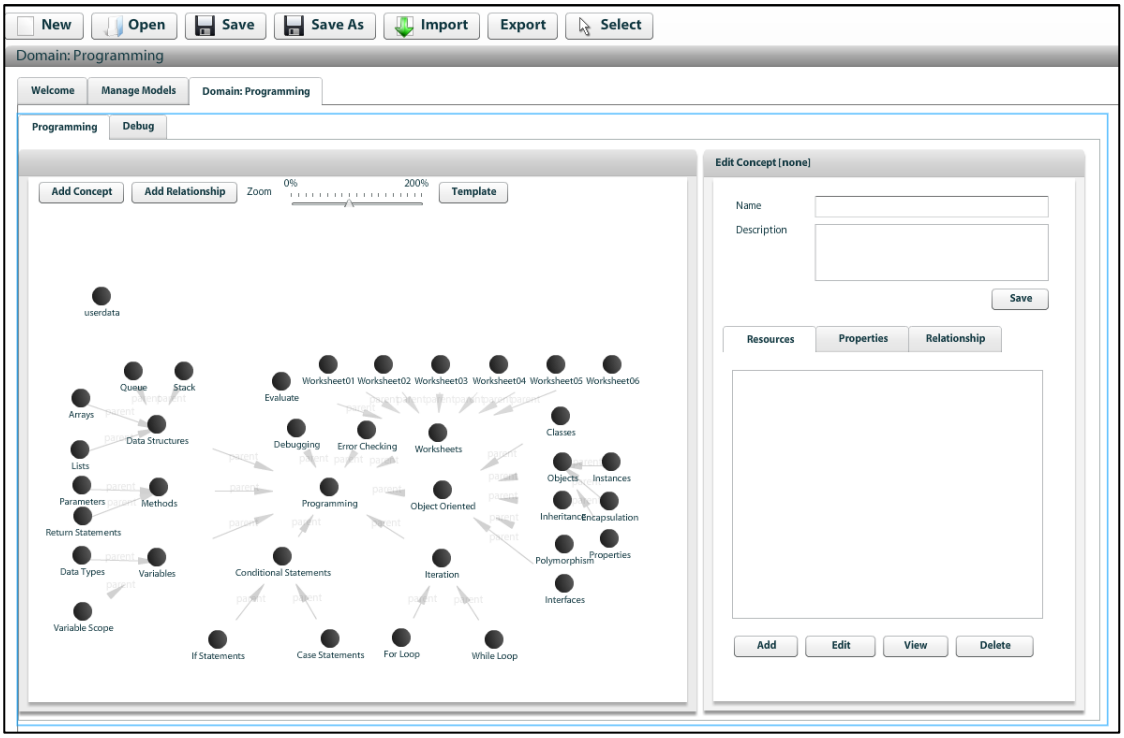

Figure 4-2 : Domain Model for Introduction to Programming Module

In this study, you can see the base level ‘programming’ concept which is what the course is about, is linked to core child concepts such as variables, conditional statements, iteration, methods, data structures, object-oriented programming and so on. From here, each of these core concepts will have their own sub concepts which form another layer of nodes which will help give a fuller understanding of their parent concept.

Each node in the domain model has a number of tabs available, also visible in Figure 4-2 : Domain Model for Introduction to Programming Module, which can be used to link both content and relationships to the concept. For example, if we were to select the ‘methods’ concept, inside the properties tab we have links to the title, any images we wish to use that are specific to this concept and a html file linked to this concept which would be the course content created to overview this concept. We can also define the next logical concept to connect to from the current concept and the order in which each concept would appear in the menu hierarchy.

Figure 4-3 : Adding Resources, Properties and Relationships to Concept Nodes

The relationship tab allows us to form connections to other concepts from the one we are creating to form the aforementioned parent/child relationship between all concepts. In the case of the 'methods' example that we have been using, 'methods' would have a parent concept of 'programming' as 'methods' were categorised in this module as the same concept as 'functions' and as a result they would both have two child concepts, those being 'parameters' and 'return statements' with 'methods' being a further extension of 'functions' as they exist within classes in the domain of object-oriented programming. These established parent/child relationships also help GALE to form a navigation sidebar for the adaptive course using the same hierarchy level with 'Programming' being the topmost concept, with a link to a html document that overviews the course and links on the sidebar to all linked child concepts. In the case of this study, the landing page for the programming course also gives students updates

on the amount of progress that they have made with the available course material on the adaptive learning environment as can be seen in Figure 4-3.

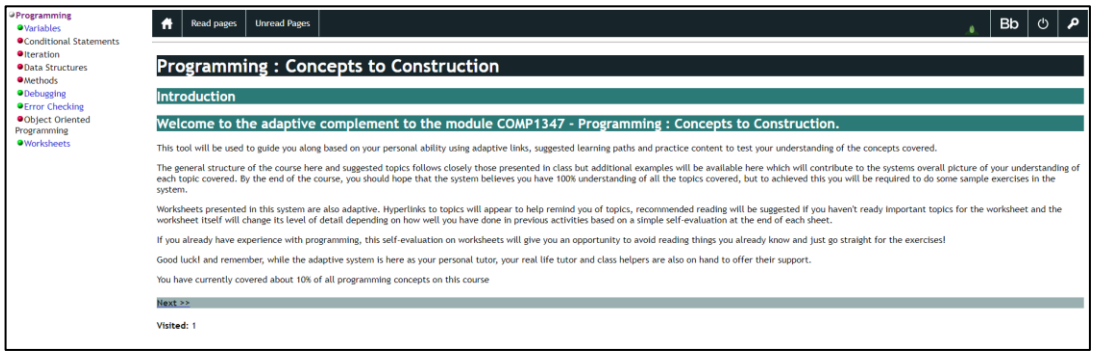

Figure 4-4 : Sidebar generated through the domain model and displayed through the course model

In terms of the adaptive links in the sidebar, an example can be seen in Figure 4-4 where ‘variables’ are considered a child concept of programming, with ‘variables’ having two sub concepts, data types and variable scope which are made visible when the user clicks on ‘variables’ from the sidebar. As can be seen in Figure 4-5 below, the links for programming and variables have changed colour to a shade of purple showing that these links have already been visited, and the sub concepts for variables have green bullets with blue text to show that they have yet to be read and are recommended for students’ reading at this point.

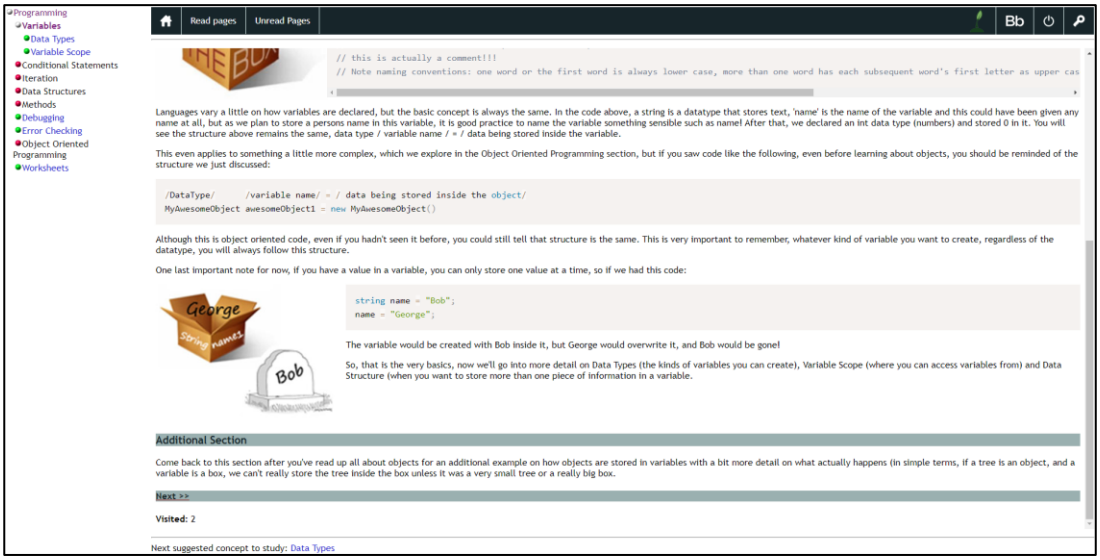

Figure 4-5: Recommended links displayed in the sidebar

Conditional statements however still have red bullets and darker text to show that these concepts are not recommended for reading. This is because the user would be expected to understand data types and variable scope before reading up on conditional statements which are impacted by both data types and variable scope as well as a fundamental understanding of variables.

In Figure 4-5, we can see an additional section has been flagged but has yet to be unlocked. This section will deal with talking about how variables can not only store basic data like text and numbers, but also store references to objects. Obviously, for a student who is just getting started with programming, this would be a tricky concept to understand as the concepts of classes and objects have not yet been covered, so the system notes that additional content will be available once the student has covered the introduction concept to object-oriented programming. From the object-oriented section, the student will also be linked back to the section on variables to read about storing object references in variables. This will be covered in more detail below as we discuss the course model and scripting adaptivity in course content.

In the above domain model, it should also be noted that the worksheets concept is not linked to any of the programming concepts. This is to ensure that this node is available at all times and not hidden from view. Ensuring the availability of worksheets was designed in this manner so that students would always be able to access worksheets regardless of their interactions with the content in the learning system. However, like the example above where certain information is unlocked only if students have read that content, the worksheets also have additional text and hyperlinks that will appear if students have not read certain pages within the course. This is to redirect them to useful content while they work on their worksheet, pointing out that there is available targeted information on the current worksheet that they are

working on and encourage them to go back and read more of the content should they get stuck while working on the activity. This aligns with the idea of just-in-time learning where the pace and place for learning is put in the hands of the learner as and when they need it (Riel, 2000). In the context of this study, the worksheet activities put students in a situation where they are required to solve a prescribed problem with minimal instruction and with only some face-to-face content delivery that happened during the lecture prior to the commencement of the lab session. When the problem presented gives a student the need for a piece of available knowledge, students are made aware of what they needed to know to solve the problem and this in turn motivates them to want to learn the content that will allow them to successfully master the problem at hand. As a result, when the problem highlights the need for knowledge that the student may not have, the suggested hyperlinks and additional text offered by the adaptive learning environment will guide them to acquire the additional knowledge needed at a time where it is needed and is relevant to what they are doing.

4.4. Developing the Course Model

The next phase of development once the domain model has been decided on is the course model which attempts to logically link concepts to an overall course structure. This helps us do the initial determination of which concepts will be available in the overall course design and when those concepts will be available based on the user model and their interactions with other concepts. This was briefly touched on when discussing the domain model above in relation to the domain model forming a hierarchy for GALE to use as a navigation sidebar for learning concepts. The Course Model decides how these concepts are presented, linked, and locked according to a set of rules.

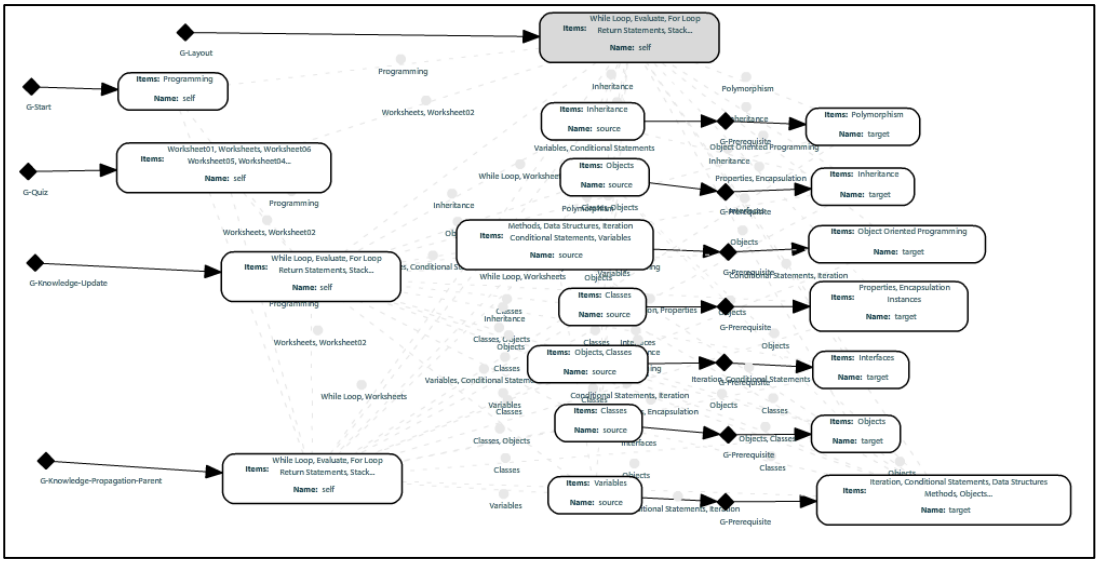

Figure 4-6 : Course model for introduction to programming module

Figure 4-6 does not have to be fully understood to get to grips with what the course model is all about, so a few key concepts will be discussed here to give the general picture. To begin, we look at the most obvious node which is the G-Start node, which is just the starting point of this particular course. This node links to the programming concept from the domain model as the root concept for the remainder of the course content. G-Quiz is linked to the worksheets, and while G-Quiz does not exactly fit the design of the worksheets as required by this study, it does have some relevant variables that could be used to track the user's progress and adapt the sheets accordingly.

G-Knowledge Update and G-Knowledge-Propagate-Parent generally work together, with concepts being recorded and updated as the user selects them to record that a concept has been covered, to a set of sub-concepts being able to propagate to the parent's completion score so that the parent concept will only be considered completed if the child concepts contributing to that completion score are also complete. As with our concept example earlier which discussed methods as an example, where the concept for methods required the user to read content both on

parameters and a return statement, these sub concepts must be completed before the parent methods is considered complete.

This covers the left side of Figure 4-6, which relates more to the basic setup. On the right side are a list of concepts with their pre-requisites. As we can see, object-oriented programming has quite a large number of pre-requisites, which implies that to get started learning about object-oriented programming, it would be wise to know about many of the fundamental programming concepts first to support a better understanding of this concept. However, to support what the literature has said on students being in control of their own learning, even though these concepts would be highlighted with red bullets and darker text to suggest that they are not recommended, if the student really wants to read up on that concept before completing the pre-requisites, they are still able to do so. This is again seen as an opportunity for just-in-time learning, where the concept will now adapt to have links to important pre-requisite content. In such instances where the student is struggling to understand certain aspects of object-oriented programming, they can always click on an adaptive link within this non-recommended content which would bring them back to some of the other fundamental concepts which are recommended based on their current knowledge level as understood by their user model.

As a result, the domain model and the course model both work together to format how things are displayed in GALE when the students log into the system. The domain model decides on all the concepts that will be covered and how they are connected through a hierarchy. The course model applies rules to those connections to decide when and how to show content and the user models keeps track of how the user has interacted with the content and allows links to be updated accordingly. Even the side bar is formatted and positioned according to a specification in the g-layout

node in the course model which connects to all the available pages. This is also where easy customisation of content for the page design can be done by clicking directly on the g-node and editing code for the node's layout structure.

4.5. Adaptive Page Content

As an addition to adaptive hyperlinks provided by GAT and GALE as part of the Grapple framework, and to ensure adaptive content was truly supporting the students in both ensuring that they only read information which was suited to their level of knowledge and pitching problems at a level which students were comfortable with while allowing students to maintain control of their learning, further features of adaptive content on pages and adaptive levels of scaffolding in worksheets were added to the adaptive learning environment.

Adaptive content refers to additional information being made available or hidden, or in simple terms, content being adapted within the course based on information stored in the user model, to ensure the most appropriate information for that particular user is displayed. A simple example of this in action (Figure 4-7) refers back to the example made earlier where a user is reading about variables, however as they have not yet looked at the section on object-oriented programming not all the information about variables is available to them at this time. In this case, information about storing object references in variables may be somewhat confusing to them. As a result, when they first read this page on variables, an 'additional section' is highlighted at the bottom of the content, informing them of the additional learning that will be available to them once they have covered the section on object-oriented programming.

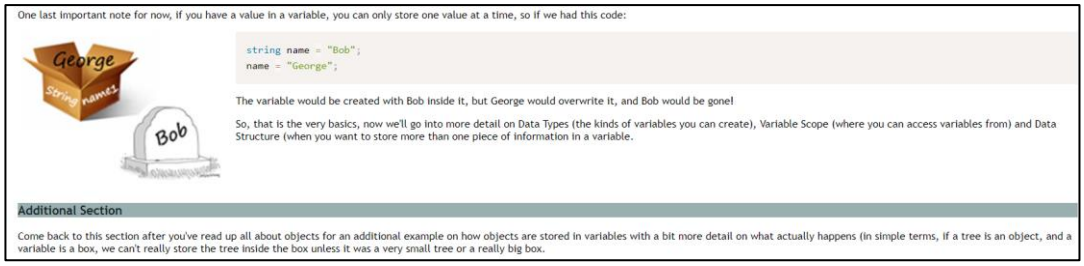

Figure 4-7 : Adaptive page content prior to completed pre-requisites

When the section on object-oriented programming is being explored by the student, the content will link them back to the page on variables to inform them of how object references can be stored in variables which can be seen in Figure 4-8.

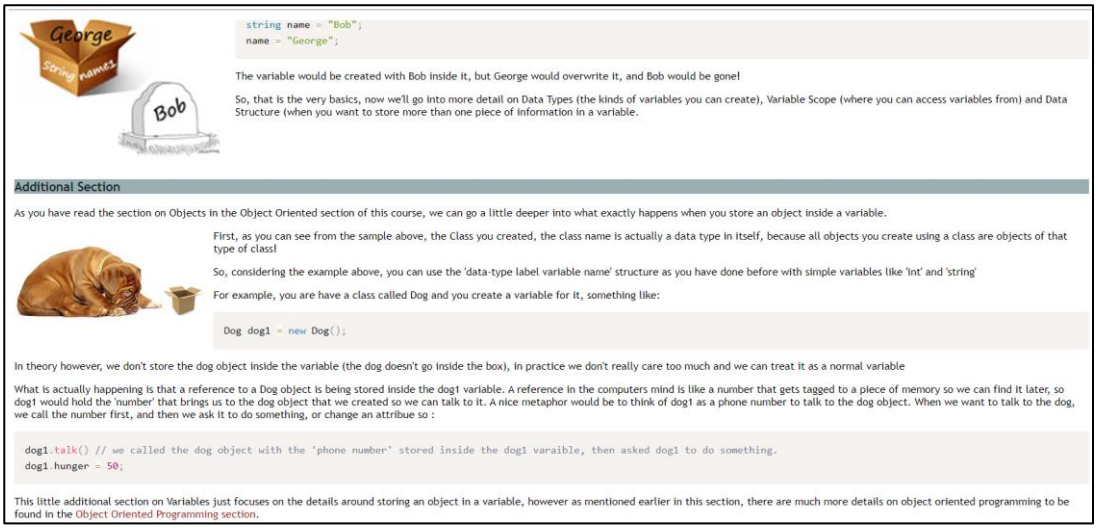

Figure 4-8 : Adaptive page content after completing pre-requisites

This additional content links them back to previously explored knowledge about variables, gives them a basic introduction to storing object references in variables and redirects them to the section on object-oriented programming to gain more knowledge on this topic. If a student wants to revisit this content or cannot remember how to store a reference to an object in a variable, they can either find the information just by going to the section on variables, or through the section on object-oriented programming.

In a similar capacity, such adaptive text can also offer users a warning if they are venturing into a page without having covered some of the pre-requisites such as trying to understand typecasting without a firm understanding of types or visiting the page on object-oriented programming before covering the basic programming concepts. Such adaptive text can be achieved using some of the scripting available in GALE, with most of the main content text being achieved through standard HTML.

The structure of these pages were designed to include a template file which set up the headers and sections for the page to be displayed and acting as the landing point for a concept from the domain model, and a text file which is displayed by the template file and contains most of the body of the learning content for a concept. GALE script can be used through the template file, allowing for access to variables from the user model to be accessed and conditional blocks to be added or removed depending on the values from those variables. For example, to allow for adaptive text to be displayed in the variable example outlined above, we would have to check on the status of the 'objects concept' to ensure a basic understanding of objects had been gained before progressing to storing references to objects. This refers to the knowledge variable of 'objects' and as such allow us to form a condition in our template file as can be seen in Figure 4-9.

```
        <gale:if expr="${gale://gale.tue.nl/cam/Programming/Objects#knowledge}
&lt; 100">

        <gale:block>

<p>Come back to this section after you've read up all about objects for an additional example on how objects are stored in variables with a bit more detail on what actually happens (in simple terms, if a tree is an object, and a variable is a box, we can't really store the tree inside the box unless it was a very small tree or a really big box.</p>

        </gale:block>

        </gale:if>
```

Figure 4-9 : Sample script for adaptive knowledge content

Here we are checking to see if the knowledge variable from the concept 'Objects' is less than complete (100%) in which case we would display the initial text to inform the user that a few more concepts needed to be understood before revisiting this section. The following condition for this code will check if the knowledge variable for the concept 'objects' is less than 100%, meaning complete, in which case the new content, relating to storing object references in variables, can be displayed.

More complex conditions can be added such as ensuring a number of sections have been completed before unlocking content using nested conditional statements or ensuring a certain level of knowledge has been gained before trying to address a new piece of knowledge using varied percentages. All of these allow not only links but also content to be adapted and targeted to the users' needs and keep them from delving into material that they do not have the pre-requisites to understand which can be intimidating to a learner.

4.6. Adaptive Levels in Worksheets

Adapting the worksheets required script that would take into consideration a number of factors, namely, from how the student has interacted with the learning content available in the adaptive environment to their self-reflection on their progress within any given worksheet. While the goal of the worksheet for each student was to remain the same, the scaffolding provided for the student, based on their individual needs, would be different for each worksheet, either giving them more direction to content that would support them or adapting how information on each part of the worksheet was presented to the student based on their own individual progress. As GALE did not naturally support this kind of process through existing editors or course nodes, internal GALE scripting mechanisms were used to implement this functionality.

The objective for adaption in the worksheets was to allow the worksheet to adapt on two levels, the first level was to use the same approach as the adaptive content, where data could be pulled from the user model to see if students had covered various content and adapt content and links in the worksheet according to what content they had or had not covered. If a student had not read a specific content that would be useful to the worksheet that they were trying to complete, this content was highlighted and hyperlinked as recommended so that in the event that they face a difficulty, they would be able to quickly access the targeted content for this specific activity. The second level was to change how the worksheet was presented to the student depending on how well they were doing. A decision was made not to include some form of test for the student on the worksheet as such testing can lead to test anxiety and a decrease in academic performance (Cassady & Johnson, 2002). Instead, for the system to simulate a natural interaction with the tutor, students would simply self-reflect and

either ‘ask for help’ by clicking on an evaluate button where they could choose two options ‘I’m struggling a little’ or ‘I’m finding this easy’. With the initial level of the content pitched at an average level for all students, a student reflecting that they were struggling would result in the content expanding, at the first level below the default average level, by including more text-based descriptions of the problem at hand. At an even lower level, the content would include images as visual descriptions of the problem and at the lowest level, instructional videos were made available to students, supporting them with key concepts required to solve the problem. This support emulated the same kind of support the lecturer would give to students who raised their hand in class to ask for help. However, to take advantage of the technology intervention, the students’ self-reflections were recorded in a newly created variable in the adaptive learning environment called ‘level’. This keeps track of the level each student was performing at in their worksheets, something which would be more challenging for a lecturer to keep track of in a large class. The recorded level would then help the adaptive worksheets decide what information was being presented to the student and allow subsequent worksheets to be pitched at the same level as the previous worksheets. This level would only change when the student reflected on their progress to state that they were struggling more or struggling less. Subsequently, the worksheet would adapt again to be more suitable to their current level of progress. As a result, the adaptive content on the worksheet would be selected based on two criteria, namely, on how much the student has read through the existing content available in the system, and how well they feel they are doing on each worksheet.

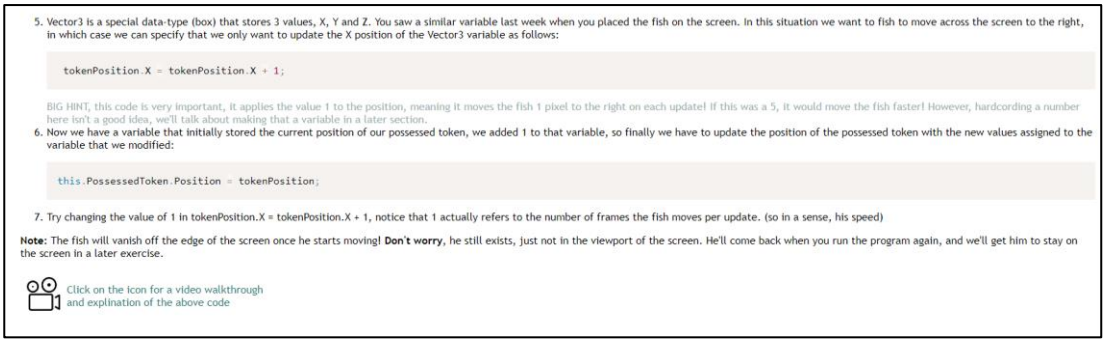

Figure 4-10 : Adaptive worksheet with 3 layers of adaptive content

Figure 4-10 is a brief sample of what this might look like at a lower level. The text for each level was also colour coded so students could track their progress and understand where additional support was being provided. The colour coding was as follows:

- Black Text: Standard instruction aimed at the mid-level students and the default level of a worksheet. This is exactly the same text students would find in a static worksheet with no adaption.
- Shades of Green Text: From the darkest shade being the lower levels of additional support to the lighter shades being the higher levels of additional support.
- Red Text: This would be at the highest level, with red text showing additional tasks or higher-level challenges for students who are performing above the expectations of the worksheet.

In Figure 4-10, there is also a video link which only show up when students are really struggling. This would be the equivalent of a tutor working through an example of the code with the student. To ensure appropriate scaffolding, only partial solutions were provided in the videos to get students on the right track. Students were still expected to work through the remainder of the problem and come up with a completed solution on their own. After this layer of support, if students continued to

struggle, then this would be the time for the lecturer to step in and give that additional support required.

As briefly mentioned previously, the above difficulty layered content was achieved by adding a new variable to the user model which was tagged as ‘level’. This level variable would shift across a scale from zero to a hundred (0 to 100), which in theory would allow the addition of as many levels of scaffolding as the lecturer wished to add, at least up to one hundred (100) levels. However, for this study and in the interest of time, the scale moved 25 units each time the user selected one of the self-evaluation options mentioned above. This scale was also selected based on the expertise of the lecturer and the layers of support the lecturer experienced providing to individual students when facilitating learning on this module. This resulted in five potential levels of scaffolding:

1. **Level 100:** For students who are exceeding the expectations of the module and may want to engage in advanced tasks to keep them interested and motivated.
2. **Level 75:** For students who are just above the average level for the class, and this would usually reduce the amount of instruction given with just an objective for the students to meet.
3. **Level 50:** This was the average level for the class, and the default entry point, acting as a very similar worksheet to the static worksheet that was traditionally used in this class.
4. **Level 25:** Lower than average, resulting in the addition of further instructions on items that students often find challenging.
5. **Level 0:** The lowest level, where students may get image or video support to further expand on challenging concepts, providing more explanation

and a detailed walkthrough on more of the foundation concepts required to complete the activity.

From here, a similar approach could be used to adapting content in the adaptive learning environment where the scale would determine what level of support and content would be displayed, using CSS and DIV elements to customise the content based on the level it was being pitched at. Figure 4-11 is a brief example of how this script looked like with access to the new 'level' variable in the user model:

```
<gale:if expr="${Worksheets#level}.intValue() &lt; 50">
<gale:block>
 <div id="moderate">
  <li> To make things a little easier, here is the code, but don't forget to include the 'using'
       statement above however do try first to form this code from the above instructions
to
       help you practice writing code from instructions rather than looking for code to
copy:
  <p> <pre><code class="language-csharp">
      namespace FishORama
      {
          class BlueFishToken:X2DToken
          {
             public BlueFishToken(String pTokenName, AquariumToken pAquarium)
             : base(pTokenName)
             {

             }
             protected override void DefaultProperties()
             {

             }
         }
      }</code></pre></p>
```

Figure 4-11 : Sample scripts for adaptive worksheet content based on evaluation level

4.7. Conclusion

Although there would be an initial increase in work for the lecturer while creating the adaptive content, the additional layers of support given by the adaptive learning environment are tuned to emulate the support the lecturer themselves would give. As a result, it is expected to be suitable for students at all levels to allow them to progress without having to ask the lecturer for help. Subsequently, the support the lecturer gives in the classroom is expected to be much more targeted to more contextual questions that are very specific or unique as it is expected that more common issues faced by students have been adequately addressed by the adaptive system. In the case of students who are more advanced and require minimal support, a common interaction with a lecturer for these students is to ask for more challenging tasks. This is also easily addressed by the adaptive learning environment, allowing them to evaluate their progress through the system which in turn results in them receiving more advanced tasks, keeping them engaged without requiring lecturer intervention.

This section addresses **objectives three and four** indicated in chapter one by deciding on the selection of a suitable adaptive learning environment for our intervention and providing an overview of the design, development and deployment of the adaptive course, adaptive learning content and adaptive worksheets which lean on the concepts for fostering academic engagement as defined through the literature review in the previous chapter.

Chapter 5

5. Conceptual Framework

5.1. Introduction

This chapter will outline the conceptual framework informed by the literature which will underpin the remainder of the study and help support and build the methodological plan (Grant and Osanloo, 2014). As the study deploys an adaptive learning environment with adaptive course content inside a standard classroom setting to explore impacts on academic emotional engagement, the conceptual framework aims to inform a number of key areas to ensure an appropriate foundation for each element of the study. This will subsequently help develop the research and inform the rest of its design (Grant and Osanloo, 2014).

5.2. Approach and Framework for Measuring Academic Emotional Engagement

As discussed in terms of existing literature in chapters two and three, the importance of engagement and engaged learners have been identified as key factors in potentially enhancing students' learning. The notion of enhancing student learning has also gone beyond just grades and performance to the type of learning that happens in the classroom and where improvement to that learning may start. While there was some evidence presented in the literature that emotionally engaged learners show signs of deep learning, and performance improvement, this study aims to focus on how students' emotional engagement itself can be enhanced. We see this as an important measure of students learning and potentially a precursor to other forms of engagement with the possibility of enhancing overall learning which may inspire the application of deep learning approaches and improve overall performance. As this study takes place in a classroom environment as a snapshot of students' emotional

engagement both with and without the use of an adaptive learning environment, it sees the measure of emotional engagement, in comparison with a control group, as a suitable measure within the timespan given. In consideration for measuring learning approaches and performance gains, these were not explored, as to do justice to the analysis of such factors, a longitudinal study would be more suitable to explore the effects over time. Likewise, based on this principle, the 'in the moment' nature of this study sees negative emotions as a non-desirable factor, as further exploration of the potential longer-term benefits of some negative emotions, such as anger leading a learner to try harder in the future or relief resulting in a learner reducing their effort, would also require longitudinal treatment.

This research is to be conducted in a classroom environment, with minimal disruption to the process of the student's natural academic routine. However, to collect more accurate data on the emotional state of the students during the class, data collection must take place as soon as possible before and after the events of the class itself. This aligns with the literature pertaining to instantaneous nature of emotions. As such, to capture the occurrence of emotions, students must be asked to reflect on their feelings as close as possible to the timing of the event which triggered them. Aligned with this, research has noted that longer questionnaires can result in data being less accurate as a result of trail off in terms of answers (just answering for the sake of getting the questionnaire done) and drop-off (not answering at all due to the questionnaire taking too much time) (Kost & Correa da Rosa, 2018; Allen, 2016). This becomes a very important consideration for this research given the limited number of participants and the time-constraints in terms of fitting the data collection into moments just before and just after the selected session(s) without disrupting the flow of the class or students' transition between modules.

To address the abovementioned issues, the questionnaire was kept as short as possible, using a short form of the Academic Emotion Questionnaire (Pekrun et al., 2002), ensuring all key academic emotions were explored using pre-validated questions to ensure appropriate validity. As well as this, elements which impact engagement were also explored considering the principles of fostering student engagement (Young, 2010) and the Demand, Control, Support Model (Karasek, 1979), which allows for the exploration of aspects of the students' experience related to control, challenge, enjoyment, motivation, support, comfort and the ability to make individual progress.

With student's affective state at the core of this research, the affective emotions are central to the exploration of engagement. As noted in the literature, emotions have been found to be linked closely to goals and goal attainment, triggered by events which are of concerns to the learner experiencing them and such emotions relating to achievement are expected to manifest frequently and quite intensively in academic situations. As also noted in the literature, many studies use a 'touch and go' approach with emotions and engagement, potentially trying to address too much with a limited number of questions. As a result, this study specifically targets affective emotional engagement as one of the potential forms of engagement that could be enhanced by the intervention proposed. The intervention is also expected to impact many of the aspects of the classroom experience which can subsequently impact a student's affective state. Should the study result in indications of positive impacts on their affective state, this could lead to further research on other aspects of emotional engagement as well as other facets of engagement such as the exploration of cognitive and behavioural elements.

5.3. Mixed Methods Approach

As emotions are complex and difficult to measure and understand, this study uses an explanatory mixed methods approach, collecting not only quantitative data but also qualitative data through semi-structured interviews. Both qualitative and quantitative empirical methods are being used in this research as a recommended way to help fully understand the phenomenon of interest (Shah and Corley, 2006). The semi-structured interviews follow the same theoretical underpinnings as the questionnaires, with questions and interview informed by the work of Pekrun et al. (2002), Karasek (1979), Young (2010). The qualitative nature of the semi-structured interviews also allowed for rich data to be obtained with a more explorative nature. It allows for a more in-depth understanding of where various emotions were materialising from and the longer-term impact the adaptive learning environment was having on the students' learning experience.

5.4. Framework for Content Design Approach

Finally, the development of content has been informed by the literature to ensure that the content itself is designed to engage the learners and provide a positive experience. As noted in the review, simply adding technology to the classroom does not make learning content good, the content itself must adhere to a solid instructional design (Manwaring et al, 2017) with the aim of the technology intervention to somehow enhance the learning and in turn enhance engagement. For this study, the learning content has been designed both in its static form without the adaptive learning environment (Microsoft Word based worksheets), and in its adaptive form through the adaptive learning environment to ensure quality, challenge, support, and inspire initial interest in the students, aligned with Young's (2010) five principles of fostering academic engagement. The learning content both with and without adaption has

exactly the same learning objectives and outcomes and covers the same topics with the only difference being the varied layers of guidance and support as well as the nature of contextual details being provided by the adaptive learning environment according to the needs of individual students. While all content is available in some format to all learners, being those with or without adaptive content, the adaptive system adds a layer of individualised and tailored content specifically for an individual learner as and when they need it rather than having to explore the lecture slides, notes or find further answers from classmates or online, addressing a point made by Hamada, et al (2013) that content should be delivered and tailored to the individual needs of the learner.

5.3. Conclusion

This chapter has outlined the conceptual framework for this study as informed by the literature. In doing so it has further justified the need to explore emotional engagement as a measure in itself, without having to also explore other aspects such as approaches to learning and performance which may be better observed in a longitudinal study. The study promotes authenticity of data being collected by setting itself in a natural environment for the participants rather than in a purely experimental setting, and as close to the trigger of emotions as possible, to ensure students' report their emotional state accurately

Using the academic emotion questionnaire and measures of demand, control and support, the study aims to measure key aspects of the classroom experience that may influence students' emotional state and be influenced by the adaptive learning environment. Furthermore, this section suggests an approach of using the principles of fostering academic engagement to ensure even before considering the main intervention, the content for all students is designed well with engagement in mind.

Chapter 6

6. Methodological Design

6.1. Participants

The participants for this study were comprised of first year students as part of a computing course at the University of Worcester who were taking first year programming modules. The majority of participants were male between the ages of 18-22 years old, with a very small number of female students taking the course. As there were so few female participants, the exact number of male to female participants has not been disclosed to protect their identity. As this research follows an education design research approach, the participants were chosen from existing class groups which resulted in usable participant data from a total of 60 individual participants, 30 from an experimental group and 30 from a control group. To minimise disruption to participants, data collection took place over just one session after which all students were given access to the adaptive learning environment to ensure all students had fair access to a tool which they may find potentially beneficial. During the session when data was collected, students had access to the same learning resources but in different formats. For the control group, all of the information and content were available on the learning management system and through interaction with the lecturer whereas for the treatment group, content was delivered based on individual needs through adaption in the adaptive learning environment. Participants generally varied in their technical ability but were assumed to have at least a basic understand of computing. Participation in the study was completely voluntary and had no impact on the natural flow of classroom activities, on students learning experience or on their assignments or grades.

6.2. Study Design

As the research design of this study follows an educational design research approach which determines that context matters (Collins, Joseph, & Bielaczyc, 2004), it is conducted in a real word classroom environment to ensure a complete picture is formed by observing variables in their naturalistic setting (McKenney & Reeves, 2014). The three main phases of educational design research are defined as:

1. Problem identification and needs analysis
2. Design development and implementation
3. Evaluation

Having explored phase one and two in the preceding chapters relating to tutor experience and expertise in the domain area, a review of existing literature and the development and deployment of the adaptive system, the evaluation part of the research will be the focus of this section. Through a discussion of the evaluation phase, it will allow for a better understanding of the intervention. An explanatory sequential mixed methods approach has been deployed to satisfy the evaluation component of this research design, allowing for quantitative data to be collected before and after lessons for the control and treatment groups and qualitative data to be collected at the end of the module to help further understand the quantitative findings.

To align with the iterative nature of an educational design research study, but having to be mindful of time constraints, and to ensure that the system and data collection tools met the requirements of the study, a small pilot study was carried out where a group of students (n=25) were given access to the system. The students completed the questionnaire to give some feedback, where required, on their understanding of the questions and perceptions of the system. From this pilot study,

the general feedback was positive with only minor clarifications required in the questionnaire. In terms of the system, some suggestions for system improvements included adding more images for those who were struggling, which would provide varied forms of instruction, as well as more challenging tasks for those who were performing well and desired for more advanced content. These suggestions were implemented for the final version of the questionnaire and adaptive system used in the study.

One piece of feedback from the pilot and again from the semi-structured interviews was that some students were concerned that the researcher would use the system to track and report on their ability. As the system would be used by all students in the treatment group due to it being the only way to access the material, and the study was designed to focus on the impact on academic emotional engagement that the system would have, it was deemed best not to instrument the system itself for the sake of this study. Students were also made aware of this so it wouldn't dissuade them from seeking support from the system for fear of getting judged based on data collected by the system. Furthermore, as it was either all or nothing, we could assume that all participants in the treatment group and no participants in the control group would have used the system while the quantitative data was being collected. For further research, tracking how many times students changed the ability of the content, or at what levels most students were operating at, could be a consideration for further data collection and potentially for a different research question.

This research is designed to demonstrate a causal relationship, where a variable is manipulated in a controlled experiment. In the case of this research the controlled environment uses a treatment and control group, so as to explore the impact of that manipulation.

As a result, we can say that the condition manipulated in the experiment caused the observed changes which can be defined as a causal relationship, also known as a cause-and-effect relationship (MacKenzie, 2013). Furthermore, to ensure that the cause has had the desired effect, a common approach is to manipulate the cause and observe the outcome, explore how variation in the cause has variation in the outcome and as much as possible attempt to reduce the plausibility of other explanations for the effect (Shadish, Cook & Campbell, 2005).

One approach to achieve the above mentioned is to run an experimental study using a pre and post-test design on a control and treatment group as well as some form of analysis of variance between the two groups. Ideally, in an experimental study design, all participants should be randomly assigned to a control and a treatment group (Shadish, Cook & Campbell, 2005). However, given this research is to happen in a natural classroom environment with minimal disruption to the student's natural learning experiences, such shuffling of students was not permitted and as a result, participants were selected from preassigned class groups to make up the treatment and control groups, making this a quasi-experimental design. The lack of randomisation of groups is somewhat mitigated by the fact that the administration randomly assigns students to class groups without any specific criteria. Although the randomisation of students into the control and treatment group was not done by the researcher, it still achieved its purpose and had the advantage of reducing any possible biases that the lecturer may have if he had to assign the students into the above-mentioned groupings.

A sequential mixed methods approach was used to collect both quantitative data via self-reporting questionnaires and qualitative data via semi-structured interviews. For the quantitative data, self-reporting questionnaires were administered to students using a pre-post-test design at the beginning and end of selected sessions

for both control and treatment groups with questions from the short form of the Academic Emotion Questionnaire. In the AEQ, scoring is suggested to be done by taking the sum of a specific item and determining the mean so as to get the overall value of that item for a specific group (Perkrun et al. 2005) which this study adheres to when analysing the data.

The final sample used after data cleaning was performed (removing students who did not complete both pre and post questionnaires) was n=60. Students were recruited based on the class groups in which the study would be conducted. They were provided with information on the study a week before the module commenced together with the participant information sheet. These were done before the students were asked about their possible participation. Students were randomly selected for interview from the same sample at which point they would be required to give written consent before the interview was conducted. The interviews were conducted at the end of the module after the quantitative data was collected in adherence to the explanatory sequential mixed methods approach.

6.3. Protocol

Data was primarily collected through the use of a self-reporting questionnaire. This was administered at the start and at the end of the selected sessions to the students in the treatment and control groups. This questionnaire was designed to gather information relating to the students' affective emotional engagement and other factors which may influence their overall engagement and classroom experience. At the end of the semester, a series of semi-structured interviews was also conducted on a sample of participants which was used to further understand the quantitative findings and explore additional potential impacts of the intervention.

6.3.1. Questionnaire Administration

The questionnaire consisted of a total of 30 questions comprised of 17 questions related to exploration of the positive and negative affective emotions related to emotional academic engagement, and 13 questions on related factors such as control, challenge, motivation, support and the ability to progress autonomously. The questionnaire itself was designed to take no more than 15 minutes to complete.

Each question in the questionnaire (annex 2) used a 5-point-Likert scale format, with all questions following a 1-strongly disagree to 5-strongly agree structure. A number of questions were reverse coded prior to analysis as they pertained to negative emotions, in which case such questions were negatively worded.

Students were given time at the start of the session to complete the questionnaire to serve as a baseline for their current affective state. Subsequently, they engaged in a 3-hour session which comprised of a 1-hour lecture and a 2-hour lab. The lecture segment of this session for both the treatment and control group was mostly lecturer driven with concepts being taught and explained to students to support them in the lab activities. This was followed by students working on a worksheet where they were required to solve problems presented to them. The standard traditional format for this lab activity would be to provide students with a list of tasks in a word document which would range from easy to more challenging tasks as the students progressed. Students would work through this activity sheet and would be allowed to ask the lecturer for support when they experienced difficulty in progressing. This standard format formed the method applied to the control group whereas the treatment group were given access to the adaptive learning environment where the same worksheet had been uploaded into the system. However, in the adaptive system, students had access to the course in an adaptive form, which tracked

what content they were reading and made suggestions both in the content itself and in the worksheets to help them further their knowledge or to recap on concepts which they may need to clearly understand in order to successfully complete the worksheet. The worksheet itself was adaptive, so students could indicate that they were struggling by selecting this option via the adaptive learning environment to get additional hints and support through the system or indicate that they were doing very well in order for the content to adapt and become more challenging. For both treatment and control groups, the lecturer was available for any questions or to provide additional support that the students may require. In essence, the only difference between the two groups was controlled to be the availability of the adaptive learning environment for the treatment group over the traditional word document format for the control group.

At the end of the session, students were given some time to complete the same questionnaire with the objective of capturing any change(s) to their affective state. As the questionnaire was being administered to both groups at the start and at the end of the session, within a natural school day for the students, it was imperative that data was collected with minimal disruption to their normal school day. As a result, the questionnaire was kept to the point and was designed only to collect the most pertinent data with further exploration to be covered during the semi-structured interviews at a later stage.

6.3.2. Semi-Structured Interview Administration

At the end of the semester, all of the students who participated in the study were invited to participate in a semi-structured interview. Although, the uptake for these interviews was relatively small (n=7), most of the points made by students during the interviews were very similar and aligned with the ideas explored in the existing literature. This group of students consisted of students with varied abilities

from two students who missed a number of sessions and struggled in the module, to three who were considered average and two who were quite strong and did well in the module. For information that was more enlightening such as their impressions around asking questions and ownership of their progress, these topics were touched on by all participants. The semi-structured interviews were conducted on a one-to-one basis, following an interview guide (annex 3), which, while left quite open, ensured students would reflect on their affective engagement during the sessions, their feelings towards perceptions of demand, control and support and also reflect on their general experiences with the adaptive learning environment. The students were invited back to campus and the interview was held in a comfortable setting to allow students to feel at ease while sharing about their experiences in using the adaptive learning environment. As all students were given access to the system after the quantitative data had initially been collected, students in these interviews were able to reflect on perceptions of their learning both with the adaptive learning environment in place, and when it was not available prior to commencement of the initial data collection.

The semi-structured interviews explored the same affective emotional aspects as the self-reporting questionnaire. However, questions in the semi-structured interviews were open ended. Questions were asked about student's general emotions, leaving room for the students to reflect on the emotions themselves and allowing the researcher to probe for additional information or explanation when required. Questions in the interviews did not specifically target any emotions to ensure reporting of specific emotions came from the student and not the question asked by the researcher. Some of these emotions emerged to be related to specific topics as mentioned above such as anxiety in asking questions or pride in the ownership of their progress, which were also not directly targeted topics in the interview and were

allowed to emerge from the interview itself. The semi-structured nature of the interviews allowed students to expand on aspects of their experiences that they found to be important or impactful as well as to elaborate on why the adaptive learning environment invoked certain emotions. In simple terms, these interviews allowed for expansion beyond if certain emotions were felt during this study to why these emotions were being felt and how the adaptive learning environment impacted these emotions and their learning in general.

6.4. Analysis of Quantitative Data

In experimental studies where a difference between two groups is being explored, it is important to determine if the difference observed is statistically significant by calculating the probability of error (p value), which is considered significant usually when the p value is 0.05% or less (i.e. 5% probability of occurring by change alone or less) (Bhattacherjee, 2012), depending on the study and the pre-determined value of p. The process of determining the probability of error depends on the type of data being analysed, however there still remains some debate as to what type of data certain datasets are. There is also a debate around scales related to opinion, specifically Likert scales (Allen and Seaman, 2007) such as ranges from strongly disagree to strongly agree which relates closely to the type of data being collected in this study. The arguments usually state that if you can rank objects but cannot consistently define and measure distances between the objects that you are interested in, you are most probably dealing with an ordinal scale. Should there be a clear definable measure between objects, the data is continuous. If those objects cannot be ranked or their distance measured, the scale is probably nominal or categorical. With a decision about the type of data we are dealing with, a decision around the probability test can be made, or at least specified and justified for the

current study. In simple terms, t-tests can be used to determine if two samples are different on continuous and normally distributed data. This test allows us to compare the means and standard deviations of two groups to test for statistical significance. The Mann-Whitney U-test is used when comparing ordinal data (ranked or rating scales) that are not normally distributed. The Wilcoxon matched pair test can be used for discontinuous data that are not normally distributed but do have a link between the two datasets such as assessing an item from the same person before and after a treatment. A chi-squared test is used with categorical data to determine if differences in frequencies between two sets of results is down to chance.

This study however follows a repeated measures design, with each group being measured at least twice (pre- and post-test). Such an approach is one of the most frequently used for experimental design and frequently used in educational research (Dugard and Todman, 1995). ANOVA and ANCOVA are commonly used for analysis of variance between groups. However, the most appropriate approach to use is another topic of some debate (Bonate 2000, Dugard and Todman, 1995). There is some alignment on the issues with ANOVA not taking into considering pre-test data as part of the analysis of variance in a pre-test/post-test situation, whereas ANCOVA takes the pre-test as a covariant and would seem to have a better chance of detecting significant differences between groups (Dugard and Todman, 1995) as long as all data assumptions are met. Although on their own, measures in this study may be considered ordinal, the process observed by AEQ where scores are added and the mean is derived, allows the data to have more interval scale properties and also suggests that the tool was developed with the intention that the resulting data could be interpreted as continuous which can also be observed in similar studies of this type that had opted for the above analysis of variance approaches.

Data analysis was performed using SPSS for quantitative data and this included ANOVA for an analysis of variance between the treatment group and control groups pre and post test score. ANOVA was selected as all data assumptions were met for ANOVA. However, while most data assumptions were met for ANCOVA which may have been more sensitive to group differences given an initial high engagement rating for both groups, the assumption for homogeneity of regression slopes was not met for ANCOVA and as a result, this approach for analysis was not selected.

The data collected could be explored via a number of angles, first and perhaps most importantly, the range of questions relating specifically to affective emotional engagement were used as a scale to explore if the overall affective engagement of the students had increased or decrease with the deployment of the adaptive learning environment in the classroom. Based on a range of questions to measure positive and negative emotions experienced during a session, this study defines an increase or decrease in overall academic emotional engagement as a significant difference in the engagement score between the two groups' pre- and post-test data, defining this statistical significance as $p < 0.05$.

As the AEQ takes into consideration the facets of emotions and also why and where they are taking place. The analysis goes into detail not only around positive and negative emotions, but also examines if these emotions are classroom based or general learning based. As a result, we can better understand if students' emotions are being impacted as a result of experiences in the classroom, or from their general learning experience, or combined looking at both learning and classroom related emotions, to see how overall positive and negative emotions are impacted as a whole.

Data was also explored looking at how demand, control, and support impact emotional engagement with the expectation that the adaptive learning environment could have an impact on these variables as well, given the nature of the adaption being able to change the demand of a task, give students control over how they engaged with tasks, and offering them a constant form of support even when the lecturer was unavailable. To explore this, a multiple regression analysis can be carried out to see which of these factors have a predictive impact on overall emotional engagement.

6.5. Analysis of Qualitative Data

As our study follows an explanatory sequential mixed methods design, qualitative data was used to gain more depth and insight into the quantitative findings. One of the most common approaches to data analysis for this type of data to form a single more comprehensive data set is thematic analysis. Data can also be coded to support this process, as well as quantified by enumerating a theme in a sample or even exploring how many times the absence of a code was observed in a sample (Driscoll et al. 2007). All semi-structured interviews were transcribed and coded in NVivo for thematic analysis. Subsequently, themes were identified deductively, using the conceptual framework as a basis for identifying themes that needed to be explored so as to help support the quantitative data. During the interviews, the researcher took notes of key topics that were arising from each interview session to see if any additional themes emerged which may be explored in the thematic analysis. Following these interviews, the researcher personally transcribed all recordings and made additional notes which could be cross referenced against the final thematic analysis which would be done through NVivo, as well as to help the researcher decide on topics to support encoding.

Finally, as the researcher was also the lecturer, to help eliminate as much bias as possible in the semi-structured interviews, the researcher ensured his own awareness of his role and position in the research as a way to address any potential issues as a result (Ortiz, 2003). Furthermore, Young et al.(2018) identified several critiques for the use of interviews, namely, the lack of transparency in sampling strategy, choice of questions and mode of analysis, which will be addressed here. In terms of the selection strategy, students selected for the interview were a subset of all students who participated in the study, which were selected based on class groups that were not assigned by the researcher as explained in the earlier part of this chapter. All students from the study were invited for interview and all students who responded to the invitation were subsequently interviewed. The questions were semi-structured, directly related to the conceptual framework and were open ended enough to allow students to openly discuss their experiences. For the mode of analysis, themes were drawn again from the conceptual framework to be explored and findings were related back to the quantitative analysis which used an existing tool not created by the researcher. As a result, these qualitative findings only formed part of the picture, designed to explain what was found in the quantitative findings and not being solely relied on as the only source of data. The researcher, understanding his role as the lecturer, also made it clear to the participants that accuracy of data was of utmost importance and regardless of what the findings revealed, the data gathered were useful and meaningful and can contribute towards the research on how such adaptive learning environments are used or enhanced in the future.

6.6. Limitations

As this was an education design research approach, which ensures the research takes place in a natural classroom environment, the size of a class group inherently

limits the size of the sample. This becomes one of the limitations where the number of students that can participate in the study is determined by the class size. Although there is no prescriptive or optimal number to determine an ideal sample size for a quantitative study, it is generally accepted that the larger the sample, the closer the results will be to the general population. Thus, making the results more generalizable. However, this is not uncommon in educational design research or indeed any local knowledge of case study work, but it is argued that having more local knowledge shared through peer review mechanisms allows for a new stock of knowledge to become available to all, enabling the possibility of transferability of knowledge to also grow (Huang, 2010). Although, from the researcher's own experience, the findings in this work would seem generalisable even if it is challenging to claim generalisability given the number of participants. However, this body of work does contribute to the overall growing body of knowledge in this area, where further repeat experiments in other works of research which may show similar results, could collectively affirm the generalisability of such findings. As far as this research could deal with generalisability, the participants were a random selection of students from varied backgrounds, mostly from the UK but included a number from other parts of Europe, who all reflected on similar perceptions and experiences during the interviews.

In this particular study, time was a recurring factor in how the study was carried out. As the class used for the intervention was scheduled to occur once a year, any delay in collecting data would have resulted in a year delay before the next opportunity to collect more data. When the study was ready for data collection to take place, the researcher only had one year left working with the institution where the study was being carried out, and as a result was unable to implement a potential historical control group which could have increased the overall number of

participants. Furthermore, within the given time frame, running multiple experiments was challenging given the time available and the need to create multiple adaptive worksheets and additional adaptive content for the adaptive learning environment. Additionally, ensuing the disruption to students learning was kept to a minimum was important for ethical reasons, so as to ensure all students had access as soon as possible to a potentially beneficial intervention, and for pedagogical reasons, so students learning wasn't being disrupted too much by the time required for data to be collected during each session.

A true experimental design would have also been preferable although impractical in the case of an educational design research approach where it is important to ensure as minimal disruption to the students' natural class environment as possible and class groups are pre-assigned by the administration of the university. The lack of randomisation may have been mitigated somewhat however due to the fact that there is no specific criteria for students to be assigned to a specific class group. As a result the administration practices random assignment of students to class groups by default. Further, from an educational design research perspective, such an experimental approach results in a more laboratory based setting and a less natural environment setting which may also lead to an incomplete understanding due to interference in the naturalistic setting.

In terms of the measures, ideally, overall engagement, including behavioural, cognitive and emotional engagement, could be measured rather than just emotional engagement. However, this would increase the total number of questions that students would have to answers in both pre- and post-test evaluations and may further limit the number and quality of responses. Other measures beyond surveys could also be used such as observations or auto-measures of engagement. In the case of this particular

research, due to the time restrictions of the study and potential for observations and auto-measures to further disrupt a natural classroom environment, these alternatives were ruled out.

Finally, although this has been discussed in Chapter 1, it is worth mentioning again that a potential limitation of this study has been that the lecturer was also the researcher and to mitigate potential bias on the part of the researcher or favourable answering on the part of participants, this issue has been carefully considered and addressed throughout this study.

Chapter 7

7. Data Analysis and Findings

7.1. Introduction

This section aims to outline the findings of this study in alignment with the original aims, objectives, and research questions. The research aims to explore the impacts of an adaptive learning environment on students' emotional engagement within a classroom environment. The review of the literature helped define the five core research questions as outlined in the introduction chapter. This section is focused on satisfying the fifth objective of our research design which is to evaluate the impact of the adaptive learning system inclusive of adaptive content and adaptive worksheet based on the study design outlined in the previous chapter.

As this research has taken a sequential mixed methods approach, the findings in both quantitative and qualitative formats will be presented. As the qualitative data serves to further explain the findings from the quantitative results, this chapter will first outline the quantitative findings followed by the qualitative which will be discussed together in the discussion chapter.

7.2. Quantitative Analysis

7.2.1. Overview and Research Questions

As the initial research question **RQ1** highlights, the core aim of this research was to assess the impact the use of an adaptive learning environment had on students' emotional engagement within the classroom. This leads to two potential hypothesis, the null hypothesis (H_0) and potentially two alternative hypothesis (H1 and H_2) as shown below:

H_0 – There is no significant change in overall emotional engagement for students using the adaptive intelligent system over a control group not using the adaptive learning environment.

H_1 – There is a significant increase in overall emotional engagement for students using the adaptive intelligent system over a control group not using the adaptive learning environment.

H_2 – There is a significant decrease in overall emotional engagement for students using the adaptive intelligent system over a control group not using the adaptive learning environment.

Although a range of data was collected for this research, questions informed by the achievement emotion questionnaire or AEQ (Pekrun et al. 2011), specifically those questions related to classroom affective engagement and learning affective engagement were used (annex 2). This scale allowed the measurement of overall affective engagement both before and after sessions where the intervention had taken place for the treatment group, or where traditional material had been used as in the case of the control group.

The sample size had a total of 60 students, with 30 students assigned to the treatment group (using the adaptive education system) and 30 students assigned to the control group (using traditional Power-Point slides and Word based worksheets).

Levene's test was not significant, $F(1, 58) = 0.13$, $p = 0.91$, indicating that the assumption of homogeneity of variance has not been broken.

Table 7-1 : Overview of emotional engagement quantitative results

	Measure	Significance between groups	Mean values pre / post		
		P value	Treatment Group	Control Group	Eta-Squared
Overall Scores	**Overall** Emotional Engagement	< 0.05 *	3.82 (pre) 4.08 (post) ▲	3.5 (pre) 3.501 (post) ▲	0.08
	Overall for *Classroom* Emotional Engagement	< 0.05 *	3.90 (pre) 4.26 (post) ▲	3.53 (pre) 3.58 (post) ▲	0.106
	Overall for *Learning* Emotional Engagement	< 0.05 *	3.83 (pre) 3.95 (post) ▲	3.49 (pre) 3.40 (post) ▼	0.066
Positive Scores	**Positive** *Classroom* Emotional Engagement	< 0.05 *	3.80 (pre) 4.28 (post) ▲	3.51 (pre) 3.60 (post) ▲	0.08
	Positive *Learning* Emotional Engagement	> 0.05	4.14 (pre) 4.19 (post) ▲	3.97 (pre) 3.82 (post) ▼	0.029
	Positive Classroom and Learning Combined	> 0.05	3.97 (pre) 4.23 (post) ▲	3.74 (pre) 3.71 (post) ▼	0.059
Negative Scores	**Negative** *Classroom* Emotional Engagement	< 0.05 *	2.04 (pre) 1.75 (post) ▼	2.45 (pre) 2.44 (post) ▼	0.105
	Negative *Learning* Emotional Engagement	< 0.05 *	2.37 (pre) 2.19 (post) ▼	2.80 (pre) 2.85 (post) ▲	0.08
	Negative Classroom and Learning Combined	< 0.05 *	2.20 (pre) 1.97 (post) ▼	2.63 (pre) 2.65 (post) ▲	0.102

An overview of the findings from the quantitative analyses is seen in Table 7-1, these findings will be discussed in the subsequent sections, starting with overall emotional engagement scores and then exploring classroom and learning emotional engagement and positive and negative emotional engagement within these settings.

7.2.2. Overall Emotional Engagement Scores

A repeat measures ANOVA test revealed that the main effect for treatment (inclusion of the adaptive learning environment) was significant with $F(1, 58) = 5.046$, $p < 0.05$, Eta-Squared = 0.08. Thus, there was an overall difference in the engagement scores of the treatment group (M=3.95) compared to the control group (M=3.50) with a medium effect (Eta-squared=0.08).

Time * Groups was not significant $F(1,58) = 3.14$, $p > 0.05$, so there is no significant interaction between these two independent variables. Looking at the mean values, we can see that although the total increase within treatment and control combined was not significant with pre-tests to post-tests being comparable, (M=3.66) and (M=3.78) respectively, there was a minimal increase in the control group (M=3.500 Pre and M=3.501 Post) but a clearly more notable increase in the treatment group (M=3.82 pre and M=4.08 post) as seen in Figure 7-1, this would explain the significant result in the between-subject effects.

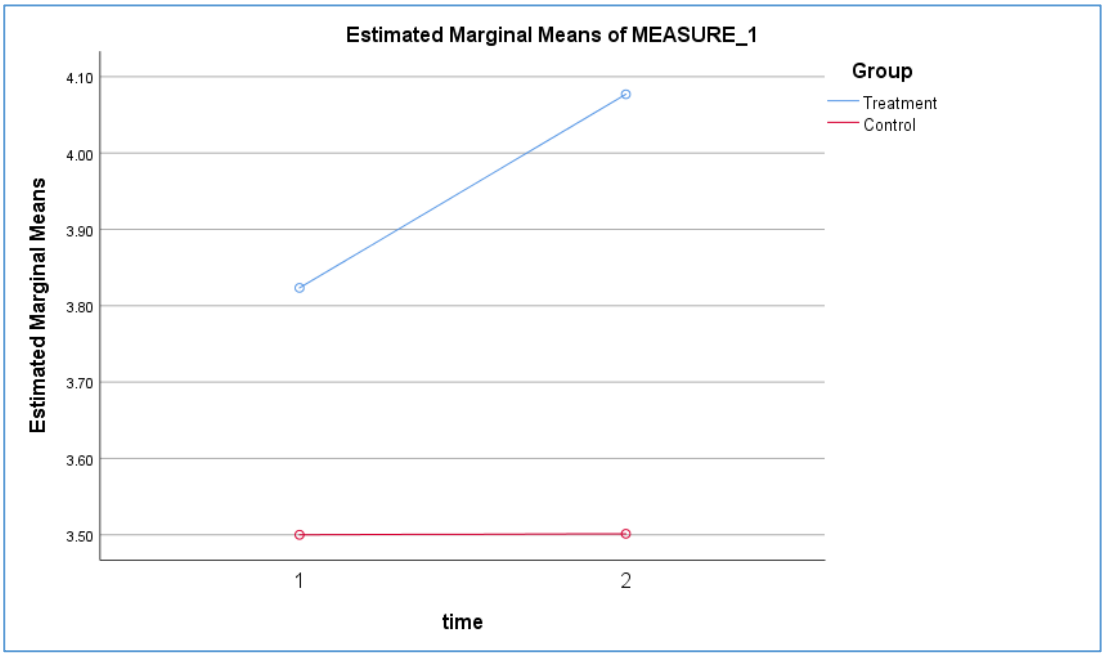

Figure 7-1 : Marginal Pre-Post Test Means for Overall Emotional Engagement between Treatment and Control

To explore the pre and post tests for the control group and treatment group independently, a non-parametric analysis was selected due to the structure of these condensed data sets and as such the Wilcoxon test was selected. When comparing pre to post test results for the treatment group, a statistically significant result of $P < .025$ was found showing a significant higher emotional engagement for the treatment groups post-test. The same test conducted on the control group showed a non-significant result of $P > .05$ as student emotional engagement increased only minimally between the pre and post-tests.

As a result of these findings, it is possible to reject both H0 and H2, and accept H1 which states that '*There is a significant increase in overall engagement for students using the adaptive intelligent system over a control group not using the adaptive intelligent system'.*

This analysis goes towards answering **RQ1** for which the data and analysis shows a significant increase in students' overall emotional engagement for the treatment group where the adaptive learning environment was deployed as compared to the minimal increase for the control group which used standard fixed documents to deliver the tasks.

7.2.3. Classroom and Learning Emotional Engagement

Exploring this data further, emotional engagement data was split into both classroom and learning engagement factors to better understand where the adaptive learning environment had more significant impacts.

When looking at overall classroom emotional engagement, the increase in the main effect for the treatment group over the control group was significant $F(1, 58)=$

6.895, P < .05, Eta-Squared =0.106. Looking at the mean values, we can see a higher increase in means for the treatment group (M=3.90 Pre and M=4.26 Post) as opposed to the control group (M=3.53 pre and M=3.58 post) which is seen in Figure 7-2.

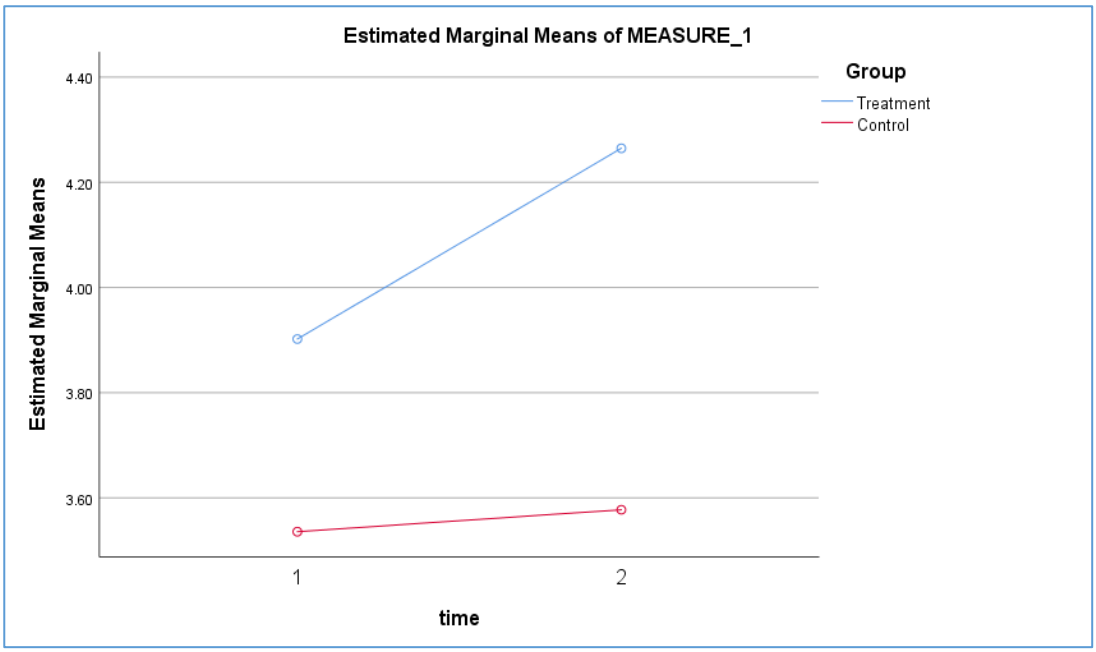

Figure 7-2 : Marginal Pre-Post Test Means for Classroom Emotional Engagement between Treatment and Control

For learning emotional engagement, there was again a significant increase in the main effect for the treatment group over the control group F(1, 58)=4.130, P < .05, Eta-Squared=0.066, showing a smaller effect size for learning emotional engagement, and while it is significant, the raw values for significance showed learning emotional engagement to be closer to the cut-off of P < .05 than the classroom emotional engagement.

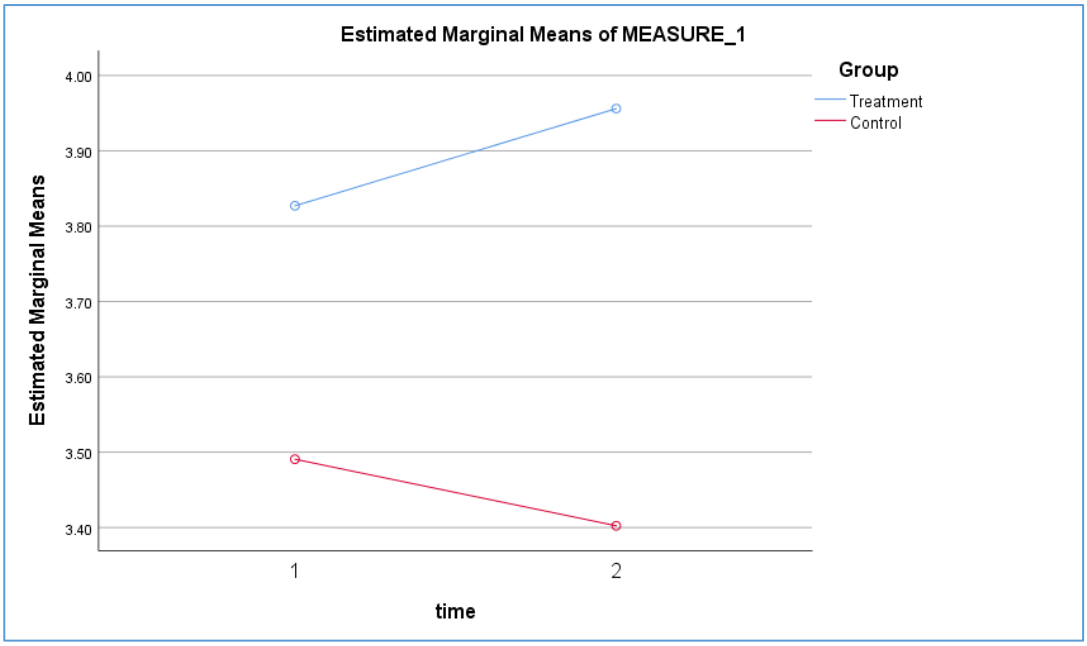

Figure 7-3 : Marginal Pre-Post Test Means for Learning Emotional Engagement between Treatment and Control

It is also worth noting here that while there was an increase in means for the treatment group (M=3.83 for pre-test and M=3.95 for post-test), there was a decrease in means for the control group (M=3.49 for pre-test and M=3.40 for the post-test) as seen in Figure 7-3.

On the whole, we can see that emotional engagement for both learning emotional engagement and classroom emotional engagement showed significant increases for the control group over the treatment group. However, the effect size for classroom emotional engagement in this case was larger than the effect size for learning emotional engagement. Likewise, although the raw values for significance were both $p<0.05$, learning emotions were much closer to the cut-off of $p<0.05$. The data and analysis in this section addressed **RQ2,** showing that the adaptive learning environment has a significant positive impact on emotional engagement both for learning emotional engagement and classroom emotional engagement, but with a larger effect size for classroom emotional engagement and a medium to low effect size for learning emotional engagement.

7.2.4. Positive and Negative Emotional Engagement

A further analysis of the data explores the impacts on positive and negative emotions in both learning contexts and classroom contexts independently and as a whole.

For positive classroom emotions, there was a significant increase for the treatment group over the control group $F(1, 58)=4.985$, $P < 0.05$ with a medium to low effect size, Eta-Squared=0.08. This results from an increase in the mean for the treatment group of M=3.80 for pre-test and M=4.28 for post-tests. The control group showed a smaller increase from M=3.51 for the pre-test to M=3.60 for the post-test for the control group as visible in Figure 7-4. Both groups also had a significant increase over time and in time within subjects, showing that an increase in classroom emotional engagement over time and between time and groups, with significance $F(1,58)=9.598$, $P < .05$ for time and $F(1,58)=4.496$, $p < 0.05$ for time * group.

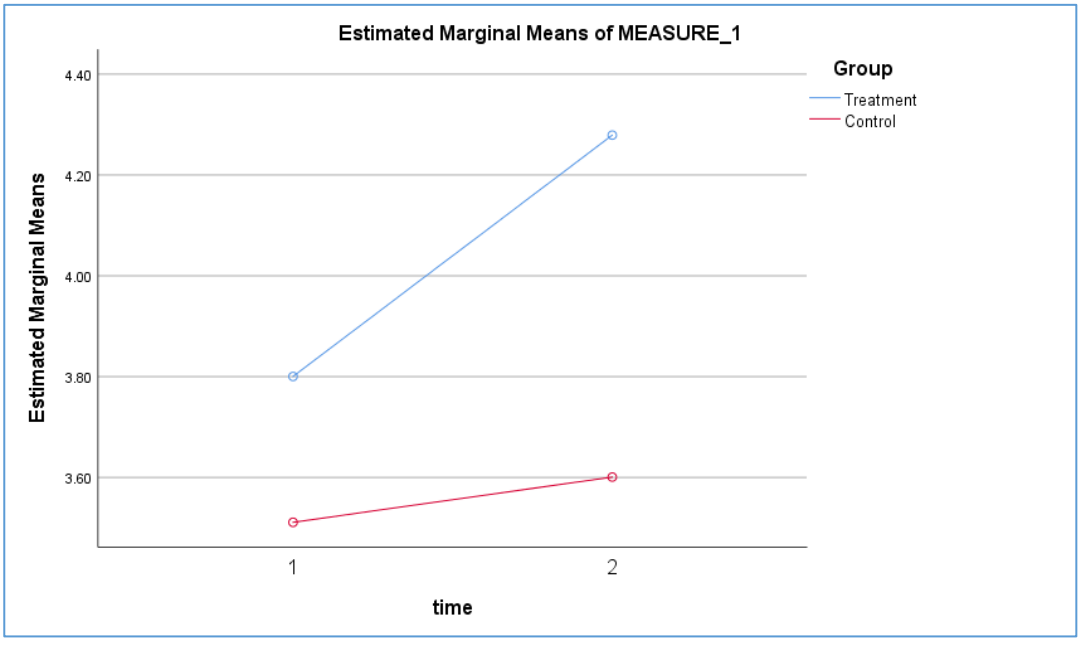

Figure 7-4 : Marginal Pre-Post Test Means for Positive Classroom Emotions between Treatment and Control

In terms of positive learning emotions, there was no significant difference between the treatment and control groups with a significance of F(1, 58) = 1.726, p > .05, Eta-squared=0.029. However, the treatment group did show a minor increase in positive learning emotions (M=4.14 for pre-test, and M=4.19 for post-test) whereas the control group showed a minor decrease in positive learning emotions (M=3.97 for pre-test and M=3.82 for post-test) as can be observed in Figure 7-5.

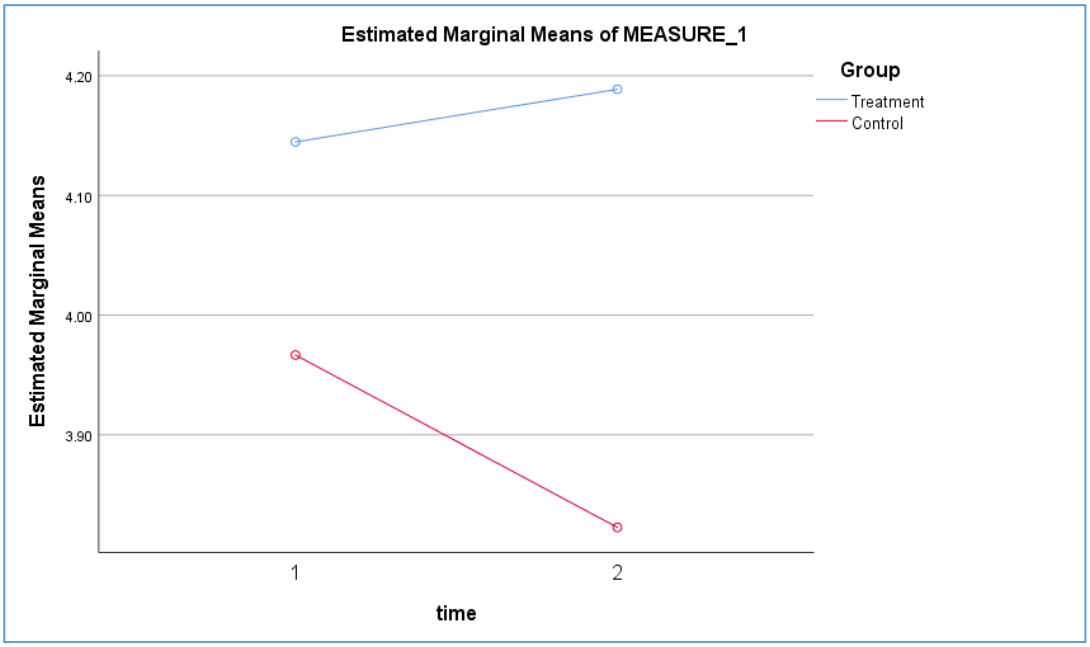

Figure 7-5 : Marginal Pre-Post Test Means for Positive Learning Emotions between Treatment and Control

Overall, the positive emotions of classroom and learning combined did not have a significant difference in means with a significance of (F1, 58) = 4.298, p > 0.05, Eta-Squared=0.059. There was, however, an increase in means for the treatment group (M=3.97 to M=4.23 respectively) and a decrease in means for the control group (M=3.74 to M=3.71) which can be seen in Figure 7-6.

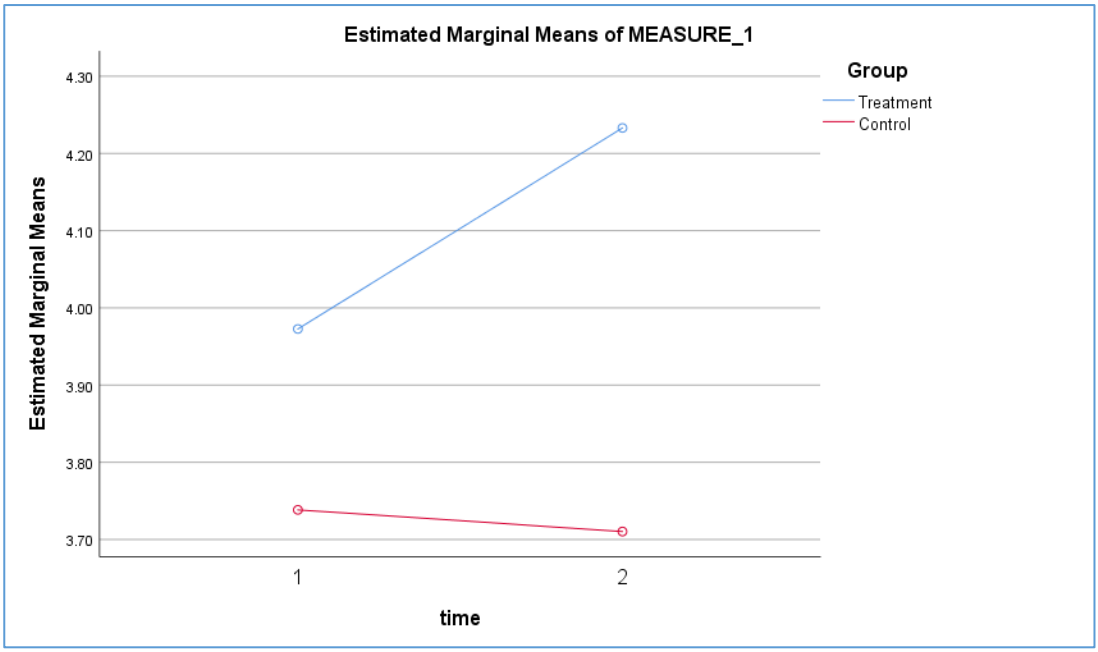

Figure 7-6 : Marginal Pre-Post Test Means for Overall Positive Emotions between Treatment and Control

When dealing with the analysis of negative emotions, it should be noted that lower scores are considered better. For the overall analysis, these scores are reverse coded to make sense against the rest of the data, but the results presented here look only at negative emotions. As such, in this section, the negative emotions showing a downward trend (meaning less negative emotions) is considered a desired result.

For negative classroom emotions, there was a significant difference between treatment and control groups with $F(1, 58) = 6.793$, $p < .05$, Eta-Squared = 0.105 which shows not only significance but a large effect size as well. For the treatment group pre- and post-test, the mean values were M=2.04 and M=1.75 respectively showing a decrease in negative classroom emotions, and M=2.45 and M=2.44 respectively for the control group showing a minor decrease in negative classroom emotions which can be observed in Figure 7-7.

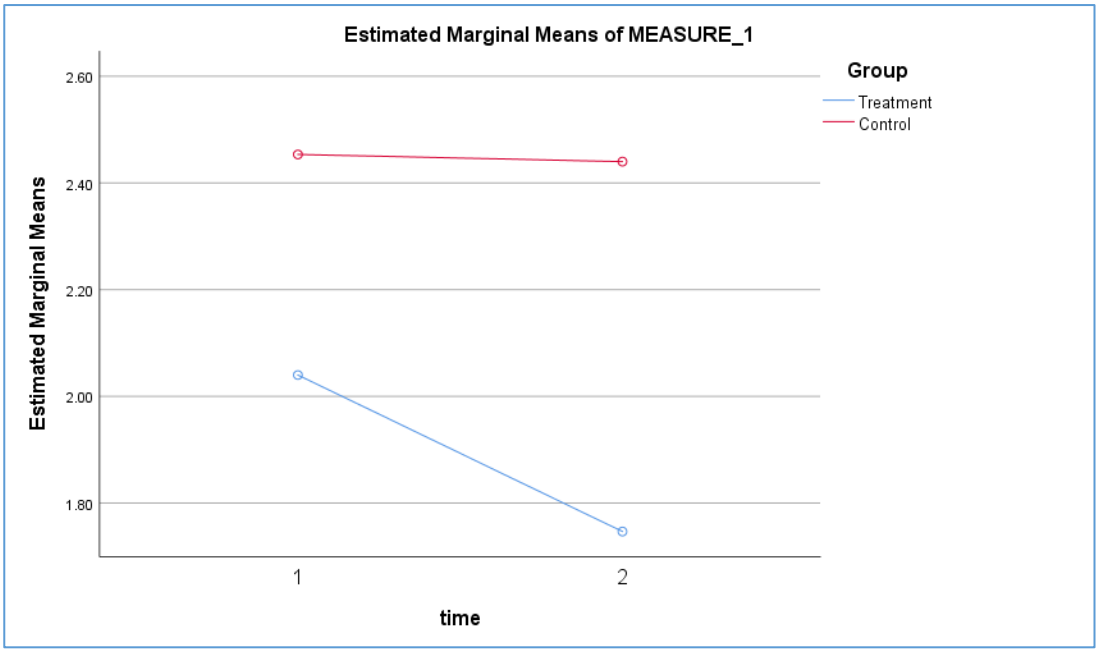

Figure 7-7 : Marginal Pre-Post Test Means for Negative Classroom Emotions between Treatment and Control

This pattern was repeated for the learning emotions, with a significant difference between the treatment and control group, $F(1,58) = 5.064$, $p < .05$, eta-Squared=.08. Looking at the mean values we see a decrease in negative learning emotions for the treatment group in the pre-test and post-tests (M=2.37 and M=.2.19 respectively) and a minor increase in negative emotions for the control group in the pre-test and post-tests (M=2.80 and M=2.85 respectively) as seen in Figure 7-8.

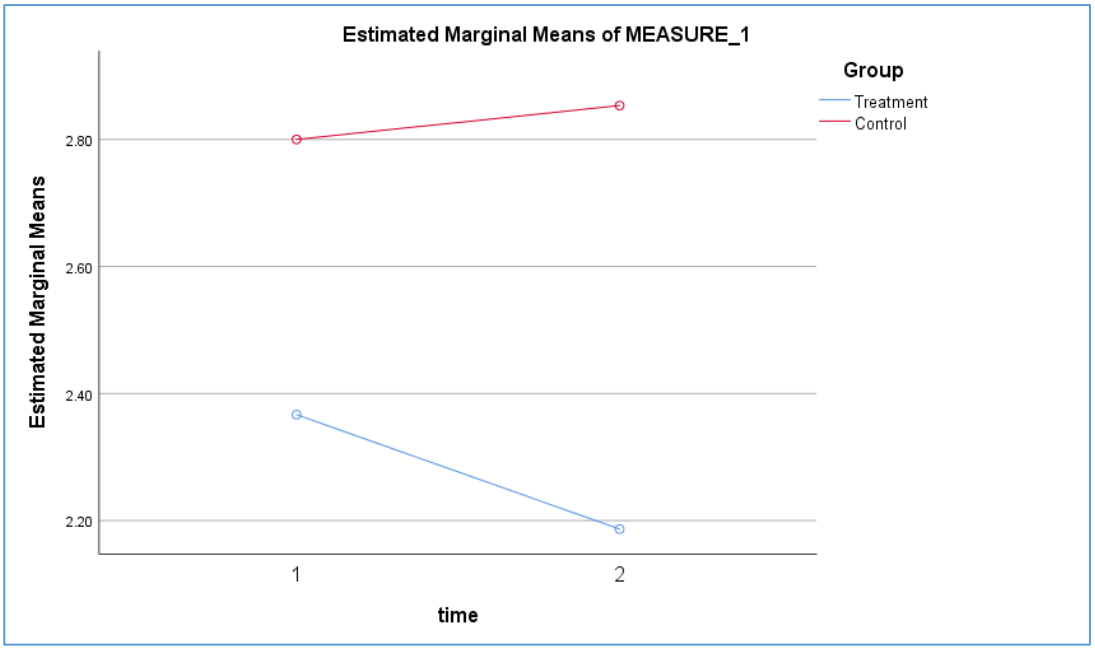

Figure 7-8 : Marginal Pre-Post Test Means for Negative Learning Emotions between Treatment and Control

For the overall negative emotions, there was a significant decrease for the treatment group against the control group $F(1, 58) = 6.590$, $p < 0.05$, eta-squared=0.102. There was a decrease in the mean for the negative emotions of the treatment group (M=2.20 and M=1.97 respectively) and a slight increase in the negative emotions for the control group (M=2.63 and M=2.65 respectively) which can be noted in Figure 7-9. The overall effect size between groups was noted to be high in this case.

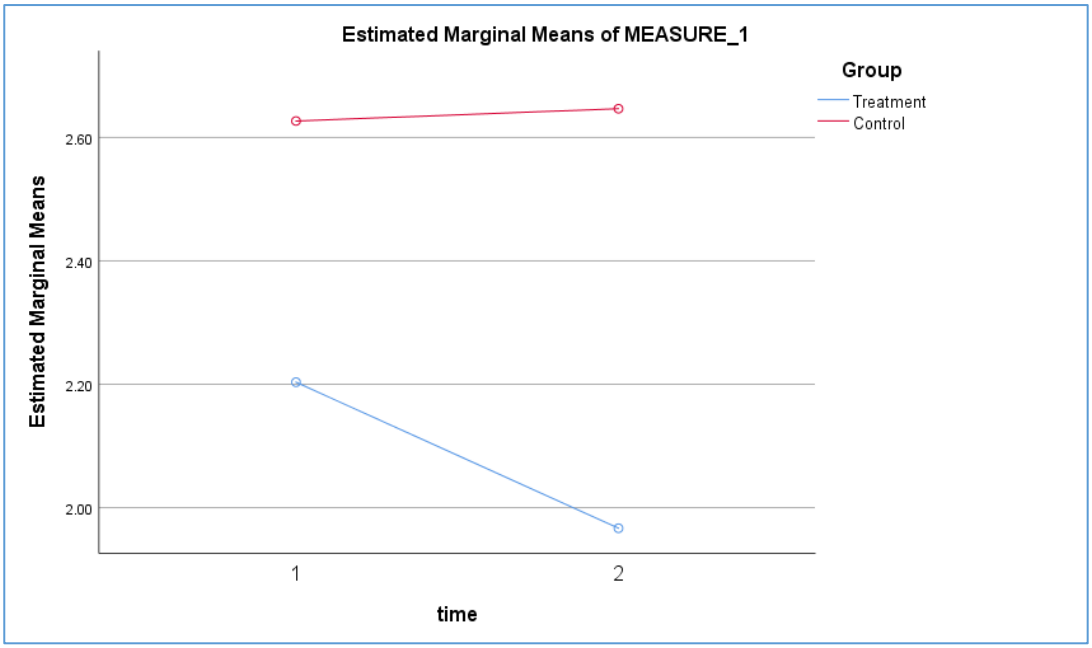

Figure 7-9 : Marginal Pre-Post Test Means for Overall Negative Emotions between Treatment and Control

The data and analysis shows that the adaptive learning environment has a greater impact on reducing negative emotions than it does on increasing positive emotions. This can be seen from an overall non-significant impact on positive emotions, but a significant impact on negative emotions with a large effect size. In terms of positive emotions, while the treatment group did have a larger increase in mean values, and had a significant increase in terms of positive classroom emotional engagement, the impact was far less for overall positive learning engagement leading to a non-significant overall result. However, for classroom emotional engagement, both classroom and learning emotional engagement were significantly improved (lower negative scores) for the treatment group as compared to the control group with an overall high effect size. In terms of negative emotions classroom emotional engagement had a more significant result with a higher effect size than learning emotional engagement. It is worth noting for both positive and negative emotions, the classroom emotional engagement was significantly improved for both when the treatment was applied, showing that the adaptive learning environment was having a

greater impact on the emotional engagement in the classroom and likewise had a greater impact in negating negative emotions. This data and analysis goes towards answer **RQ3** in exploring how negative and positive emotions are impacted by the treatment of using an adaptive learning environment in the classroom. In summary, it showed a greater impact on classroom emotional engagement for both positive and negative emotions, and a significant impact on overall negative emotions, with only positive classroom emotional engagement showing a significant impact as opposed to positive learning emotional engagement which while did increase, was not deemed to be significant.

7.2.5. Impacts of Perceptions of Demand, Control and Support

To assist with an understanding of the influence demand, control, and support have on emotional engagement, a linear regression analysis was carried out on the perceptions of demand, control, and support on students' own perception of overall emotional engagement. This is done to see how these factors influenced a student's perception of their emotional engagement. In this analysis, students' scores on their perceptions of the demands of the task, the control they had over their learning and the support that they felt they had received were taken as independent variables, with their overall emotional engagement taken as the main dependent variable. The data conformed to the assumptions of the test with appropriate tolerance, variance inflation factor, probability plots with minor deviations from the line (Figure 7-10), scatter plots with only two cases outside the range of -3 and 3 (Figure 7-11) and Cook's distance not greater than 1.0.

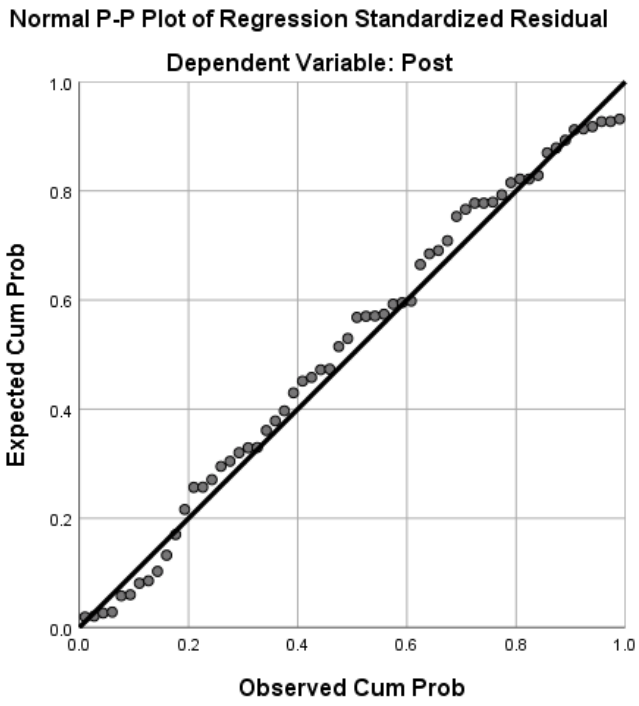

Figure 7-10 : P-P Plot of Regression Standardized Residual for demand, control and support independent variables

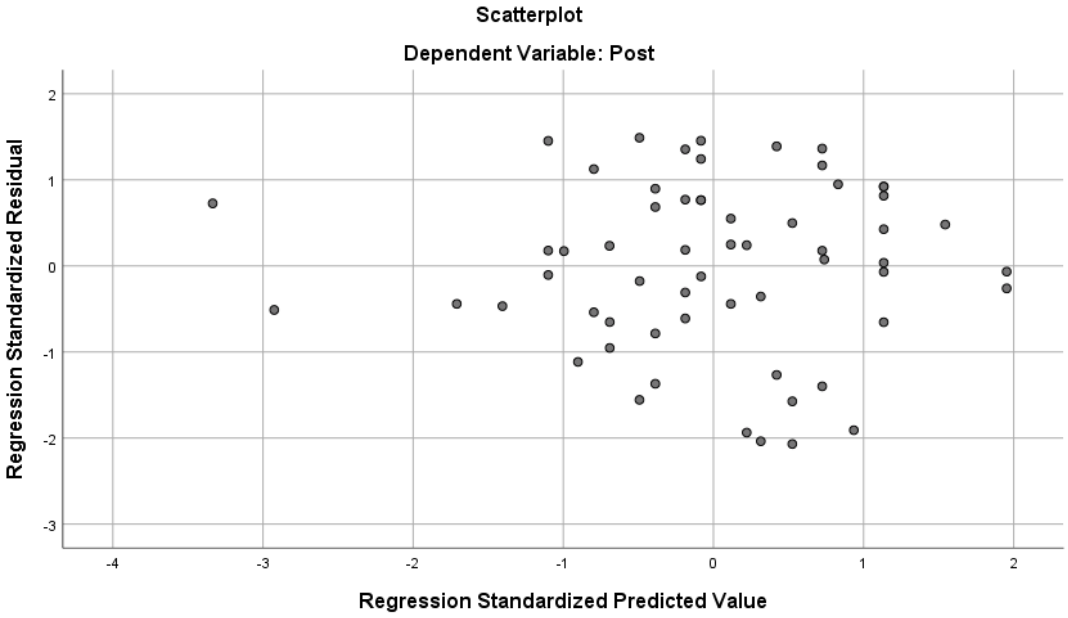

Figure 7-11 : Scatter plot for regression analysis of demand, control, and support

For the evaluation of the model, adjusted R squared which is the amount of variance explained in the dependent variable as explained by movement in the independent variables was R-Squared=0.52 which is expected to be above 0.30 or

30%, therefore the independent variables do explain to a reasonable degree the variance in the dependent variable. In the case of a linear regression, the null hypothesis is that the slope of the line will be zero. If ANOVA shows a significant difference on the line, it allows us to reject this null hypothesis. As a result of this test, the significance value was $p < 0.001$ showing a high significance allowing us to reject this null hypothesis, meaning that the model can predict the outcome better than chance.

Looking independently at each independent variable and the coefficients, the impact of each independent variable on the model can be explored in terms of their impact on the model and how they might impact the model if they were removed.

Using standardized coefficients, we note that the independent variable of 'control' explains more of the change in the dependent variable with standardized coefficient beta = 0.490, significance < 0.001 than 'support' with a standardized coefficient beta of 0.232, significance < 0.05.

Aside, 'demand' which was also part of the model showed a negative relationship, noting that when the demand of the task was deemed as less demanding by the student, emotional engagement is seen to increase. In the case of challenge, the standardized coefficient was -.264, significance < 0.05 so while it is a significance part of the model, it shows a negative relationship to higher engagement scores.

7.2.6. Treatment and Control Analysis on Demand, Control and Support

Based on the factors of demand, control, and support having an impact on engagement, this section looks at the impacts that the adaptive learning environment has on these aspects on student learning. To achieve this, an ANOVA analysis has

been done for the pre and post test results of both control and treatment groups. This is to explore the variance between groups and to ascertain which of these three variables were most impacted by the deployment of the treatment. An overview of the results which will be discussed in this section is seen in Table 7-2.

Table 7-2 : Overview of demand, control and support quantitative results

Measures	Significance	Means values pre and post		
	P value	Treatment Group	Control Group	Eta-Squared
Control	> 0.05	3.33 (pre) 4.0 (post) ▲	3.40 (pre) 3.60 (post) ▲	0.155
Support	< 0.05 *	3.93 (pre) 4.53 (post) ▲	3.50 (pre) 3.93 (post) ▲	0.072
Demand	> 0.05	3.83 (pre) 3.50 (post) ▼	3.47 (pre) 3.33 (post) ▼	0.040

For the control variable there is a significant increase over time for both treatment and control groups combined $F(1, 58)=10.63$, $P<0.05$ with a large effect size, Eta-Squared=0.155. This shows an increase in perception of control of learning both in treatment and control groups. When exploring between-subject effects, there was no significant increase in perception of control, $F(1,58)=0.371$, $P>0.05$. If we look at the mean values, there was a slight increase in the mean for the control group (M=3.40 for pre-test and M=3.60 for post-test results). However, this was greater for the treatment group (M=3.33 for the pre-test and M=4.0) for the post test (Figure 7-12). Likewise, when exploring these mean values independently, there was no significant increase in the control group between pre- and post-test but there was a significant

increase (P<0.05) between pre and post tests for the treatment group.

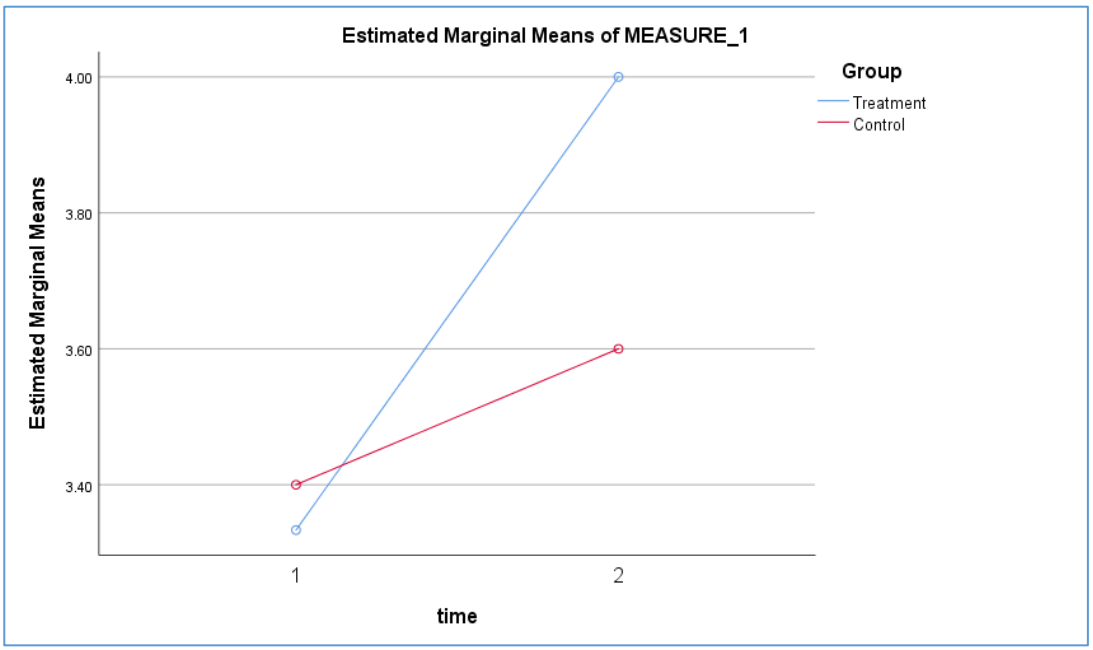

Figure 7-12 : Marginal Pre-Post Test Means for Perception of Control for Control and Treatment Groups

For support, between groups there was a significant increase over time for both treatment and control groups combined F(1, 58)=12.46, P<0.05 with a large effect size, Eta-Squared=0.177. This showed an increase in perception of support for learning both in treatment and control groups. When exploring between-subject effects, there was also a significant increase in perception of support, F(1,58)=4.491, P<0.05 with a moderate to low effect size, Eta Squared 0.072. The mean values showed a slight increase in the mean for the control group (M=3.50 for pre-test and M=3.93 for post-test results). However, this was greater for the treatment group (M=3.93 for the pre-test and M=4.53) for the post test as seen in Figure 7-13.

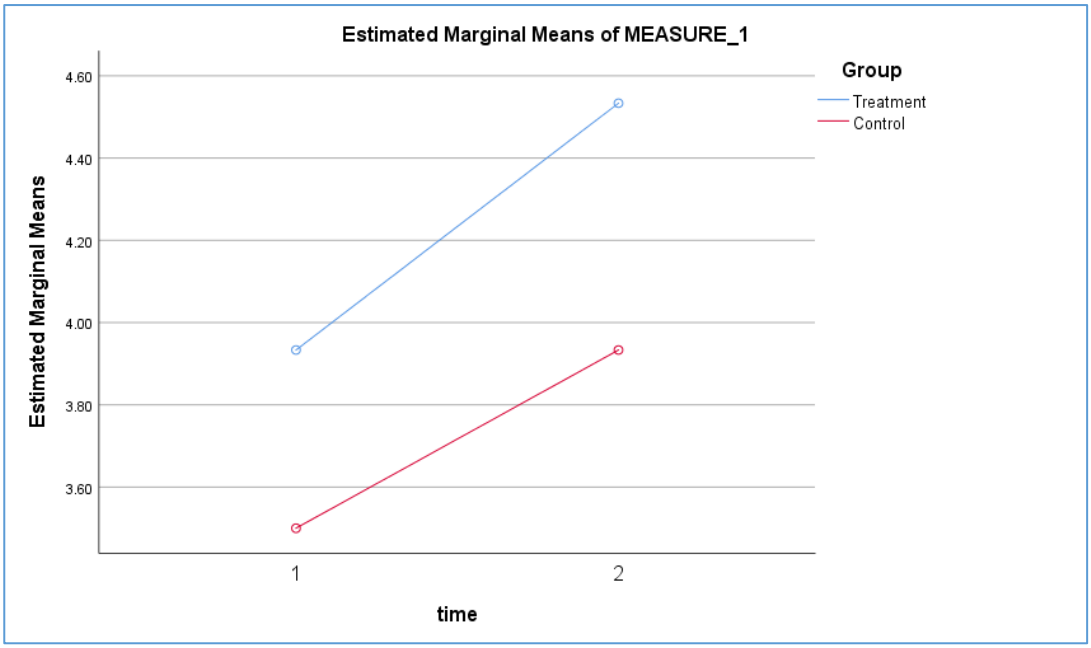

Figure 7-13 : Marginal Pre-Post Test Means for Perception of Support for Control and Treatment Groups

As noted from the linear regression, the relationship between demand and engagement was negative, so students felt more emotional engagement when challenge was lower than when it was too high, and this was noted to be a linear relationship.

For the perceived demand of tasks, between groups there was no significant increase over time for both treatment and control groups combined $F(1, 58)=3.63$, $P>0.05$ with a small effect size, Eta-Squared=0.059. When exploring between-subject effects, there was no significant increase in perception of demand, $F(1,58)=2.392$, $P>0.05$ with a low effect size, Eta Squared 0.040. The mean values showed a decrease in perception of demand for both the control group ($M=3.83$ for pre-test and $M=3.50$ for post-test results), and for the treatment group ($M=3.47$ for the pre-test and $M=3.33$ for the post test) as observed in Figure 7-14. It is noted that the treatment group had less of a decrease in perceived demand but also had a lower initial perception of demand in the pre-test.

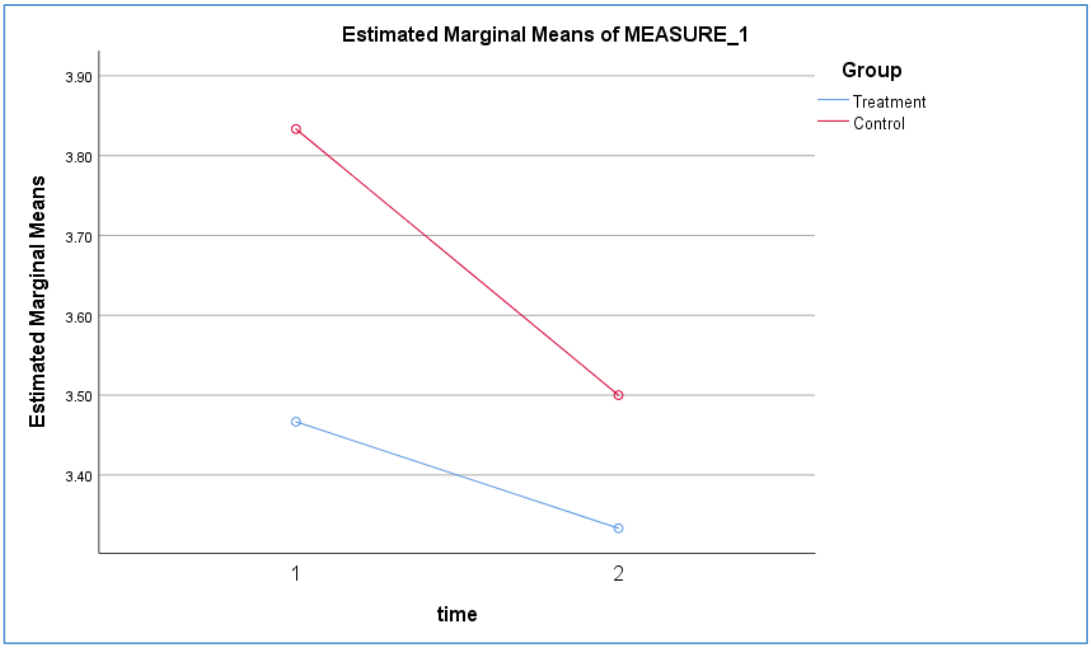

Figure 7-14 : Marginal Pre-Post Test Means for Perception of Demand for Control and Treatment Groups

Overall, it would seem that only support was significantly impacted by the treatment of having the adaptive learning environment in the classroom. Although there was a significant increase in perception of control in the treatment group and the control group, the overall between subject factors was not deemed to be significant. Demand was noted to be the least impacted between the three factors. It showed that student's initial perception of demand was lower for the treatment group and their final perception of challenge in the post test was overall lower, but this did not change as much as for the control group. This goes towards shedding some light on **RQ4**, where factors expected to enhance engagement are explored in terms of how they are impacted by the adaptive learning environment. The results showed a significant positive effect in terms of the students' perception of support, and while demand and control showed non-significant difference between treatment and control, the means for demand and control were more positive in the groups that used the adaptive learning environment.

7.3. Qualitative Analysis

In alignment with the conceptual framework, the deductive qualitative analysis leaned on the work of Pekrun et al. (2011, 2002), Karasek (1979), and Young (2010) to structure the semi-structured interviews as well as to inform the thematic analysis of the data that was collected. As the mixed methods approach here is explanatory, the following sections aim to complement and reveal further insights into the quantitative findings discussed in the previous section. In simple terms the qualitative findings hope to answer the question of why the numbers and significance of the quantitative data aligned the way they did which may give us a more nuanced understanding of the impacts the adaptive learning environment had on the students' engagement and overall learning experience. This may also give us insights into best practices in terms of how we use such adaptive learning environments in classroom and learning environments to further engage students in the content being delivered. To begin with, we will break down the qualitative findings based on some key themes that were informed by the literature and emerged from the data. Subsequently, these themes will be discussed individually with evidence from the data collected, and finally in the discussion section where the findings will be linked back to the research questions and help shed light into the reasoning behind what we have found in the quantitative analyse and discussion.

7.3.1. Academic Emotions

In this section, we will look at the emotions reported by students during their interviews in relation to their experiences in class and using the adaptive learning environment. The interviews were kept open, allowing students to express and share on how they felt while using the system without being directed to discuss any specific emotions, ensuing non-bias responses.

This section will first review data on all the basic emotions as defined by Pekrun et al. (2011, 2002) that were brought up during the interviews, as well as what instigated these emotions in the students based on their reflections both when using the adaptive learning environment with adaptive content and worksheets as well as when they did not use this system and instead used standard non adaptive worksheets and specific content was gained through power-point slides. In both cases, with or without the system, the lecturer was available in the classroom offering support to the students as they worked on their activities. Subsequently, this section will touch on confidence, which in itself is not classified as an emotion but was regularly reported by the students and acted as an antecedent to their emotional engagement, where the system would allow them to build confidence in what they were doing leading to higher levels of enjoyment, hope, and pride.

Out of the basic emotions, those being anger, anxiety, boredom, enjoyment, hope, hopelessness, pride and shame, among all interviews each emotion was reported at least once by participants in various contexts. The following table shows a breakdown of each emotion and the percentage of participants who reported that emotion during their interview in relation to their learning experiences.

Table 7-3 : Participant reporting of basic emotions by percentage

Emotion	Percentage
Pride	100%
Shame	100%
Enjoyment	100%
Anxiety	86%
Hopelessness	71%
Anger	57%
Hope	43%
Boredom	29%

From Table 7-3 we can see that positive emotions such as pride and enjoyment were reported by all participants, close behind them were the negative emotions of shame (100%) which was also reported by all participants, anxiety reported by 86% of participants and hopelessness reported by 71% of participants. This section will explore in depth the most reported emotions from participants followed by an overview of those lesser reported emotions.

7.3.1.1. Reported Pride

In general, all participants reported feeling a sense of pride when reflecting on their efforts in their work and making individual achievement with their work. Even though in many instances these individual achievements were as a result of interacting with the adaptive learning environment, either by clicking on adaptive hyperlinks which would direct them to relevant content or indicating that they were struggling which would reveal more information on the worksheet, this sense of working with the system made them feel as though their progress was their own, individual and belonged to them, and not as a result of getting support from someone else, as in, another actual person.

I still feel I did this by myself, even if I got extended support, but it's not like, I asked for someone else to do it, so it's kind of, still building on the (idea) 'I did this by myself, sort of, kind of feeling. – Participant 4

A lot less waiting on a different person, and probably a bit more pride because, just because, you have not asked someone else as much as you have, you have not, if you know what I mean. – Participant 6

You've got a concept you've managed to fix it on your own without asking somebody. – Participant 7

Interestingly, the way in which participants interacted with the adaptive learning environment also had an influence in the pride they felt beyond just removing the need for 'human' support. Four of the participants reported feeling a sense of pride when they did not have to ask the adaptive learning environment for support directly (indicating that they were struggling), or that indeed they had raised the difficulty and did not have to lower it while working through the activities, so in effect the nature of the adaption when related to overcoming a challenge with less support or working against an increased challenge was also giving them a sense of pride.

It would sort of be an achievement, like yea, I did not really struggle with this lesson, or I did not struggle with this worksheet, so I did it, sort of. Not hitting that button (asking for support) was rewarding in its own way. – Participant 2

Pride kicked in more of, because the next week's worksheet was up before the current lecture, and the pride really kicked in when I was like 'oh, I'm ahead of the worksheets now' that's actually (making me) really happy. – Participant 4

I'd probably press to go up a rank, but then if I got stuck then Google it instead. – Participant 1

I feel for my learning, I always wanted to keep a level of difficulty there… I never kind of just purposely went down all the way to the bottom so it was really easy for me. – Participant 3

7.3.1.2. Reported Enjoyment

Participants generally reported an increase in the level of enjoyment in relation to how their interaction with tasks changed as a result of the adaptive learning environment being in place. This often related to a number of elements, one of which was related to their ability to work more independently. This was facilitated as they

had access to specific and directed content via adaptive hyperlinks embedded in the worksheets which were made available after the system reviewed the user model to see what content the students had engaged with previously. The worksheets were also adapting to their need for support by providing it as the students worked on the different activities and allowing them to 'ask for help' from the system while working, or even ask for less help to challenge themselves and as such, giving the students full control over the support needed or the level of challenge they desire as they learn. This leads into the idea of control, where participants felt that they could control their pace, what they worked on next, how they worked on it and when they engaged with the content.

In terms of working independently, participants reflect on their ability to control elements such as when they worked on the tasks, being able to ask for support whenever they needed it without waiting or indeed just being aware that the support was available through the adaptive learning environment but not actually having to use it, and being able to move ahead of the current worksheet with more advanced tasks or insights into work for the following week if they were really progressing well.

Yea, so you can feel, you can think ok, I'm finding this worksheet a bit more difficult so I'll get up to number 9 then we'll have dinner and that'll do until after dinner or something, so you know, you can sort of break it down a bit. – Participant 1

I'd see the I'm struggling button is always there for you to hit, but when you do not have to or do not need to in a session, once you reach the end of a lecture, you kind of feel, oh well, I actually go through that on my own, so, yeah. – Participant 2

I did a couple of times make a start on next week's worksheets. I did really enjoy the module, so I enjoyed learning about it and trying to kind of problem solve and stuff, so I think I did a couple of times do it, go ahead (in the module). – Participant 3

I can get happy, but it's all about me, nothing about anyone else… (If) I could have done more I probably would. – Participant 5

You do not have to worry about you know that middle ground very rarely is good enough for both people, whereas with the system you can go whichever way you want, it is a lot nicer. – Participant 6

A number of participants also reflected on the ability to control the challenge or the demand of the tasks that they were engaging in. This had a multifaceted impact from being able to make more independent progress as mentioned above, to being able to avoid frustration or boredom as they could overcome issues with the automated support provided. This contributed to an increase in their enjoyment levels in the classroom. Furthermore, the concept of achievable demand was touched on where participants enjoyed being able to open up more challenging tasks, or tasks tailored to them, to keep them motivated to move forward.

Advanced tasks, they were like challenging but I did enjoy that because I did not feel that it was impossible. – Participant 1

I definitely felt like the pace was more tailored to me. – Participant 2

Yea, because obviously it is more tailored around the course we're doing at a level that we'd be able to understand. – Participant 4

I think it can help (to) push you further than you were supposed to. – Participant 5

I would say it felt more engaging just because you could actually vary it based on your skill of course. It did not mean that you had to be stuck to such a rigid line, so the code particularly hiding certain amounts of code, it would make you think through the algorithm a lot more so that, more that, if you did not, so you'd have a much better idea of where you were skill-wise. – Participant 6

Finally, the idea of support, which we will unpack further in a later section, being readily available from the adaptive learning environment, allowing students to make progress, build confidence and not have to wait for answers as well as control the level of assistance that they received, had played a part in enhancing their enjoyment while working on activities.

I could hit that button and have something explained to me as soon as I need it versus waiting for the lecturer to come across. – Participant 2

It did make me enjoy it more because I felt that I could do it almost like with less assistance, because I know that if I do need the assistance, I can bring up more information or something like that… I think it was a little more enjoyable to use and a lot more helpful to use than just the normal worksheets. – Participant 3

To ask for help for a bit (from the system) more as well if you really just had no idea you could refer back which means you could carry out the activities without the whole sort of hitting the deadline or the stopping point. So, yeah, a lot more variation with that… it opened it up to every ability so you do not have, if you get really, really difficult people would learn a lot more but a lot of people would just sort of stop after like 5 minutes, (and) say, oh, I cannot do it. – Participant 6

One participant also mentioned that as the content and support on the system was very targeted to what they were learning, they could spend more time focusing on a core element of this module, which was problem solving, rather than having to look for content which may not be as tailored for their learning.

You could focus more on the problem solving and how to apply what you wanted to find, which I suppose was more interesting, so you were less bored. – Participant 7

7.3.1.3. Reported Shame

The feeling of shame was mostly reported by participants in relation to how they felt about not knowing content, feeling bad about not knowing something they believed they should have already learned, or being embarrassed about asking a question which they deemed 'silly' or too simple to be asking. Interestingly, the data showed that a number of participants felt bad about taking time away from other students who might have more valid or complex questions. Even though students are reassured that there is no such thing as a 'silly' or 'too simple' a question, their self-perception of what they should or should not know gives them their own parameters in terms of what warrants a 'silly' question. Additionally, out of all the reported emotions, shame was the one that was most readily discussed by students totalling in 28 references, as opposed to 26 references for enjoyment, and 25 references for pride, with all other emotions falling below 20 references in total.

If it is something basic like that I'd rather find out from the system and not be seen to be asking stupid questions, and you'd be like, I covered this in week 2 and you do not know it! [laughs]– Participant 1

When I used to ask questions, I just kind of like, ramble, kind of, I'm not sure what I'm supposed to be asking and it's kind of, I might just waste a person's time by asking a stupid question or a question that does not make sense, and I get an answer that I really was not looking for and I've wasted both my time and their (the tutor) time. It's kind of how it usually goes – Participant 4

When I'm talking with a tutor sometimes you know, you can get embarrassed because you know, you're supposed to know more, and you know the tutor expects from you that you know that and if you do not, it's kind of embarrassing. – Participant 5

You have not got the awkward embarrassment of forgetting something you fully feel you should know by now, you can check the system rather than having to tell someone (that) you've forgotten something, so you've got that aspect, it's a bit less, public if you know what I mean. – Participant 7

Some participants also reported that having the adaptive learning environment in place to support them, made it easier for them to feel like they could catch up if they had missed sessions. Again, this may result in that sense of embarrassment to ask for help when they have missed classes, but it does allude to the notion that the adaptive learning environment may allow students to catch up when they fall behind as, from their perspective, the adaptive learning environment is a non-judgemental support structure.

Going into class maybe if you had missed a lecture, having that (adaptive learning system) there was definitely a helping hand, but knowing that you could go into the lecture and basically get the help that you need when you want it, using the system made me feel a bit more comfortable with going in. – Participant 3

If I'd missed more, I might feel embarrassed about coming back and not knowing about what is going on. – Participant 7

Much of this hesitation to ask a 'human' tutor comes from the feeling of being judged by the tutor, or as the participant would be asking in front of the class group, being judged by the class group. This was negated by the system where students could gain more information and so, they felt more confident about asking a 'good' question, or not having to ask a question at all if the system provided enough scaffolding to ensure they could find their own way to solve the problem at hand.

I sort of worry about being judged, and not being good enough to do the course to start with, kind of thing, so having the system anonymous is easier that way. – Participant 1

It's not even just about the lecturer, it's about the other students who can hear you asking the question, and you're like, I really hope this is not a ridiculous question. – Participant 1

Looking at reading through the system, it kind of gave me the extra information that I was too afraid to ask of in case of it being like really basic stuff. – Participant 4

The system has the information, and they can check that without having to ask what they would deem as a stupid question. – Participant 7

7.3.1.4. Reported Anxiety

Anxiety can come from a number of sources and indeed much of what was mentioned was related to concerns around asking questions, or feelings of being judged or not knowing what one believes one should know, which are all factors that can additionally contribute to anxiety. This section touches both on elements in class

which seemed to cause anxiety and user interaction with the adaptive learning environment which seemed to help mitigate anxiety. Participants reported anxiety around additional class interactions related to being put on the spot with particularly challenging content, face-to-face communication with the lecturer, anxiety related to returning to class after missing lessons and being worried about falling too far behind.

If it is something particularly challenging, then I do not (want to) turn up on the day with being put on the spot, and being asked direct questions without being able to process the information so I could kind of like, if I had any issues where I was like, I'm not quite sure where we're going with this, by the time the lecture came I could have done enough research to kind of know what the point of it was or whatever, you know. – Participant 1

I'd missed lectures, so having it there (the adaptive learning environment) when I'd missed a lecture or two or having it there when I had not understood something was really helpful because I could just go back to it, read it, and I suppose get myself a bit more clued up. – Participant 2

The problem with me asking lecturers is that I feel like I'm going to ramble into a vague problem and I do not know if it'll actually get across, with the system, it is like, oh, I actually know what I'm asking for help with. – Participant 4

Yea, and it also made me feel a little more relaxed because obviously, I'm not that far behind, I'm more ahead, it is a calming thing to know. – Participant 4

I was not really attending, coz (because) I was kind of scared what you'd say, or, because you saw me a couple of times… I was a few times in front of the class, I'm not getting it, I just go back, I was feeling a bit anxious, uneasy. – Participant 5

Asking a question, it feels a bit more you know, risky but you know, it's not. But it always feels like that, you might ask the wrong question which is going to go bad. - Participant 6

"It (having the adaptive learning environment) meant that you could keep going at your pace for that week and not worry about falling behind. – Participant 7

If I was behind, I'd then worry that I did not know how to apply something that I needed which would stress me out a bit. – Participant 7

7.3.1.5. Reported Hopelessness

The feeling of hopelessness was generally reported when participants felt that they were unable to make additional progress. This was reported to be negated somewhat when the adaptive learning environment allowed them to make more individual progress as a result of the support it offered. The concept of being stuck on a topic where perhaps the challenge is too great, making no progress and the despair around this feeling often leads to a feeling of hopelessness and wanting to give up.

I think I just would have sort of given up from the start really if I was put on the spot and you know, had to think of something and all of the other distractions going on in the class and I had not looked at that area before." – Participant 1

Basically, you feel that desperation (that) you've just tried everything, and I have no idea what is going on. This just feels like it should work but no matter what you do it just does not. – Participant 6

I think (that) there are a few people that when they reach a problem they think, no, I would not bother about tha.t I'll just do something else. – Participant 6

(In relation to finding it too hard to catch up) That is why some of the people in my group stopped turning up a lot, so, yeah, I guess, it would kind of help with that. – Participant 7

7.3.1.6. Reported Boredom, Hope, and Anger

The emotions of anger, boredom, and hope were lesser directly reported by participants. Again, this does not mean that they were not experienced by the students, but perhaps had less of an impact on the participants.

Boredom was least reported and only accounted for two of the participants discussing this. Even when boredom was mentioned, it was related to participants reflecting on not having the adaptive learning environment in place, so in effect they were discussing how the inclusion of the adaptive learning environment in the classroom actually negated boredom. This was achieved by allowing them to have additional support so that they would not feel like they were not making progress, allowing them to focus more energy on solving problems than finding syntax and having more content available to them week on week.

Well, when I come in and understand nothing I would feel bored, because asking you something I did not understand and we did that a couple of months ago, it's just, pfff, I'm just going to try and learn that back home. So, ya, I did feel quite bored sometimes, but not because the content or the lecturer was bad, it's just me not understanding it. It kinda (kind of) loses the point. – Participant 1

When you get stuck on something, it is a little less enjoyable but hmm, you get less, you do not get stuck as often with the information there (on the adaptive learning environment) I suppose. That would be the easiest way to explain it. – Participant 7

Participants reported feeling positive and hopeful when the adaptive learning environment was supporting them to move forward, do as best they can and keep up with the activities.

I feel as though I'm doing as well as I can. – Participant 1

If you have more ability, you would not have as many difficulties because you can push a lot easier. – Participant 6

I was learning, I was able to keep up, my learning was going well. – Participant 7

For feelings of anger, which was higher in terms of being reported by participants, it was mentioned in relation to getting angry at self, the environment, or the lecturer. In relation to the lecturer, the comment was a reflection on a different module, but related to having to wait for specific support needed to solve a specific problem for a long period of time, beyond the session itself. This was also reflected in relation to the idea that the adaptive learning environment would have the information that they needed embedded in it allowing them to find the solution to a particular problem in their own time rather than waiting for the lecturer to cover the topic.

Yeah, you have to wait for them to go to the next thing as well because (for) some lectures, you're just not getting much but there were times where you were waiting for like 6 weeks to get to the thing you needed which, no names, but it was kind of annoying when you're waiting for 6 weeks and you kind of started it, 2 weeks before it's due. – Participant 6

In relation to getting angry at oneself, this is often referred to as shame, as anger is seen as directed towards an external source. However, in this case, the

participants refer to the emotion as being mad or angry, but are clearly directing this feeling inwards and not externally. The emotion was provoked by their need to keep asking question, and their own lack of organization skills, which prevented them from taking advantage of all the support that was available.

I did not use it properly, and I'm getting mad (shame) at myself a lot because of it, I mean, I know I can do stuff but I'm just not organised enough. – Participant 5

I had to put my hand up to ask questions multiple times or ask the same question multiple times even, eh, then I would certainly feel emotions such as embarrassment and frustration or maybe even anger at some point. – Participant 2

Finally, one participant in relation to 'getting angry with others' or 'getting angry with yourself' did reflect on the fact that the adaptive learning environment is not a person, so it is harder to blame it for their own lack of engagement with it, in which case they could only blame themselves.

This is still a machine, no emotions are… interactions between me and the system, there is no emotions in-between us, I can get angry, but I can only get angry at myself, and that's all emotions, or I can get happy, but it's all about me, not about anyone else. – Participant 5

7.3.1.7. Reported Confidence

Confidence can be reported as more of something that leads to and even results from emotional engagement rather than an emotion in itself. It was highly reported or referred to by participants with 100% of participants reflecting on confidence and it being referenced more than all other emotions. In this respect, participants often reflected on their confidence and how it grew or declined based on classroom experiences, and how this would in turn impact their emotional state.

For example, participants often reported a feeling of ownership over their accomplishments, acknowledging the support that the adaptive learning environment gave them. Also, due to the fact that they were able to complete an activity without any other human intervention, their sense of accomplishment was higher, increasing their confidence and in turn their enjoyment and pride related to the activities that they were engaged in.

I think that I could make quite a lot of progress largely on my own with it, and then when sharing with the lecturers, it was like a bigger improvement than there might otherwise have been. – Participant3

I think it makes you feel a bit more confident when you feel like you can do it on your own whereas like with the system kind of thing, you do not feel so much reliance on people. So, it means you can see how fast you're pushing through. If you're pushing through a bit faster, it makes you feel a lot more confident. – Participant 6

Even though you have asked the system, you do not perceive it in the same way, you think, 'I've figured it out on my own', you have a bit of confidence rather than someone telling you this is the answer. – Participant 7

The support from the adaptive learning environment also seemed to act a bit like a safety net, where participants felt they could rely on this support to help them ensure that what they were doing was correct, or the direction that they were taking was the right one. Some also commented that asking questions when they knew they were on the right track made the process of asking a bit easier.

It definitely helped because you've already processed the information so I'd hope that all the obvious questions you'd already worked through in your mind and then you're just left with anything you're really stumped on. – Participant 1

When I actually understand more, its rather than asking the tutor what do I do here, or rather than having really simple questions, because my understanding was a lot greater, I was able to pinpoint problems within my code or where something was and then, I'd be able to ask the tutor, do I use certain functions to get this outcome? Rather than straight up, asking what do I do and the tutor having to read through my code to understand what I'm doing. – Participant 2

When the system was there, I did feel more confident with what I was doing just because I had that as a safety net in case I did get stuck. But then, it also did help me to sort of gain a lot of confidence in how I'd code stuff. – Participant 2

I'd say it probably boosts confidence just because, of course, you do not, you do not want to be reaching roadblocks that should not really be roadblocks, so you hit a link (on the adaptive learning environment) and it's just like, oh, you've got those two lines of code the wrong way around. – Participant 6

If they know they've used it right, they've got the confidence, oh, I've used it right, it is not quite working, they know (that) they've done something right, rather than they think it's all gone wrong and they're too embarrassed to ask, they know (that) they've done something right but something's not quite there, they've obviously got that confidence that if they've got something right, that gives them a confidence boost. – Participant 7

7.3.2. Perception of Demand, Control, and Support

In this section, we will review the data related to the concepts of demand, control, and support as discussed by the participants. All participants were recorded as having discussed each of these areas in relation to the adaptive learning environment. Participants discussed demand in relation to how challenging or how

easy the tasks were either as a result of the adaptive learning environment or in comparison to not having this system available to them. For control, participants often reflected on the control that the adaptive learning environment gave them over how they approached tasks or how much support they received as well as the control over the challenge they presented to themselves. Finally, for support, reflections were noted to have been in relation to the type of support that the system gave them, how this support was used as well as how lacking that support impacted their learning. Participants were also noted to have compared support from the lecturer against support from the system and this will be further explored in the subsequent section on support.

7.3.2.1. Demand

All participants reported the demanding tasks as having impacts in a number of different ways. Some participants reported the concept of being able to adjust the difficulty of their worksheets as a method of revision or review, where if they had previously completed the worksheet on a lower level, they may increase the difficulty to a higher level to check if they knew the content better or to push their knowledge a bit further.

I did not feel it was easy, it was more of a refresher, but some of the advanced tasks they were like challenging but I did enjoy that because I did not feel that it was impossible. Participant 1

Definitely being able to change the level of difficulty, at some point, I did change it to the higher one, well like no, when I was redoing them all for revision purposes, I'd change them to the higher ones and that is something like, helped me a lot to get a deeper grasp on coding and when I did a run the first time, the lower level

of difficulty help me to understand what I was doing in the first place anyway. – Participant 4

Others reported that being able to work on tasks at a higher level meant that they enjoyed what they were doing more or had a higher sense of accomplishment or achievement as well as giving a sense of learning more as opposed to attempting to do tasks on the lowest difficulty. Adversely, it was reported that if a challenge was too great, one might just not do it, whereas with the adaptive learning environment in place, rather than giving up, the option was available to adapt the sheet to your level allowing one to carry on rather than stop completely.

I was just keeping it on the lowest and I was just like breezing through it, I also did not realise that, 'hey, I'm not really just taking this much in', that was like a point that 'hey, I should probably try these harder, so that I can actually learn something. – Participant 4

I definitely say you feel prouder using the system particularly if it's in the harder stages because if it's, you know, make this function or whatever it's a lot more prouder than, here is the function fill in the gaps so you can progress a bit but I did not really do anything here I just sort of typed what it was prompting me to do, and then the lecturer's side would be sort of just depends on the question more than anything it's how difficult the task is really but definitely the harder it seems the better it feels at the end. – Participant6

Yeah, it definitely felt like I learned more when I did the hard stuff. Yeah, when I did the easy stuff it felt a bit more like its done great whatever but I do not know how to do it again, whereas the harder stuff definitely felt like I learned a lot more. – Participant 6

Yeah, you can say if it's too difficult you can drop the difficulty and say I can do this though I can keep pushing through it as opposed to not, I'll just drop it or I'm not doing any. – Participant 6

It made me think a bit more which was enjoyable when I got it working, so it added a challenge when I'd finished something which was nice. If I felt it was, oh, yea, this made sense, this was easy, the extra bit was like, oh, try to do this using this method, it was then like a puzzle and when you figured it out, it was rewarding. – Participant 7

One participant believed that the adaption on the system was a nice way to gauge difficulty, allowing the adaptive learning environment to give more or less information depending on the ability of the user.

I think the adaptive part of it is a good way to gauge difficulty for every different person. So, if you do not understand something, you can get more information on it. – Participant 3

Another participant reflected on the fact that when facing a challenge, he could get instant support from the system towards working out a problem rather than having to wait for support from the lecturer or peers.

If I get stuck somewhere, I have to e-mail you and wait for a reply or call some of my friends who did the same work and wait for them to kind of explain it and now, I can just click on it (the adaptive learning system) and try to work it out. – Participant 5

7.3.2.2. Control

Participants reflected on the control over their learning as being able to report if they were struggling or otherwise. Subsequently, this involved adjusting the amount

of information in the worksheets or adding some additional challenge if the participant felt that they were doing well. This was linked to both aspects relating to support and challenge as participants felt like they had control over the amount of support they received, when they received it, and they also felt that they could have the challenge adjusted on the spot based on their needs. Some participants reported trying to ensure a high level of challenge so that they would be able to learn more and sharing that they were struggling only if they were not able to make any progress.

Once the initial quantitative data collection was completed, students were able to use the system more freely. Based on this, a number of students reflected on the fact that they were finding it advantageous to be able to access and use the system whenever they wanted to. This resulted in a number of them engaging with the content from home, perceiving it as a way to continue to get support outside of the classroom. In simple terms, they were able to control when and where they engaged with the system and to have access to support when they needed it without involving their tutor directly.

So, if I'm at home, in my own space, I can do when it is quiet. So, I can properly get my head into(it) whereas it's awful when you're trying to concentrate on code when people are interrupting you constantly and it is like a form of torture because your brain has got to go back in and out all the time so it. – Participant 1

I'd actually been through it in class and used that 'I'm struggling' button if I was struggling and then come home and try and do the code from scratch. I was able to actually remember a lot more and sort of produce more of my own code in a way. – Participant 2

Yeah, definitely because like I say, when I was out of class, I could easily follow on and get a lot more support than just the normal worksheets. – Participant 3

The support I get from the system is basically available whenever really. Like I do not have to email you at midnight asking for help with small, tiny mistakes. – Participant 4

The system was online, it was always online, so, you could get it (information) whenever you needed to, and the explanations were very useful and nearly every time, they were sufficient for what I needed. – Participant 7

Although generally the information available with or without the system was the same, the source was somewhat different. For the most part, all of the information that the students require, would be available either in the PowerPoint slides or in other external sources (such as by searching on the Internet). However, many perceived more information were available with the adaptive learning environment in place. This was most probably due to the information being available contextually and on demand, either through adaptive hyperlinks or when students reported that they were struggling with a targeted problem.

The worksheets, you just had the (PowerPoint) slides and then the lab tasks, but then this (adaptive learning system) had more information. – Participant 1

I know that if I do need the assistance, I can bring up more information. – Participant 3

The system, it kind of gave me extra information that I was too afraid to ask, in case of it being like really basic stuff-Participant 4

You could get the information whenever you needed to because you did not have to be in the lesson itself with the lecturer. – Participant 7

Participants shared that they liked to have a level of difficulty to support their learning. As such, they preferred to not adjust content to be too easy for them just for the purpose of clearing or completing the content. They used this control really as a support mechanism as well as a confidence boost when they were able to perform at a higher level of difficulty or maintain their level of learning or progress. This control over their pace was also noted in the section on confidence above.

I feel for my learning, I always wanted to keep a level of difficulty there. – Participant 3

I'd lower the difficulty if I got stuck and then increase it if I knew what I was doing and I wanted to sort of challenge myself a bit more or get a better understanding of it. – Participant 6

Definitely the harder it seems, the better it feels at the end. – Participant 6

It meant that you could keep going at your pace for that week and not worry about falling behind or getting too far ahead and having nothing to do because there were always the advanced tasks. – Participant 7

In terms of negative response to control, one participant reflected on the lack of content, or a lack of granularity offered by the adaptive learning environment in its current state. This was a result of time limitation that influenced the content, but it is definitely something that can be improved upon in the future and will be further discussed in chapter 9 section 9.3.

I did try to go onto other things, but then it would always say (that) the content is not available yet or things like that. – Participant 1

Some students touched on the idea of being able to just enable all of the support, as this was something they could control. However the desire to actually learn and not just see all the answers ensured they used the support in the right way and controlled how and when they would get additional scaffolding from the adaptive learning environment. One participant even reflected that having too much content available might give them too much control and make it difficult for them to manage their workload themselves resulting in them doing too much work.

I think a week ahead is good or you know, sometimes two weeks, but I think any more than that I might have just gone on a 3-day bender or something and not sleep – Participant 1

(In relation to making the content very easy) Yeah, because I do not think it would have helped my learning if I was doing it like that.- Participant 3

If you just watch all the videos, you'll get all the answers. – Participant 5

7.3.2.3. Support (Lecturer vs System)

Support has been touched on in a number of other sections as a result of the student's interactions with the adaptive learning environment. For example, when they were able to adapt worksheets to support them with challenging content, or to give them additional control over their learning. In addition, the nature of the support coming from a system rather than a lecturer gave students a higher level of perception of their work and progress being their own and this resulted in an increase in the level of enjoyment, confidence, and pride.

This section will explore how students perceive support to be different when it is provided by the lecturer and the adaptive learning system. It explores this from a number of perspectives based on what was reported by the participants. Participants shared the differences as; involving their feelings of being judged as opposed to not being judged when comparing the support received from the lecturer and support from the adaptive learning environment, not taking time away from the lecturer with simple questions, instant support from the adaptive learning environment as compared to waiting for support from the lecturer as well as the additional content and targeted support a lecturer could give that the adaptive learning environment could not.

The concept of judgement was also apparent in terms of students reporting a feeling of shame in relation to asking questions that they perceived as silly or unworthy of the lecturer's time. However, some reported this concern of judgement directly in comparison to how the lecturer might perceive them when asking a question and in comparison to this, how getting the answer from the system would be better for them in this respect.

Clearly, the system is not a human being, so it might be the tutor judging me. – Participant 1

Yah, it is like this (lecturer) is going to judge me pretty poorly after asking a stupid little question that I have not figured out ye,. And obviously, with the system, it cannot judge you for what you've asked or what you're stuck with. – Participant 4

(In relation to forgetting something simple and getting system support) They do not have to worry about somebody else judging them. – Participant 7

Five participants reflected on the concept of the value of time. This was discussed in terms of how they perceived the lecturer's time should be spent, or at

which juncture or situation that they would direct the question to the lecturer rather than turning to get the support from the adaptive learning system. Participants felt that simple questions were not really worth the lecturer's time and with the adaptive learning environment in place, such questions could be efficiently answered by the system itself. Participants felt the lecturer's time was best spent answering more contextual or complex questions which may have been more challenging for the adaptive learning environment to support. As such, by dealing with less complex questions via the adaptive learning system, it was felt that they were enabling the lecturer to focus on the more difficult questions which were more worthy in the participant's opinion.

I would not want to waste your time by asking a stupid question, and yeah, I would only sort of ask if I got to a point where I was sort of, this is wasting my time because I cannot progress and I'd tried using the system. – Participant 1

The lecturer has to answer everyone else's questions and help everyone else so I guess it makes that more efficient for those kind of smaller problems. – Participant 3

If I lower the difficulty, I do not have to ask for you (the lecturer), so you can help the others, and then when I get to the point that I cannot do anything, it's the only time when I have to actually ask for you (the lecturer). – Participant 4

Yep, particularly when you have a class full of people and yeah, you do not want to take attention away for something dumb particularly if someone else needs help. – Participant 6

I think it would save (you) the tutor (from) having to remind people all the time if they're using the tool wrongly, if they're checking the system, oh, I have not written

it right and save the question, and then you (the tutor) have got more time to help people, maybe more with the application side of it which is also important. I think it frees up more of the lecturer's time to work on stuff that is probably more the kind of stuff you'd want the lecturer helping you with rather than I cannot use a for loop. – Participant 7

One important factor that was raised by participants was the time in which it took for them to receive the support that they needed. The concept of bottleneck exists in a classroom as the relationship between a lecturer and students is usually one lecturer to many students. As such, at any one time, there can be many questions being directed at the lecturer. In this case, usually a lecturer will try to take questions in order but will need to address one at a time before they can move to other questions or potentially, if they can identify that multiple questions are similar in nature then they can address the class or get a small group of individuals with the same problem and work through it with the group. However, participants reported that the system was sufficient in providing the support for many of the problems that they faced, which allowed them to get instant support. To an extent, they felt that it was on par with the support the lecturer would give but without the waiting time. This was partially due to the fact that the lecturer had built the support that the system offers, based on the lecturer's teaching experience with such classes. This enabled the lecturer to design and provide the needed guidance or support from the system to the students in the format that addressed their learning needs, and which was contextual to the learning content and objectives.

(When asked about difference between tutor and system support) Well, I mean, seeing as the tutor wrote the content, not a great deal I suppose, unless it is you know,

you being there and explaining things in more detail, but I do not think it would be able to replace the tutor, I would not go that far [laughs] – Participant 1

(When asked about difference between tutor and system support) To be fair, I would say it is relatively the same because at the end, I'm still getting the knowledge that I need, I'm just reading it in a way that it's more, I supposed, in context. – Participant 2

Yes, dropping, dropping the level was basically like raising my hand and asking you (the tutor) for help in my eyes, that's what it was. – Participant 4

Tutor cannot be with everyone all the time, he can only do one on one, or one to two or one to three if it is a group, but when it is one to one and there are fifty students in the room, it is hard for the tutor to walk around and ask everyone if they need help, this way it kind of lifts a bit of weight from the tutor and it makes it easier for students. – Participant 5

Yah, it (the system) gave me what I needed, if I needed more, I could ask in the lessons, but it always answered the questions I had so it was great in that regard. – Participant 7

What I liked a lot about the system is that it is still trying to be as human as possible, it is still trying to push you, it is not just there to like, you know, you're reading a book and you're just getting the answers, it's not like that, it's still trying not to be the one that teaches you. – Participant 7

Well, I do not think it is reasonable to think the tutor would get back to people immediately anyway. – Participant 1

It was a lot easier to go to because like there was no waiting time or anything like that and I could just keep reading through everything for as long as it took me to understand what I was trying to do or what we were being asked to do. – Participant 2

The adaptive learning environment was basically there as soon as I found myself having a problem so if something did go wrong or I did not understand something, I could just go straight to that rather than having to wait for other people to get through their problems. – Participant 2

If the answer, it literally, is covered in this part, it is a very sure answers from the lecturer, then you'd have to wait quite a while to get that question answered. – Participant 3

Well, first, you just check the system right away whereas obviously if it is 20 people asking questions, you're going to have to wait for the lecturer. – Participant 6

He might be busy helping someone else too, who needs help so ya, it means you did not have to wait for 5 minutes as it may be, you could go straight in, obviously, if you then could not find it or still needed further explanations, you could always ask the lecturer. – Participant 7

The lecturer not being able to be in all places concurrently placed the adaptive learning environment in a positive light from the participant's perspective, with some even seeing it as an equivalent to one-to-one support. However, two areas in which that the lecturer did perform better than the adaptive learning system were in terms of granularity of support and for specific and contextual support. In terms of granularity, the lecturer can always go further than the adaptive learning environment can go. To illustrate, for students who require support for the tasks at hand, the adaptive learning

system may be the answer. For those that require in-depth information or knowledge that goes beyond the expectations of the module itself, then the lecturer would be more appropriate in this instance. The lecturer would be able to provide support in addressing more abstract problems, or provide reflections from industry practice or in sharing the lecturer's own experiences. Similarly, the lecturer can also offer highly contextualised support. For example, if a student has a very specific problem with their code or their logic, or they are doing their own personal project and need help with their own system design, having a lecturer that can scan through the code, or understand the big picture of the student's system and offer advice would be more beneficial to the students. In this regard, students appreciated the combination of both the adaptive learning environment support and the additional layer of support offered by the lecturer.

The benefit of being in class was having the tutor there, as somebody, so if you get particularly stuck, you can get it, sort of, explained in a different way. – Participant 1

If it was something quite specific then I could, you know, get help from a real person. – Participant 1

Obviously, asking the lecturer is very good and they can give you a very specific answer for a specific problem. – Participant 3

To really elaborate on things, I still have to actually like get someone to explain it to me properly, but for the most part it (the system) gave me a better idea of what I was doing. – Participant 4

I get a bug out of nowhere and I'm not sure what went wrong, the tutor can help me figure it out, exactly what was the problem, much faster than what the system can. – Participant 5

(With the system), you cannot just say show me this and then have more external knowledge so I will say it just tells you about that project normally whereas you can say to the lecturer, 'I'm hoping to apply this here' which is a lot more external knowledge.-Participant 6

It's that outside knowledge, or industry knowledge that it (the system) would not provide.-Participant 6

Yeah, I think the system, it was more supplying you with the tools and how to use them, the lecturer more on how to apply them in the context you want.- Participant 7

7.3.3. Working with or without the Adaptive Learning Environment

7.3.3.1. Working with the Adaptive Learning Environment

Generally, impressions of working with the system were very positive from all participants. Only three references to reflection on the system were considered negative, one being related to the system not being able to support as much on unique problems proposed by projects as it was more designed around core concepts and specifics related to worksheets.

I feel when we got into making our own projects the questions got a lot more detailed and would not have been helped as much by the system. – Participant 3

Similarly, when participants wanted to expand their knowledge into more advanced topics, the system was relatively limited, and the tutor could obviously go

further. However, this is something that can be resolved with time as additional content can be developed for the system.

You might feel less inclined because it does not expand as much, like to ask a really vague question so, you know, on more Advanced Collision methods or something, you could not really ask the system as easily as you do with the lecturer. – Participant 6

Finally, one participant felt that they could have used the system better themselves, in simple terms stating the system cannot do the work for them. As a result they highlighted the need for the students to engage with the content and support structures provided by the system in order to truly benefit from them.

The system helps when I try, but (the) system cannot work instead of me, I have to put my own work so it can help me progress even more. - Participant 5

In terms of positive response to using the system, 79 references were reported. Many of these positive responses were related to elements discussed in the preceding sections. Further, students also perceived the content to be easier when the support of the system was in place. Students shared that they felt it was easier for them to write code, to get the information they needed and ultimately, to make progress.

It was definitely easier when the system was being used. – Participant 1

It actually helped me sort of learn the code a bit, understand the code a bit easier especially with the links back to the content. – Participant 2

With the system, it (information) was a lot more similar to what we had learned so there was not anything unnecessary or anything in the content that we had not already been thought or shown. – Participant 2

If I was confused about what something was on, how to do something, then I could bring (it) up in more detail on how to do that, I guess it stopped it (from) being like so much of following instructions and made it more of an interactive experience. – Participant 3

It was kind of, (for questions of) lower difficulty, definitely, certainly helped, just to push me like the tiny bit forward. – Participant4

I think if I had system, I could have progressed faster and in the same amount of time, I think, I could have improved even more, and learned even more than I did. – Participant 5

I'd say more progress because it was easier to progress at whatever pace you wanted to. – Participant 6

Yeah, because I did not have to try and Google it or wait till the tutor had a minute to ask the tutor a question because I could find it, look it up, because of the way everything was laid out, it was easy enough to find the bit I needed. – Participant 7

Participants also reported appreciation for the information in the adaptive learning environment being targeted or customised to their learning needs and to the module. This was sometimes compared to trying to do a search online for information which at times, was more confusing and less directed than the information or content that the adaptive learning system was able to provide. Further, such contextual and directed information was able to help them progress at their own pace so they could keep moving forward without getting stuck and requiring as much assistance.

This was targeted information, so you were learning a specific thing in the way that you'd want us to learn it and not just some random Internet thing so. – Participant 1

Being able to select if I was struggling or not, which I usually ended up coding, it actually helped me sort of learn the code a bit, understand the code a bit easier especially with the links back to the content. – Participant 2

Google - there is a lot of like trying to filter out what you would find, because there is a lot of like, jargon in there that we either in our first year had not heard of or when you were looking at someone's code for something you would find that there were like a lot of things that you did not need or a lot of things that you did not understand why they were there, whereas with the system, it was a lot more similar to what we had learned, so there was not anything like unnecessary or anything in the content that we had not already been taught or shown." – Participant 2

Yeah, like, if I search up a problem, then someone would have posted a specific problem that they had and someone would have posted a specific solution for their project, and it would not be explaining how to solve a problem more globally (generally), it would be more specific to that, and you'd have to search around a lot to find something which was more relative to what you were trying to do and you'd have to weed out the important bits of information from Google. – Participant 3

It helped me progress a lot more than what I was doing in normal lectures, because like it helped, it was kind of, the lower (level of) difficulty definitely, certainly helped, just to push me like the tiny bit forward, like the small tiny mistakes (that) I keep making and obviously (the system) would say 'hey, remember this tiny little bit'

and it was like 'oh, right, I forgot that', so, it definitely helped push me forward. – Participant 4

(With the system) If you wanted to challenge yourself, you could. But then you could jump back a little bit if you found out that you were stuck. – Participant 6

The system, of course, would be a lot more specific to what you're doing because it is what you're doing whereas Google would be a bit more generalized so if you need to figure out why it was not working in your software, the system will be a lot better. – Participant 6

Comparatively, it was more annoying trying to find this, like the functions and the methods, whereas in the system you can just look, if you want a reminder on how to do a for loop or whatever, you just went straight in there, whereas, when it (adaptive learning system) was down (not available), you had to then Google it and make sure you had the right context for what you wanted, it made it much easier when it was up and running as to when we did not have it. – Participant 7

7.3.3.2. Working without the Adaptive learning environment

As participants had experiences working both with and without the adaptive learning environment at the time of the qualitative data gathering, all participants reflected on the differences between working with and without this system in place. Some of these reflections were evident in the discussion in the previous section, specifically relating to comparison between information that they could search for on Google and being directed via an adaptive hyperlink to context specific content which was more tailored to their needs. As the information and content on the adaptive learning system was either coming from or vetted by the lecturer, it was perceived to be a good source of information as opposed to searching for answers and sometimes

being unsure of its source, which tends to happen when they come across it on the Internet.

Yeah, it gave you extra information if you needed it, ya, it was useful because it gave you a place to look if you wanted more information rather than having to just guess and obviously because it was advised, we knew the source was good. – Participant 7

As this was a first-year module, this directed content may have been more relevant as they would need time to understand basic syntax, focus on the core concepts and build their confidence in programming as well as to develop a sense of what they needed and how they needed it before exploring more complex sources of information. The latter may seem intimidating and may lead them in different directions away from the information that they needed.

When you're sort of doing independent research, you end up going down this mad rabbit hole of stuff going to stack overflow and all sorts of things, and go off on a tangent and might learn some completely bonkers stuff. – Participant 1

Without the system I kind of found myself Googling a lot more things and trying to find other solutions and stuff.-Participant 3

Googling was pretty horrible, it does not really give you the answer you specifically want most of the time, it takes like half an hour to find even a vague-ish answer close to what you want, ya, it is just a lot more time consuming. – Participant 4

Yeah, and certainly incredibly hard to understand at someone's first attempt at programming because there is also so much stuff that you do not know what it is yet and how it interacts. – Participant 4

I do not know what to do here, it was hard to get more information of course, just certain points it was a bit more tricky to find out where I really was, particularly if I came back to something, like if I left the worksheet halfway through and had to come back to the worksheet, that can cause issues if I do not remember where I actually was. – Participant 6

7.3.4. Experience Working with the Adaptive Learning Environment

All participants were asked to reflect on their overall experience using the adaptive learning environment and they were also asked for any suggestions for improvements. On the whole, their experiences were mostly positive, with many reporting that the system met their expectations in that it was able to do what they needed or expected. In this regard, the system was also found to be familiar and they did not highlight any changes required. Some participants felt that it would be useful to have even more information at their fingertips such as topics which might help them push their understanding even further or to go beyond the module's learning objectives. Some participants also mentioned being able to track their progress by using the system. For example, based on one's exact position on a worksheet, he or she can obtain some information or analytics about his or her performance and progress such as the difficulty level and progress made from week to week

I supposed hmm, more content eh, if things like when we were doing the distance formula, I did not kind of know it was a thing, I just kind of a formula about distances, I did not think that is a thing if you see what I mean, so maybe sort of, here is the basic idea of this or, like maths, maths would be good. – Participant 1

Maybe the ability to save the very specific point where you were. – Participant 6

Maybe gives you a general view of how long you were on the hard (worksheet) and how long you were on the easy (worksheet) to give you a general idea of how hard you found the topics. If you found collision detection, it was really hard, I think, 'I do not know that (topic) so well' (then) I might look into it a little bit more. If you spent ages on it or you did the whole thing on hard (worksheet), you would know, 'I know that really well'. – Participant 6

I think if you are doing well it is nice to have that confirmation that you're doing well. – Participant 7

It was natural to just sort of have it there like hmm, there was not any getting used to it, hmm I dunno (don't know) it was just easy and simple to use. – Participant 2

I felt it was fairly intuitive, I think obviously having the links and things like coloured. I think, I do not remember anything about not being able to use it so I guess it was fairly intuitive, so I did not have any problems with that. – Participant 3

I actually hope you or someone else will continue developing the system and that one point in the future maybe my kids or grandkids are going to have one on one tutor that is going to be almost the same like human so it is going to be easier for them. – Participant 5

I felt it was pretty intuitive to be honest I probably did not know all the parts I did not know the tree was there [laugh] but more about not knowing it existed rather than finding it difficult to use. – Participant 6

I did not have any problems with it, it had everything I needed so I just worked with it, I suppose occasionally a link would not work on a few pages, but that was not

much of an issue. I was quite content with it, it had everything I needed so I was quite happy with it. – Participant 7

7.4. Conclusion

This chapter has served to present the data analysis and findings for both the quantitative and qualitative data collected as part of this study.

For the quantitative findings presented in section 7.2, data was analysed in accordance to the research questions and sliced according to:

- Overall emotional engagement
- Classroom emotional engagement
- Learning emotional engagement
- Positive and Negative emotional Engagement
- Impacts of perceived Demand, Control and Support

The qualitative analysis in section 7.3 is presented mostly according to emotions discussed by the participants, listing the emotions and the frequency in which they were discussed. The section also presents findings on students' experiences using the adaptive learning environment and working without the adaptive learning environment in place.

All findings are presented openly in this chapter with the intention to discuss the findings in more detail and relate the findings back to core literature in our discussion in Chapter 8.

Chapter 8

8. Discussion

8.1. Introduction

The previous chapter looked at reviewing and analysing both the survey data and the semi-structured interviews to address the research questions. This chapter aims to explore these findings through a detailed discussion linked to previously reviewed theory from the literature review. Reasoning behind the results will inevitably overlap as the qualitative findings serve to shed further light on what we have found in our quantitative findings, as such this chapter is divided into the main themes of the research, aligned with the research questions and within each theme, the related quantitative and qualitative findings are discussed.

This chapter addresses part of **objective six** which is to discuss the findings and contributions of this study with the remainder of this objective being addressed in the conclusion.

8.2. Quantitative and Qualitative Findings Overview

The structure of each section of this discussion will start with a quick recap of the relevant quantitative findings followed by an exploration and explanation of these results with support from the qualitative results with links, when necessary, back to the literature.

Due to the structure of the quantitative data it was possible to look at not only overall emotional engagement but also at emotional engagement from a classroom perspective, from a general learning perspective and within both of these perspectives from a positive emotion and negative emotion view point. (Pekrun et al., 2011, 2002). Finally the impacts of demand, control and support (Karasek, 1979; Young, 2010)

were examined to see which of these elements influenced overall emotional engagement and which were impacted by the presence adaptive learning environment.

This discussion of the findings aims to not only address the research questions proposed in this study, but also aims to provide us with further insights and suggestions into future possible directions and improvements for potential subsequent studies, which will be discussed in the conclusion.

8.2.1. Discussion on Overall Emotional Engagement

To address our main research question, **RQ1**, a combination of all emotional engagement scores from classroom to learning engagement and positive to negative engagement, are used to give us an impression of the overall emotional engagement for both the treatment and control groups.

The lab-based sessions are structured, both for the treatment and control groups, in such a way that students are able to control the pace of their learning, make mistakes, and work through problems with the available support. In both groups, the lecturer was on hand to answer questions which was the norm for such sessions, and the objectives of the worksheets, adaptive or otherwise, were the same, with the adaptive system providing information on demand through adaptive hyperlinks, and adjustable scaffolding of information in the worksheets depending on the abilities of individual students.

The initial expectation of this study was that students would have a higher level of emotional engagement where the adaptive learning environment was in place. It was originally assumed that the adaptive system would provide a similar level of effective scaffolding and support as provided by the lecturer. As noted in the work of VanLehn (2011), it was hypothesized that although human tutoring may be able to

provide scaffolding at a higher level that an adaptive learning environment, an interaction plateau was identified where such additional scaffolding would not yield better results. As a result, the students at this point would have to progress from where they were in their understanding of the content to gain more depth of knowledge through application. Likewise Stockwell et al., (2015) suspected that blended learning could complement learning paths and enhance the overall student experience. De Bra et al (2013) alluded to the placement of such adaptive learning environments in the classroom as being the most suitable application. De Bra et al (2013) noted that too much autonomy may not be suitable for all students, and the guidance of the lecturer in a formal classroom setting may resolve this issue for all but the more self-directed learners who would need less support.

As a result of the above mentioned, the expectation was that students would have a much more positive overall learning experience, showing an increase in positive emotional engagement and a decrease in negative emotional engagement. From the quantitative data analysed in this study, this seems to be the case due to a significantly higher level of emotional engagement in the treatment group. The qualitative data also aligned to this expectation with students reporting on positive experiences gained through their interactions with the adaptive learning environment, and often reported negative experiences as either mitigated by the adaptive system or as a result of not having access to this system.

At this point we are only focused on the overall results and note their alignment with initial expectations, however in subsequent sections we will dive deeper into exactly why overall emotional engagement was increased by the adaptive learning environment by exploring individual facets of the results. For this section however, we can address **RQ1** with our findings that overall emotional engagement is

significantly improved in a classroom where an adaptive learning environment has been deployed.

8.2.2. Exploring Classroom and Learning Engagement

To further explore emotional engagement as a construct, and work towards answering **RQ2**, the data was split for analysis into classroom related emotions and learning related emotions. As all of the students attend classes with their own history of learning experiences, they may have preconceptions of how they feel about certain topics or modules. This in turn would have an impact on the initial state of their classroom and learning emotions. These preconceptions of their emotions, which in this study are captured by the pre-test, are referred to by Pekrun (2006) as habitualised achievement emotions which he defines as occurring without a new appraisal happening, but as a result of past or existing experiences. An intervention can result in students revaluating their appraisal state in which case their habitualised emotions may be overridden by a new appraisal if the situation changes as a result. Likewise, if their learning situation does not change or give students any reason to re-evaluate their appraisal state in a certain class, very often the classroom and learning emotions they leave a session with are very similar to those they began the session with.

As this study is cross-sectional and within a classroom environment, exploring impacts on both sets of emotions can provide further insights into what was contributing to the students' overall emotional state. This split was also inspired by an understanding that blending learning using technology in classroom environments is widely accepted as a pedagogical approach which enhances experiences in the classroom through improvements in engagement, satisfaction, and performance. It also enables learners to have a more active involvement in their own learning (Roblyer, 2004). The AEQ (Pekrun, 2002) was designed to allow for the extraction

of classroom related emotions and learning related emotions allowing us to explore the data further and to better ascertain where the overall emotional engagement score was actually coming from, or at least which was most influenced by the adaptive learning environment. Manwaring at al (2017) also noted that emotional engagement is uniquely influenced by different aspects of individual students such as their interaction with activities (such as engaging with the worksheets). As such, although there are many facets to engagement, such as behavioural and cognitive, it is possible and justifiable to look at an individual element, which in this case is academic emotional engagement, so as to explore this in more depth, rather than a brief review of all aspects of engagement which are uniquely impacted by other factors.

While reflecting on how the adaptive learning environment can impact the natural classroom environment and considering the work of Graham (2009) in the evaluation of the use of technology in blended learning, the adaptive learning environment allows for a level of one-to-one support which is not possible in a one-to-many environment which is basically having one lecturer and many students. The technology here also contains a user model for each student which tracks exactly what content a student has explored and what level to pitch a worksheet at. This helps us to evaluate the use of the adaptive learning environment in the classroom, as a transforming blend, as the nature of adaption through the use of technology and the ability of the adaptive learning environment to track very specific details of an individual student, is beyond what an individual lecturer would be able to achieve in a large classroom environment.

With the above mentioned as potential support for an expectation of significant impacts on classroom emotions, the data does align with this expectation. Both classroom emotional engagement and learning emotional engagement significantly

increased for the treatment group over the control group. However, classroom engagement showed a more significant increase in emotional engagement and a large effect size.

There are a few possible theories for this, one being the issue of bottlenecks, where many students required the support of one lecturer potentially at the same time, being resolved in that students may find answers through interactions with the adaptive learning environment as opposed to waiting for the lecturer to be available before asking a question. In our qualitative findings, students reflected that they felt they could overcome many fundamental problems they faced through the support of the adaptive learning environment, seeing it as similar to one-to-one support and acknowledging they could make more process on their own with the adaptive environment in place.

As stated by (Ben-Eliyahu et al., 2018), engagement emanates from learner-activities interaction, meaning the more actively involved in the activity students are, the more engaged they feel. This ability for the adaptive learning environment to support the students to have continued and active engagement on the activities, without waiting for the lecturer, likely increased their engagement, and enjoyment in the class.

In addition, with the intervention in place, students were able to re-evaluate their learning experiences both inside and outside of the classroom with the intervention itself giving them an opportunity to re-evaluate their goal expectancy which, if it is a positive experience, could lead to further engagement on the activity (Weiner, 1985). This can be seen somewhat in that the quantitative results often showed a higher level of initial engagement at the start of a session with the

intervention in place, as well as through the qualitative data where students reflected on feeling more positive about their lessons when the adaptive learning environment was in place to support them while they worked on the activities.

All of the above mentioned helps us to address **RQ2**, finding that both classroom and learning emotional engagement are significantly positively impacted for the treatment group over the control group. We have also explored potential reasons why this impact has a greater effect size for classroom related emotional engagement over general learning related emotional engagement and how re-evaluation of goal expectancy for the treatment group could also account for the initial higher emotional engagement levels during their pre-test. This leads us up nicely to exploring positive and negative emotions, to determine which are most impacted by the intervention from a quantitative perspective and which aspects of emotional engagement students discussed most from a qualitative perspective. Again, the quantitative findings with reasoning through qualitative discussions from participants will help us providing deeper explanations as to why classroom engagement was impacted most by the intervention.

8.2.3. Exploring Positive and Negative Emotional Engagement

To address **RQ3** and with the existing knowledge that the adaptive learning environment has had a significant impact on overall emotional engagement, both classroom and learning engagement and had a larger effect size impact on classroom engagement, we can now delve deeper into the data and separate positive and negative emotions to see which are most impacted (positive or negative), in what context (classroom or learning) and why.

From our quantitative findings we found that the impact on a reduction in negative emotions was significant and with a large effect size, which points to the theory that the system may indeed have helped students avoid negative emotions. As previously discussed, negative emotions may have been a result of bottlenecks or students having a difficult time to make progress without the lecturer's support. This would point to the idea that the system was helping students learn and make individual progress with support from the adaptive learning environment. The support provided in this case was perceived by the students to be sufficient for them to make autonomous progress.

When looking at classroom and learning related emotions separately, both showed a significant decline in negative emotions where the intervention was present, with classroom related emotions showing a large effect size and general learning related emotions having a medium to low effect size. Anxiety is a key contributing factor in negative classroom emotions, not just pertaining to exams but also due to just being in class (Pekrun et al., 2002). So what invokes this and other negative emotions in the classroom and how does the adaptive learning environment address these emotions. The findings in this study showed that students expressed feeling anxiety and shame about asking 'silly' questions or being judged by the lecturer or peers, regardless of how supportive the classroom environment was designed to be. Students also reflected on being able to build a sense of confidence or self-efficacy through their interactions with the adaptive content and worksheets on the adaptive learning system which allowed them to ask more involved and directed questions which they were more comfortable with and felt less likely to be judged on. This notion of fear of being judged was also reported by Kahu, Stephens, Leach, & Zepke (2014) in relation to students being hesitant to engage in online, course, or campus

discussions. Other negative emotions students reflected on feeling were boredom, hopelessness, or anger if they got stuck, could not make progress, or did not have enough to do if they are making progress. These were all elements participants mentioned were addressed by the adaptive learning environment again relating back to that feeling of getting one-to-one support, making individual progress and in the case of the stronger students, having adaptive options available in the worksheet when they were progressing faster than the rest of their peers.

The impact on positive emotions was not significant, although there was a higher increase in positive emotions for the treatment group over the control group. Looking at the mean values from our findings, this could point to the fact that the level of emotional engagement was already quite high at almost 4 and just above 4 between the pre-test and post-tests. Beyond this, there may be some polarity to the answer of why positive emotions were not significantly impacted. At one end, weaker students who don't find enough scaffolding and support provided by the system may continue to struggle and still be required to wait for the lecturer's support, in this case the system would not have a major influence on their positive experiences. On the other end, stronger students may not see the available tasks as challenging enough for them, or they may still not have enough to work on even with the system providing them with additional content. Manwaring et al., (2017) found something similar with higher GPA students having more negatively impacted engagement. Young, (2010) describes this as lacking 'good stress' brought about by an appropriately challenging activity. As such, as the adaptive learning environment grows over time with more varied content, these two ends of the spectrum of ability could be something that is better or more explicitly addressed by providing more scaffolding and support for weaker students and more complex and involved tasks for stronger students. However,

in current state of the intervention for this study, time was a factor in creating such additional content to further satisfy these two groups of students, yet this does present a most intriguing aspects for further research.

While the above mentioned relates more to learning experiences, further examination of the results showed that positive classroom related emotions actually did have a significant increase, whereas positive learning related emotions did not, again this data supports the students qualitative accounts of how the system helped them build more positive experiences in the classroom, indeed the emotions of pride and enjoyment were discussed by all participants. Of particular interest here again may be that sense of making their own progress in class by using the adaptive learning environment and not having to get as much support from the lecture. Students reported this gave them more confidence and also gave them ownership over their progress and achievement and pride in the work they were doing, specifically in relation to not having to ask the lecturer for support.

The above section helps us answer **RQ3** with an exploration of how positive and negative emotions are impacted, showing that overall the adaptive learning environment had a significant positive impact on increasing positive emotions and decreasing negative emotions and in further exploration showed that only positive learning emotions weren't significantly changed by the adaptive learning environment, raising an interesting challenge for further research. The qualitative data also supported us in answering the question of why these findings were as such, with adaption and support being two key factors which seemed to influence their perceptions of positive and negative emotions both in the classroom and for their general learning experiences.

8.2.4. Exploring Demand, Control, Support

As was mentioned earlier, the initial expectation of this research is that the adaptive learning environment would be a stronger form of individual support that students could receive without having to wait for the lecturer with the hope that this support would impact their emotional state in the classroom. The current findings do support this with negative emotions being more impacted across the board, and classroom related emotions having the greatest impact in all aspects of emotions currently explored. Going deeper, the elements discussed in the literature by Karasek (1979) and Young (2010) of demanding tasks, control over learning and varied forms of support were examined to see if these were indeed impacted by the presence of the adaptive learning environment.

Interestingly, the only factor which showed a significant impact as a result of the treatment was support with a large effect size. This aligns with the initial expectations of this study and makes sense in relation to the discussion of the previous data which showed that students felt a greater emotional impact in the classroom setting and this having a greater effect on mitigating their negative emotions as the support from the system helped them ask better questions and make more individual progress. As such, this data helps us understand with greater clarity that as students felt more supported, their overall emotional engagement increased and points at support as being a key factor in their emotional state, even if this support is offered through an adaptive learning environment as opposed to from a lecturer.

As classroom related emotions were greater impacted with high positive emotions but a larger impact on negating negative emotions especially in the classroom, this also points to the idea that the adaptive learning environment was somehow making the classroom experience better for the students and enhancing

support structures. The qualitative findings support this as students reflected on how the support offered by the adaptive learning environment was very similar to that which would have been given by the lecturer. Participants felt that although the adaptive support was created by the lecturer, they perceived it as not a 'human tutor' which helped them take ownership of their progress and develop more pride in their achievement over having being supported by the lecturer directly. The support was also 'on-demand' and there for them as and when they needed it, which due to the previously mentioned bottleneck effect, was something a human lecturer in a classroom environment could not achieve. Furthermore, there was a clear perception from participants that the adaptive learning environment enhancing the support the lecturer was able to give, as it removed the need for the lecturer to answer as many simple questions and allowed the lecturer's time to be dedicated to more complex or more specific questions.

Control had a significant weight in terms of its predictive power in relation to engagement but wasn't deemed to be significantly impacted by the adaptive learning environment. There may be some caveats to these results however. Control was probably still somewhat limited in the current implementation of the adaptive learning environment. Although students reflected that they appreciated the control they had over the difficulty of the worksheets, and often used this feature, which allowed them to decide which content they read and what activities to engage with, the actual content was still somewhat linear, and activities were fixed by week initially rather than being completely open. Allowing students to progress to the following week or stay on the current week depending on how they were progressing may have had the impact of enhancing perceptions of both control and demand for the students. Further, many students reflected on control as being able to use the system to control how,

when and what type of support they required and received when they need it. This may have aligned with their perception of support rather than their perception of control. However, as the linear regression showed higher control to be predictive in increasing emotional engagement scores, this is an area well worth exploring in further research.

In terms of demand, there was a negative relationship between demand and engagement, suggesting that less demanding tasks resulted in more engagement. This could be due to understanding, where students may be perceiving a task as less demanding if they are making more individual progress and asking less questions. However, this may be the case due to the support the adaptive learning environment is offering. The qualitative data supports this with participants discussing how the adaptive learning environment allowed them to work at their own pace and adjust the difficulty of tasks when they were struggling or increase the difficulty when they weren't. Participants didn't mention finding the work easy in general but did feel that it was easier to make progress when the adaptive environment was in place which may have impacted their perception of challenge. Additionally, regardless of the current level of adaptability in the system, students who continued to find the tasks highly demanding despite this extra support, may have struggled too much and as a result which could have still resulted in negative emotional engagement.

The above findings and discussion align well with existing literature in which variations in demand, control, and support had different impacts on students' experience (Karasek, 1979; Young, 2010; Pekrun 2016). High demand with high control may be perceived better than low demand with low control. Perception of control might also be related to their perception of demand. For example, if a student finds a task challenging but achievable, they may remain in 'control' of their learning,

whereas if a student sees the challenge as too great or difficult, they may feel a sense of loss of control.

This section addresses **RQ4** in that support is clearly significantly impacted by the adaptive learning environment, has a large effect size, and has a predictive impact on emotional engagement in that if support increases, engagement levels increased as well. Meanwhile it was found that demand and control were not significantly impacted by the adaptive learning environment however they are both still significant contributors to emotional engagement. The qualitative findings help us shed more light on this and also helped us understand that support has an influence on how students perceive demand, how adaptive support gives them a sense of control, and how when and where support is offered gives them a higher sense of the overall support they receive. The interplay between the elements of demand, control and support and exploration of how to enhance demand and control further have thus been identified here as interesting aspects for further study.

8.2.5. Enhancing Curricular Content Design

This section addresses some of the curricular design considerations for content development for an adaptive learning environment based on feedback from participants who engaged with the system and participated in the semi-structured interviews.

For the most part, feedback from participants and open-ended questions asked in the survey was very positive. Students felt that the system was familiar, easy to use, and gave them sufficient support to emulate the kind of scaffolding and support the lecturer would provide during in-class lab-based activities where students had to

complete a worksheet based on a topic that they had covered theoretically during the lecture.

One of the major advantages as expected through the design which was also reported by participants was that the content in the adaptive learning environment was contextual and targeted to the module that the students were engaging in. As this was a technical module covering fundamental concepts of programming for first year students with mixed abilities in this domain, many of whom had not done programming before, participants reported that such tailored and targeted content allowed them to focus on more important learning elements such as getting familiar with syntax, solving problems, and building up their confidence in their own programming abilities. In this regard, confidence was reported by all of the participants as they discussed the impacts that the adaptive learning environment had on various aspects of their engagement with the module. These included the type of support it offered to them, the feeling of ownership of their progress and learning and the fact that this support was always there as and when they needed it.

A number of participants also reflected on the differences between using the adaptive learning environment with its targeted hyperlinks adapted to their learning needs and compared it to the alternative of searching for answers online, such as via search engines like Google. While searching for answers online participants reported on feeling confused, obtaining more information than they would require for the tasks that they had, which in itself could be quite intimidating especially when they were relatively new to the subject area or topic. While it must be acknowledged that this is something that could be controlled depending on the level of the student's knowledge and understanding, where they can benefit from having access to a wealth of information and content online, tailored information based on their level or ability was

found to contribute towards a positive experience. This is because it allowed them to build up their core skills and knowledge until they felt more capable and confident of knowing what they were are for when they search for more specific or broad knowledge that could be gained from an online search.

In addition, this concept of more specific knowledge was reported by participants as being best served by the lecturer, as participants identified that specific problems such as an error in their code, or a unique problem that needed to be solved brought about by a unique project or activity that they were working on, was more difficult to predict and thus harder for the system to be able to support with.

As such, the targeted and tailored information available to the students (suggested through their user model), the adaptive-worksheets that contained the adaptive hyper-links, the reporting mechanism to detect when students were struggling and ability within the adaptive learning environment to basically 'ask for help' so the worksheet could adapt to an individual's level, providing them with support and scaffolding on demand, all worked well as reported by the participants.

All of the participants were asked to reflect on what did not work in regard to the adaptive learning environment and to provide any suggestions for improvements. While not all participants felt there was anything to improve on in particular, some shared interesting areas for further exploration and research and this will be discussed next.

One of the ideas included having more information available that would complement the module and support their learning beyond the module itself. This would align with the notion of more demanding tasks and having content that not only targets the weaker students in terms of additional scaffolding and support, but also

targets the more advanced students who want to expand their knowledge further, who are clearly motivated by the content and want to learn more. When targeting engagement, it would be good to ensure that the learning needs of these different segments of learners are adequately addressed by providing content that was generally pitched in the middle where we would expect most students to perform at and to incorporate ways to engage and support the weaker students, and keep the stronger students motivated with additional material. While it must be acknowledged that this takes time, and in the case of this particular study, the researcher/lecturer had already included some content for students with a higher level of ability, given more time, it would be possible to develop and include additional content for students of varied levels of ability. In so doing, it would keep the students of differing levels of ability engaged in the module. As mentioned, this is something which may have a greater impact on control and is well worth exploring in future research.

Other participants reflected on the idea of analytics and tracking. In terms of tracking, they would have liked an exact record of where they left off, a way for them to log back into the system and to be able to know exactly what part of a worksheet that they had been working on which will enable them to pick up and continue where they had previously stopped. A supplement to this idea was data analytics, such as having information pertaining to the length of time spent on each task, the level of difficulty of the tasks that they were working on or have completed and prompts as a form of encouragement such as ‘you are doing well’ were suggested by one of the participants. Incorporating such data analytics would work well in terms of enabling students to know more about their own progress which goes beyond assessments and exam grades. It might motivate them to continue learning and challenging themselves if they are aware of their own levels of progress. For example, if they noticed that they

are doing more tasks at a lower level of difficulty, they might want to attempt to move to a higher level or for others, they may tap on the support available via the system if they were experiencing difficulty or to access advanced levels if they wanted a challenge.

8.3. Conclusion

At this juncture of the discussion, it would be best to reflect on the work of Young (2010) pertaining to ways in which to foster engagement in learning. Young (2010) highlighted five principles: empowering students, providing support resources, creating demanding learning tasks, role overload, and utilizing multiple targets of engagement which can be exercised or implemented via the use of an adaptive learning environment in the classroom. In the case of this study, participants reported feeling empowered, having control over their learning, and even taking their learning beyond the classroom, all of which suggested more intrinsic motivation as was the expectation of Young (2010) when these five principles were addressed.

In terms of providing support resources, the preceding sections discussed the ways in which the adaptive system has had an impact on support according to the data collected. However, it also addresses the need for lecturer guided support and feedback as outlined by Young (2010). In the case of this study, students reported that the support provided by the system was to an extent, tailored and targeted to their learning with an appreciation for the fact that this support was created by the lecturer. Students also relate that in specific situations, support from the lecturer was still necessary such as when they faced a problem that was too specific for the adaptive learning environment to address. In this instance, the lecturer was able to provide that additional layer of scaffolding and support that the students required.

In terms of creating demanding tasks, students appreciated that the tasks were challenging, but reported that they found it easier to make progress with the support of the system in place. This meant that on the whole, the students felt that the system helped them to better manage their learning. However, as previously pointed out and discussed, the system can be improved upon to cater to students at the lower and higher ends of the ability spectrum by having content that provided more support or additional level of challenge respectively.

In terms of role overload, the worksheets were designed to ensure that students did not feel that they had to finish everything at a specific point in time, but to make the best use of their class time to complete as much as they could and come back to the remainder of the activities another time if required. Challenging and advanced tasks were optional and hidden to those who were struggling, to manage their expectations and help them focus on the target of completing the minimal baseline for them to be considered as having completed the worksheet. Further, with the system made available even after the data needed for this study was collected, it provided them with the opportunity to continue accessing and using the system beyond the classroom. This allowed for students to continue having the one-to-one support via the adaptive learning environment, with the cognitive effort required to complete a task remaining under their control, where layers of scaffolding could be added or removed based on their needs.

For utilizing multiple targets of engagement, students could use the system for support or ask the lecturer for support, the system had an in-depth understanding of the students' needs based on an evolving user model that recorded their interactions with the system while the lecturer was on hand to offer more nuanced support and deal with the unique and specific needs of the students. The ability for the worksheet

to adapt also ensured tasks were designed to utilize multiple levels of engagement, targeting students at different levels of ability and in different ways, from vague complex tasks at the highest levels to video walk-throughs at the lower levels. Reflecting specifically on the varying levels of students' abilities which was previously discussed, the data showed that all students were able to appreciate the support rendered by the adaptive learning environment at the base level set by the lecturer in accordance to the needs of the module. It is possible to add more scaffolding and support via sub-tasks or additional content and instructions for students at the lower end of the spectrum who are experiencing difficulty in making progress and to add more advanced content and challenging activities for students on the higher end of the spectrum. In this way, the adaptive learning environment becomes more dynamic in addressing the needs of learners at different levels of ability, by equipping them with the baseline knowledge for the module, enabling those struggling to obtain foundation skills through more scaffolding and facilitating those who can progress further with more advanced content.

Chapter 9

9. Conclusion

9.1. Introduction

As the use of technology in the classroom has become prevalent as the world braces for impacts of the artificial intelligence revolution, it would not be unexpected that the use of artificial intelligence for teaching should become more common place. However, adaptive learning environments are not a new phenomenon, with open source and free versions of such systems readily available for use, so what may be more unexpected is the fact that such systems are not more heavily in use in education. One potential direction would be to encourage wider use of the system through clarity in terms of the benefits of its use. Development of an adaptive course, as we have discussed in the previous chapters, does require additional initial setup time for the lecturer or those involved in creating the module. As an example, a standard worksheet for a programming course may have a number of sections with activities that students are expected to complete during the session. This worksheet is a one-size fits all design, usually pitched at the intermediate level students, with weaker students relying on the lecturer and peers for support and stronger students looking for worksheets at more advanced levels.

Creating adaptive content means creating all the layers in-between, having on-demand learning available, influenced by the user model so the content recommended is tailored to each specific individual student. Scaffolding is built into the worksheet so that students can get sufficient support from the system as and when they need it and deep consideration must be made for the domain and course models within the adaptive learning environment. This is so that the concepts link intelligently and logically ensuring that the students are able to navigate this adaptive environment,

based on their individual needs, seamlessly. Before committing to such an effort, the benefits of such a system should be understood to encourage their use, and this seems to be where research is currently lacking. It would be even better if real-life scenarios can be explored such as in the context of actual classroom use. This can develop a deeper understanding of how such systems can not only be effectively embedded into the classroom experience, but the ways in which it can support different stakeholders in the classroom environment, namely, the students and the lecturers.

This research aimed to address these issues by taking into consideration not only the initial setup time factor for the lecturer, but also, focusing more on the after effect. For example, by also exploring how the adaptive learning environment could support the lecturer afterwards and support the students through the lens of academic emotional engagement. This lens of emotional engagement was chosen for its potential to influence other facets of engagement such as behavioural and cognitive but with an appreciation that each has their own unique influencers and could be subject to further studies in the future. In terms of emotional engagement, both classroom and learning emotions have been explored, as well as potential factors which may be affected by the adaptive learning environments could influence engagement such as demanding tasks, control over learning and perception of support (Karasek, 1979). To address this from a content design perspective, Young's (2010) five principles of fostering academic engagement were considered while both designing the content and reflecting on the impacts that the adaptive learning environment may have.

The initial expectations of the research were that the adaptive learning environment would have a positive impact on the emotional engagement of students in the classroom and on their general experience with learning. The initial expectation

was that support would play a key role as the most obvious advantage of the adaptive learning environment was the additional layer of support it could offer. This aspect would have contextual similarities to the lecturer's support and in effect act like a one-to-one tutor for each student. These similarities come in the form of the contextual content that was developed by the lecturer simulating the kind of support the lecturer would usually offer to students when they ask for help or guidance on specific tasks. The adaptive learning environment also enhanced what the lecturer was capable of in terms of knowing the student, where the lecturer may have a fair idea of the students' ability, the adaptive learning environment had a detailed user model of the students' interactions within the system and was able to pitch worksheets and content at a level that was suitable to that individual. Through the literature review, measures for classroom and general learning emotions were identified as being useful to explore in this context. This helped to identify and selected a suitable tool for data collection which was capable of being further broken down in the analysis phase to examine positive and negative emotions that may be experience in the classroom, in relation to learning and in consideration for the overall classroom environment. The elements of control and demand were also identified as potentially influenced and became part of the conceptual model to help us understand further the influence the adaptive learning environment had on these factors.

This chapter will address **the sixth objective** of our study through providing suggestions for improvements and future directions of the research, providing an overview of the limitations of this study as a whole and highlighting the strengths of the findings to provide potential suggestions for educators who wish to explore the use of adaptive educational systems in their courses in the future.

9.2. Summary of Findings

Given the above mentioned expectations relating to the adaptive learning environment being capable of providing a similar level of support to the lecturer, only on a one-to-one bases, the data aligned, showing that based on our measure of emotional engagement in the classroom, a significant increase in a treatment group with the system in place was measured over a control group who used traditional worksheets. It was found that students appreciated that feeling of one-to-one support, meaning they did not have to wait for the lecturer to be available when they needed support, finding the scaffolding and support from the adaptive learning environment as suitable to their needs, thus addressing **RQ1**.

Breaking down the measures of emotional engagement further into classroom-based emotions and learning based emotions, it was found that while both learning and classroom emotions were significantly impacted, classroom emotional engagement was most impacted by the adaptive learning environment with a large effect size. Through our quantitative data it was found that students felt a higher level of ownership of their learning and progress when supported by the adaptive learning environment as compared to being supported by a lecturer. This led them to perceiving their progress as their own and contributed towards enhanced emotions such as pride and enjoyment. They were able to make more progress without support from their lecturer or peers, removing the need to ask many questions, or getting stuck to a point where they could not make any more progress until there was human intervention. They reported feeling less anxiety (about asking questions) and less boredom, anger, and hopelessness as a result of not getting stuck or having to wait for support, especially in the case of what they deemed to be simple problems and/or simple questions. As such, this addressed **RQ2.**

From the perspective of positive and negative emotions, the data showed that negative emotions were most impacted, addressing the impact of the emotions mentioned in **RQ2**, where both positive and negative emotional impacts were supported. However, from a quantitative perspective we found only positive classroom emotions were significantly impacted by the adaptive learning environment as opposed to positive learning emotions, but both negative classroom and negative learning emotions were significantly reduced by the system with classroom emotions being more significantly reduced with a large effect size, thus answering **RQ3**.

Finally, returning to our initial expectation that the adaptive learning environment would have an impact on support, when exploring demand, control and support we found that an increase in support could sufficiently predict to a significant degree an increase in engagement, as could control but only support was significantly impacted by the addition of the adaptive learning environment. Control was positively impacted by the adaptive learning environment but not to a significant degree, whereas demand was negatively impacted. This means that with less challenge, students seemed more engaged. However, again, this was not to a significant degree and may be as a result of the support that the adaptive learning environment offered giving the students a perception of tasks being more manageable.

This does open up some more questions for further research such as designing modules to allow further control, as some students reflected that they would have liked more broad concepts to be covered beyond the scope of the module and more challenging activities in the worksheet. Students reported that activities felt easier with the support of the system. This may be due to the perception of challenge coming from being stuck with a problem as compared to the system providing support which helped ensure that students were able to make progress. This was a finding rather

than a directive for this study, but interestingly, highlighted a possible area for further exploration of this phenomenon. On the whole, this suitably answers **RQ4**, where support seems to be the most influenced factor that was expected to have an impact on engagement and was influenced by the adaptive learning environment.

Combining both qualitative and quantitative findings, the issue of how we can use an adaptive system in the classroom to enhance curricular content design could be addressed from a data perspective. With support as a very impactful element of such systems, the design of support should be carefully considered to ensure enough nuance to support all levels of student abilities. This could include additional small activities to help weaker students develop their understanding of concepts and syntax to tackle an activity that they are struggling on, to challenging tasks which take into consideration wider knowledge for students who are excelling in the class and are motivated to learn more. Likewise, where possible, activities from additional weeks can be made available to students to allow them to control their own pace of learning, while giving the weaker students scope and room to catch up without time pressure beyond specific milestones such as possible assessment points during the module.

Students also reported appreciating the design of the content within the adaptive learning environment, where a version of the course content was available to read, through a menu of hyperlinks. These hyperlinks were colour coded to show them what they have and have not read, and the content available within each section was adaptive to ensure that they had not been given information which may be beyond their level of understanding and learning until they are ready for it. Links to content were adaptively controlled, and available based on the user model inside the adaptive worksheets. Students could either read through content whenever they wanted or

respond to prompts to read content ‘just in time’, related to the current activity, when they were getting stuck in an activity in the worksheet.

All of these factors encouraged students to make more individual progress, reduced the need for asking questions on simple topics, which in turn they reported as being a way to free up time for the lecturer to answer more specific and challenging questions which they deemed more worthy of the lecturer’s time. The user model which was tracking what students were reading, what level they were working at in their worksheets and how much overall progress they were making, allowed tailored and specific content to be designed around their learning needs. Students were also able to decide how and when they got support as the system was always available to each individual, and they could control the challenges they faced by getting more or less support in the worksheets and being able to gain more fundamental knowledge before asking the lecturer questions. The students reported that as being most useful when the question was very specific, related to a very specific error they were having or related to a unique problem in a project/activity they were working on which was beyond the scope of the class activities. These findings address all 5 principles of fostering academic engagement (Young, 2010) as reported in the discussion chapter and thus addresses **RQ5.**

How technology is used is as important as the usefulness of the technology itself. As such the design of content within the adaptive learning environment is of high importance to ensure that the impact of the system is optimal. Indeed, in this research, we found room for improvement around the layers of support the system has available to all levels of students, and the breadth of content that could be offered. Further, more could be done to help students track their progress such as in-built analytics and further tracking on individual progress within worksheets. For this

study, time was a factor, but for a module which uses such technology which runs over a number of years, this content could be expanded on, year after year, based on lessons learned about the needs of the students across all ability levels. Students reported that the adaptive learning environment allowed them to control the amount of support they received as and when they needed it. This seemed to alter their perception of demand and control, as now students were in control of their cognitive load and could adjust the amount of scaffolding the system provided when they found the content too demanding. As a result, support would seem to have influences on perceptions of control and perceptions of demand, meaning the design of content to ensure it fulfils the support needs to the students is crucial.

9.3. Further Research

Engagement is complex, multifaceted and influenced by a wide array of factors. This study attempted to mediate external factors as much as possible by setting up a treatment and control group, giving each group similar support but in different formats, and running pre and post tests on each group so as to perform an analysis of variance to better understand the cause-and-effect results as a direct impact of the intervention. Furthermore, the focus on emotional engagement using a mixed methods approach allowed for a more in-depth exploration of the findings, not only seeing where significant impact was detected but exploring the reasons behind the impact which may help more targeted interventions in the future. For example, this can be taken into consideration as other facets of engagement such as cognitive and behavioural could be further explored. For additional research into these other dimensions, it would be recommended that a similar mixed methods approach is used, focusing on specific facets of engagement to ensure an appropriate depth of

exploration is done to develop a more nuanced understanding of the findings for each additional engagement dimension

Even just addressing academic emotional engagement, further interventions could target the content created to support the stronger students, as well as additional layers of support for the weaker students, to explore how the adaptive educational system could further impact other components which predict emotional engagement such as control over learning and demanding tasks, and potentially further enhance the positive learning engagement experienced by students. Indeed control has been identified in this research as particularly interesting as a sufficient predictor of engagement, and positively impacted by the adaptive learning environment. As a result, more nuanced support and content at both the higher and lower rage of student abilities could potentially increase the impact of the adaptive learning environment relating to control and demand to a significant level.

For educational research, there are also benefits of longitudinal research, exploring how such a system impacts all factors of engagement over time. For example, to examine if any of the impacts fluctuate, improve and decline over time would be beneficial when considering adding such a system beyond just a single module. This would also allow us to explore activating and deactivating emotions further to see if any of the negative emotions in an earlier year of study results in any positive impacts over time (such as anger resulting in increased effort). In addition, exploring the impact that sustained positive emotional engagement has on students' performance, or if emotional engagement over time can predict better performance would add more weight to the argument around the importance of emotional engagement in their learning process. Based on this, it may be useful to study performance from a longitudinal perspective. This is because higher emotional

engagement could potentially lead to deeper learning and intrinsic motivation where performance effects may not be seen so instantly but may be more evident over time.

This leads to another factor that can be further explored, namely, intrinsic motivation. Previous research has suggested that engaged learners would have a higher sense of intrinsic motivation, and indeed the qualitative data did suggest this with many students reporting that by using the system beyond class hours, they felt that the support was always available to them, resulting in the desire to have further content available and purposefully challenge themselves to enhance their overall learning. As a result, students were doing the task for the sake of their enjoyment of the task and not for any other external factors beyond enhancing their learning and abilities. This could be explored further by specifically measuring their engagement and type of motivation and determining if the adaptive learning environment is impacting intrinsic motivation for a class group.

Considering this potential engagement beyond the classroom, gamification could also be considered as a way to influence behaviour. It would be important for the gamification to be meaningful so as to influence student behaviours by getting them to engage intrinsically with content outside the classroom. Elements such as instant feedback, confirmation of success and weekly challenges or events to encourage students to write code beyond the classroom would be some possible ways to encourage positive behaviours, enhance abilities and develop a mindset of their course content being more than just activities in class, assessments and grades. This may also encourage students to keep up to date with the content, with specific events being related to activities being covered in class. Most importantly, the gamification should be related to the activities and the learning so as to ensure motivation remains intrinsic.

9.4. Limitations

There were a number of limitations relating to this study, the first being more by design to ensure adequate response rates rather than an oversight. This relates to the choice to use the short form of the AEQ and to focus specifically on two areas of emotional engagement. One of the two areas relate to general learning engagement and the other for emotional engagement in the context of the classroom. There are larger and more complex versions of this tool, but as students had to answer the survey before and after the session as part of their natural course structure (so not strictly a signed up for experimental group type of project), it was important for the study not to interfere too much with their day-to-day lessons, their perception of the sessions as a result of the survey itself and their willingness to complete the survey. For instance, given that the students had to complete the survey before and after the lesson/session in order for the data to be useful, a lengthy survey might deter them and result in a low or poor response rate from the students. With the current short form of the survey, some trail off did occur but the overall response rate was acceptable.

As a mixed methods approach was used, it was however possible to further explore the quantitative analysis against the qualitative findings for justification and explanation of what was found between the two. This approach works well on two fronts, one to help understand the numbers from the quantitative findings using qualitative data, and two, to mediate any bias in the qualitative findings. For instance, any possible lack of alignment between the qualitative findings with the quantitative data would indicate a potential misrepresentation of the findings. In all cases, for both qualitative and quantitative data, there was a clear alignment which helped to improve the validity of the findings and justify the usefulness of the tools.

Similarly, although it would have been interesting to explore cognitive and behavioural engagement as well, opening up an exploration of the interplay between these facets of engagement, it was felt that doing one particular and important facet in depth was better than doing all facets at a more surface level. Having each one explored in-depth would also mean a significantly larger survey which may in turn have resulted in lower response rate. Such considerations influenced the design of the study and a balance was sought to get the most meaningful results for this particular study.

Educational design research itself has some pros and cons. The most prominent of which in this research study was the class size. This is a natural limitation of both educational design research and action research as in some instances, the class size that you are assigned is what you need to work with. Also, taking into consideration that not all students will agree to participate in the study, and of those that do, not all will complete both the pre-test and post-test surveys, meaning, ensuring the final number of responses is high can be quite a daunting challenge. After considering these factors, this research managed to have sixty participants. This was ideal in enabling for a split between the control and treatment groups. However, having the ability to acquire higher numbers in terms of participants would allow for better claims of generalisability and higher statistical validity on the significance of findings.

In terms of carrying out educational design research, in many instances, the researcher is also the educator/lecturer and this ensures that they remain close to the context of the research. The benefit here is that the role of the lecturer helps facilitate access to participants (given the approval from the institution/university) and an in-depth understanding of how the study is being conducted and the nature of the module

being examined. It also helps to ensure both experiences for treatment and control groups are as closely matched as possible to content and teaching style to mitigate potential confounding factors. However, it is also important for the researcher to detach themselves from the study as much as possible in order to reduce or mitigate any possibility of bias. This was something that had been taken into consideration by the researcher throughout the research process. The tool chosen for the quantitative data collection was an existing tool that had a number of published papers related to its validity, and as such helped to ensure that the questions being asked were suitable and not leading the students towards any specific answers. The quantitative data was also collected anonymously so students could answer honestly. The same guiding principles of this survey helped with the open-ended questions of the semi-structured interviews, allowing participants to talk openly about their experience. So, while bias can possibly exist in the research process such as in the interviews or in the analysis of the qualitative data, the mixed methods approach helped by ensuring that the quantitative data acts as a check in terms of the analysis and findings. In addition, students were informed that there would be no benefit derived from answering questions that were asked in one way or the other. They were also informed that regardless of the findings, the system would be made available to all once the data had been collected and the end results of the study would have no impact on whether or not the system was used in the future. Students were made aware that the nature of the research valued both positive and negative findings equally. Discovering such a system was non-beneficial to students was just as important as finding out that it was actually beneficial and would still add to the body of knowledge on the impacts of adaptive learning environments in classroom environments.

9.5. Summary

On the whole, the study shed light on interesting findings relating to the use of adaptive learning environments in a classroom environment. While some of the findings were somewhat expected and hoped for given the extensive teaching experience of the researcher, the findings in the literature and the effectiveness of the tool being used, other findings were less expected and helped answer the final research question in terms of what to target when designing curriculum for such a system and where effort in design would be best served.

Support is clearly an important aspect of learning and has traditionally been the fundamental role of a lecturer in any classroom environment. The lecturer is responsible for designing a learning journey, a path for the learners to follow and often acts as a facilitator to guide students along this path towards achieving the intended learning outcomes of the module. The challenge in a classroom with one lecturer and many students will always be this concept of bottlenecks, where the lecturer can only handle one student at a time, but many students may have questions all at once. The adaptive learning environment by no means replaces the lecturer as the nature of the content and the support in the system should all come from the lecturer whose style the students are most familiar with for this particular module. While the adaptive learning environment can now act as a new layer of support, emulating the one-to-one interaction that supports the students as and when they need it, there is clearly a need for the lecturer to still offer more nuanced support for more challenging, complex, and unique problems that the students may face. This support becomes more targeted with the core questions being handled by the system affording the lecturer more time to focus on other problems that students may face. Such problems may necessitate the additional layers of scaffolding that the adaptive learning environment cannot provide,

making the best use of the lecturer's in-depth knowledge and ability to provide more in-depth and contextual support. This interplay between the lecturer and the adaptive learning environment seems to provide an optimal arrangement or balance to ensure the best possible learning experience for the students.

The most significant impact being on negating negative emotions was definitely an interesting finding. While it aligns to the students' perception of support from the adaptive learning environment leading them to feel a sense of ownership of their progress, their achievement, and their learning without human intervention, it also helps us to further consider the impacts of control and support on the students' learning experiences. This further justifies the need to ensure appropriate and quality practices are implemented for the use of technology in the classroom and enhanced curriculum design with engagement in mind is followed.

Finally, the adaptive learning environment can clearly address a fundamental truth of all classrooms, that being, all students are different, and have their own needs and abilities. The content on the adaptive learning environment must be diverse and address the variety of students' needs by extending the support needed to those who struggle and to enhance the learning for those who are able to progress to higher or more advanced levels. Most importantly, regardless of ability, we must ensure that all students are engaged and motivated as intrinsically as possible to promote such sought after behaviours such as deep learning, a lifelong learning mindset and a constant desire to know and learn more.

References

Aldowah, H., Al-Samarraie, H., Alzahrani, A. I., & Alalwan, N. (2020). Factors affecting student dropout in MOOCs: a cause and effect decision-making model. *Journal of Computing in Higher Education*, *32*(2), 429–454. https://doi.org/10.1007/s12528-019-09241-y

Allen, D. S. (2016). The Impact of Shortening a Long Survey on Response Rate and Response Quality, 60. Retrieved from https://scholarsarchive.byu.edu/etd/5968

Allen, I. E., & Seaman, C. A. (2007). Likert Scales and Data Analyses. *Quality Progress*, *40*(7), 64–65.

Archambault, I., Janosz, M., Morizot, J., & Pagani, L. (2009). Adolescent Behavioral, Affective, and Cognitive Engagement in School: Relationship to Dropout. *Journal of School Health, 79*(9), 408–415. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1746-1561.2009.00428.x/full

Askham, P. (2008). Context and identity: Exploring adult learners' experiences of higher education. *Journal of Further and Higher Education, 32*(1), 85–97. https://doi.org/10.1080/03098770701781481

Baker, J. W. (2000). The "Classroom Flip" : Using web course management tolls to become the guide by side. *In J.A Chambers (Ed.). Selected Papers from the 11th International Conference on College Teaching and Learning*, 9–17.

Barkley, E. F. (2009). *Student engagement techniques: A handbook for college faculty*. Jossey-Bass.

Ben-Eliyahu, A., Moore, D., Dorph, R., & Schunn, C. D. (2018). Investigating the multidimensionality of engagement: Affective, behavioral, and cognitive engagement across science activities and contexts. *Contemporary Educational Psychology*, *53*(January), 87–105. https://doi.org/10.1016/j.cedpsych.2018.01.002

Bhattacherjee, A. (2012). *Social Science Research: Principles, Methods, and Practices* (2nd ed.). Scholar Commons. Retrieved from http://www.degruyter.com/view/j/pac.1989.61.issue-9/pac198961091657/pac198961091657.xml

Bloom, B. S. (1984). The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. *Educational Researcher*. https://doi.org/10.3102/0013189X013006004

Boling, E. C. (2008). Learning from teachers' conceptions of technology integration: What do blogs, instant messages, and 3D chat rooms have to do with it? *Research in the Teaching of English*, *43*(1), 74–100.

Bonate, P. L. (2000). *Analysis of Pretest-Posttest Designs* (1st ed.). Chapman and Hall/CRC.

Brdovčak, B. (2017). The Relationship between Achievement Emotions, Appraisals

of Control and Value, and Academic Success / Odnos emocija postignuća, procjena kontrole i vrijednosti te akademskog uspjeha. *Croatian Journal of Education - Hrvatski Časopis Za Odgoj i Obrazovanje*, *19*(0), 29–41. https://doi.org/10.15516/cje.v19i0.2744

Bryson, C., & Hand, L. (2007). The role of engagement in inspiring teaching and learning. *Innovations in Education and Teaching International*, *44*(4), 349–362. https://doi.org/10.1080/14703290701602748

Burbules, N. C., & Callister, T. A. (2001). *Watch IT : The risks and promises of new information technologies*. Routledge.

Cabanac, M. (2002). What is emotion? *Behavioural Processes*, *60*(2), 69–83. https://doi.org/10.1016/S0376-6357(02)00078-5

Carini, R., Kuh, G., & Klein, S. P. (2006). Student Engagement and Student Learning: Testing the Linkages Student Engagement and Student Learning: How Can We Characterize the Linkages? Background. *Research in Higher Education*, *47*(1), 1–32. https://doi.org/10.1007/s11162-005-8150-9

Carini, R. M., Kuh, G. D., & Klein, S. P. (2006). Student engagement and student learning: Testing the linkages. *Research in Higher Education*, *47*(1), 1–32. https://doi.org/10.1007/s11162-005-8150-9

Cassady, J. C., & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology*, *27*(2), 270–295. https://doi.org/10.1006/ceps.2001.1094

Colby, B. N., Ortony, A., Clore, G. L., & Collins, A. (1989). The Cognitive Structure of Emotions. *Contemporary Sociology*. https://doi.org/10.2307/2074241

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues. *Journal of the Learning Sciences*, *13*(1), 15–42. https://doi.org/10.1207/s15327809jls1301_2

De Bra, P. De, Smits, D., Knutov, E., Nussbaumer, A., & Lorenzon, A. (2010). "Stand-alone" Adaptive Learning Environment, final implementation. Retrieved December 12, 2018, from http://grapple.win.tue.nl/deliverables/index.html

De Bra, P., Smits, D., van der Sluijs, K., Cristea, A., Foss, J., Glahn, C., & Steiner, C. (2013). GRAPPLE Learning Management Systems Meet Adaptive Learning Environments.pdf. In *Intelligent and Adaptive Educational-Learning Systems* (pp. 133–160). https://doi.org/10.1007/978-3-642-30171-1_6

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*.

Dornyei, Z., & Otto, I. (1998). Motivation in action: A process model of L2 motivation. *Working Papers in Applied Linguistics*, *4*, 43–69. Retrieved from http://eprints.nottingham.ac.uk/39/

Dugard, P., & Todman, J. (1995). Analysis of Pre-test-Post-test Control Group Designs in Educational Research. *Educational Psychology*, *15*(2), 181–198. https://doi.org/10.1080/0144341950150207

Dziuban, C., Moskal, P., Johnson, C., & Evans, D. (2017). Adaptive Learning : A Tale of Two Contexts. *Current Issues in Emerging ELearning*, *4*(1), 25–62.

Ekman, P. (1992). An Argument for Basic Emotions. *Cognition and Emotion*, *6*(3–4), 169–200. https://doi.org/10.1080/02699939208411068

Ekman, P. (1999). Basic Emotions. In T. Dalgleish & M. Power (Eds.), *Handbook of Cognition and Emotion* (pp. 45–60). John Wiley & Sons Ltd. https://doi.org/10.1002/0470013494

Ekman, P., & Friesen, W. (1975). *Unmasking the Face*. *Unmasking the face*. Prentice Hall. https://doi.org/10.4324/9780429493188-10

Fredricks, J. A. (2015). *Academic Engagement*. *International Encyclopedia of the Social & Behavioral Sciences: Second Edition* (Second Edi, Vol. 1). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.26085-6

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Fredricks, J. A., Filsecker, M., & Lawson, M. A. (2016). Student engagement, Context, And adjustment: Addressing definitional, Measurement, And methodological issues. *Learning and Instruction*, *43*, 1–4. https://doi.org/10.1016/j.learninstruc.2016.02.002

Fredricks, J. A., & McColskey, W. (2012). The Measurement of Student Engagement: A Comparative Analysis of Various Methods and Student Self-report Instruments. In S. L. Christenson, A. L. Reschely, & C. Wylie (Eds.), *Handbook of Research on Student Engagement* (pp. 763–781). Springer Science and Business Media. https://doi.org/10.1007/978-1-4614-2018-7

Fredricks, J. a, Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*. https://doi.org/10.3102/00346543074001059

Frijda, N. H., Markam, S., Sato, K., & Wiers, R. (1995). Emotions and Emotion Words. In *Everyday Conceptions of Emotion: An Introduction to the Psychology, Anthropology and Linguistics of Emotion* (Vol. 81, pp. 121–143).

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education*, *7*(2), 95–105. https://doi.org/10.1016/j.iheduc.2004.02.001

Graham, C. R. (2004). Blended Learning Systems: Definition, Current Trends, and Future Directions. *Handbook of Blended Learning: Global Perspectives, Local Designs*.

Graham, C. R. (2009). Blended Learning Models. *Encyclopedia of Information Science and Technology, Second Edition*, 375–382. https://doi.org/10.4018/978-1-60566-026-4.ch063

Gregori, P., Martínez, V., & Moyano-Fernández, J. J. (2018). Basic actions to reduce dropout rates in distance learning. *Evaluation and Program Planning*, *66*(September 2017), 48–52. https://doi.org/10.1016/j.evalprogplan.2017.10.004

Halverson, L. R., Graham, C. R., Spring, K. J., Drysdale, J. S., & Henrie, C. R. (2014). A thematic analysis of the most highly cited scholarship in the first decade of blended learning research. *Internet and Higher Education*, *20*, 20–34. https://doi.org/10.1016/j.iheduc.2013.09.004

Hamada, M., Nishikawa, K., & Brine, J. (2013). Intelligent and Adaptive Educational-Learning Systems. *Intelligent and Adaptive Educational-Learning Systems*, 109–132.

Hefce. (2013). Non-Continuation Rates at English HEIs, (April).

Hernández, Y., Sucar, L. E., Arroyo-figueroa, G., & Erro, L. E. (2013). Affective Modeling for an Intelligent. *Intelligent and Adaptive Educational-Learning Systems: Achievements and Trends (Smart Innovation, Systems and Technologies)*, *17*, 3–24.

Holzhüter, M., Frosch-Wilke, D., & Klein, U. (2013). Exploiting Learner Models Using Data Mining for E-Learning: A Rule Based Approach. In *Intelligent and Adaptive Educational-Learning Systems* (pp. 77–105). https://doi.org/10.1007/978-3-642-30171-1_4

Huang, H. B. (2010). What is good action research?: Why the resurgent interest? *Action Research*, *8*(1), 93–109. https://doi.org/10.1177/1476750310362435

Johnson-Laird, P. N., & Oatley, K. (1989). The Language of Emotions: An Analysis of a Semantic Field. *Cognition and Emotion*, *3*(2), 81–123. https://doi.org/10.1080/02699938908408075

Kahu, E. R. (2011). Framing student engagement in higher education. *Studies in Higher Education*, (January 2015), 1–16. https://doi.org/10.1080/03075079.2011.598505

Kahu, E. R. (2013). Framing student engagement in higher education. *Studies in Higher Education*, *38*(5), 758–773. https://doi.org/10.1080/03075079.2011.598505

Kahu, E., Stephens, C., Leach, L., & Zepke, N. (2014a). Linking academic emotions and student engagement: mature-aged distance students' transition to university. *Journal of Further and Higher Education*, *39*(4), 481–497. https://doi.org/10.1080/0309877X.2014.895305

Kahu, E., Stephens, C., Leach, L., & Zepke, N. (2014b). Linking academic emotions and student engagement: mature-aged distance students' transition to

university. *Journal of Further and Higher Education*, *39*(4), 481–497. https://doi.org/10.1080/0309877X.2014.895305

Karampiperis, P., & Sampson, D. (2009). Evaluating the Performance of Adaptive Learning Objects Selection and Sequencing in Adaptive Educational Hypermedia Systems. *2009 Ninth IEEE International Conference on Advanced Learning Technologies*, 6–8. https://doi.org/10.1109/ICALT.2009.134

Karasek, R. A. (1979). Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. *Administrative Science Quarterly*, *24*(2), 285. https://doi.org/10.2307/2392498

Kaw, A. K., Besterfield, G. H., & Eison, J. (2005). Assessment of a web-enhanced course in numerical methods. *International Journal of Engineering Education*, *21*(4 PART I AND II), 712–722.

Khosravi, H., Sadiq, S., & Gasevic, D. (2020). Development and adoption of an adaptive learning system reflections and lessons learned. *Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE*, 58–64. https://doi.org/10.1145/3328778.3366900

King, R. B., McInerney, D. M., Ganotice, F. A., & Villarosa, J. B. (2015). Positive affect catalyzes academic engagement: Cross-sectional, longitudinal, and experimental evidence. *Learning and Individual Differences*, *39*, 64–72. https://doi.org/10.1016/j.lindif.2015.03.005

Kobsa, A. (1993). User Modeling : Recent Work , Prospects and Hazards 1. *Adaptive User Interfaces: Principles and Practice*, 111–128. https://doi.org/10.1007/s11257-005-6468-9

Kost, R. G., & Correa da Rosa, J. (2018). Impact of survey length and compensation on validity, reliability, and sample characteristics for Ultrashort-, Short-, and Long-Research Participant Perception Surveys. *Journal of Clinical and Translational Science*, *2*(1), 31–37. https://doi.org/10.1017/cts.2018.18

Krischner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquity-based teaching. *Educational Psychologist*, *41.2*, 75–86.

Kuh, G. D. (2009). What student affairs professionals need to know about student engagement. *Journal of College Student Development*, *50*(6), 683–706. https://doi.org/10.1353/csd.0.0099

Kuh, G. D., Kinzie, J., & Buckley, J. A. (2006). What Matters to Student Success : A Review of the Literature Spearheading a Dialog on Student Success. *Commissioned Report for the National Symposium on Postsecondary Student Success Spearheading a Dialog on Student Success*, *18*(July), 156. Retrieved from http://cpe.ky.gov/NR/rdonlyres/AFA304F0-C125-40C2-96E5-7A8C98915797/0/WhatMatterstoStudentSuccessAReviewoftheLiterature.pdf

Laurillard, D. (2002). *Rethinking University Teaching: A Conversationla*

Framework for the Effective Use of Learning Techonlogies. *Rethinking University Teaching* (2nd ed.). Routledge Falmer. https://doi.org/10.4324/9781315012940

Lavin, A. M., Korte, L., & Davies, T. L. (2011a). The impact of classroom technology on student behavior. *Journal of Technology Research*, *2*, 1–13. https://doi.org/47

Lavin, A. M., Korte, L., & Davies, T. L. (2011b). The impact of classroom technology on student behavior. *Journal of Technology Research*, *2*, 1–13. https://doi.org/47

Linnenbrink-Garcia, L., & Pekrun, R. (2011). Students' emotions and academic engagement: Introduction to the special issue. *Contemporary Educational Psychology*, *36*(1), 1–3. https://doi.org/10.1016/j.cedpsych.2010.11.004

Locke, E. A. (1996). Motivation through conscious goal setting. *Applied and Preventive Psychology*, *5*(2), 117–124. https://doi.org/10.1016/S0962-1849(96)80005-9

Lyubomirsky, S., King, L., & Diener, E. (2005). The benefits of frequent positive affect: Does happiness lead to success? *Psychological Bulletin*, *131*(6), 803–855. https://doi.org/10.1037/0033-2909.131.6.803

MacKenzie, I. S. (2013). Scientific Foundations. *Human-Computer Interaction*, 121–156. https://doi.org/10.1016/b978-0-12-405865-1.00004-2

Manwaring, K. C., Larsen, R., Graham, C. R., Henrie, C. R., & Halverson, L. R. (2017). Investigating student engagement in blended learning settings using experience sampling and structural equation modeling. *Internet and Higher Education*, *35*(December 2016), 21–33. https://doi.org/10.1016/j.iheduc.2017.06.002

Martins, António Constantino, Faria, L., Carvalho, C. V. De, & Carrapatoso, E. (2008). U s e r m o d e l i n g i n a d a p t i v e h y p e r m e d i a e d u c a t i o n a l s y s t e m s. *Educational Technology & Society*, *11.1*, 194–207.

Martins, Antonio Constantino, Faria, L., De Carvalho, C. V., & Carrapatoso, E. (2008). User Modeling in adaptive hypermedia educational systems. *Educational Technology Society*, *11*(1), 194–207.

Mazur, E., & Somers, M. D. (1999). *Peer Instruction: A User's Manual*. *American Journal of Physics* (Vol. 67). https://doi.org/10.1119/1.19265

Mazzetti, A., Tenerini, P., Dicerto, M., van der Sluijs, K., Smits, D., Rambout, D., … Vasilyeva, E. (2010). *Final Specification of the operational infrastructure* (Vol. 1).

McCrae, R. R., & John, O. P. (1992). An introduction to the five-factor model and its applications. *Journal of Personality*, *60*, 175–215. https://doi.org/10.1111/j.1467-6494.1992.tb00970.x

McKenney, S., & Reeves, T. C. (2014). Educational design research. *Handbook of Research on Educational Communications and Technology: Fourth Edition*, (July), 131–140. https://doi.org/10.1007/978-1-4614-3185-5_11

Meyer, D. K., & Turner, J. C. (2007). Scaffolding Emotions in Classrooms. *Emotion in Education*, (December), 243–258. https://doi.org/10.1016/B978-012372545-5/50015-0

Moore, M. G. (1980). Independent study. *Redefining the Discipline of Adult Education*.

Mori, T. (2018). The Flipped Classroom: An Instructional Framework for Promotion of Active Learning. In *Deep Active Learning: Toward Greater Depth in University Education* (pp. 95–109). Springer. https://doi.org/10.1007/978-981-10-5660-4_10

NSSE. (2013). *A Fresh Look at Student Engagement - Annual Results 2013*. *A FRESH LOOK AT STUDENT ENGAGEMENT - ANNUAL RESULTS 2013*. Retrieved from nsse.iub.edu

NSSE. (2015). *Engagement Insights Survey Findings on the Quality of Undergraduate Education*. *Annual Results*.

Ortiz, S. M. (2003). Muted Masculinity as an Outsider Strategy: Gender Sharing in Ethnographic Work with Wives of Professional Athletes. *Symbolic Interaction*, *26*(4), 601–611. https://doi.org/10.1525/si.2003.26.4.601

Ortony, A., & Turner, T. J. (1990). What's basic about basic emotions? *Psychological Review*, *97*(3), 315–331. https://doi.org/10.1037/0033-295X.97.3.315

Ottenbreit-Leftwich, A. T., Brush, T. A., Strycker, J., Gronseth, S., Roman, T., Abaci, S., … Plucker, J. (2012). Preparation versus practice: How do teacher education programs and practicing teachers align in their use of technology to support teaching and learning? *Computers and Education*, *59*(2), 399–411. https://doi.org/10.1016/j.compedu.2012.01.014

Pappas, I. O., Giannakos, M. N., & Jaccheri, L. (2016). Investigating factors influencing students intention to dropout computer science studies. *Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE*, *11-13-July*(7491), 198–203. https://doi.org/10.1145/2899415.2899455

Park, J. Y., Joo, S. H., Cornillie, F., van der Maas, H. L. J., & Van den Noortgate, W. (2019). An explanatory item response theory method for alleviating the cold-start problem in adaptive learning environments. *Behavior Research Methods*, *51*(2), 895–909. https://doi.org/10.3758/s13428-018-1166-9

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2008). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*(4), 315–341. https://doi.org/10.1007/s10648-006-9029-9

Pekrun, R. (2016). Handbook of motivation at school: Second edition. In *Handbook of Motivation at School: Second Edition* (pp. 120–144). https://doi.org/10.4324/9781315773384

Pekrun, R., Elliot, A. J., & Maier, M. A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology*, *98*(3), 583–597. https://doi.org/10.1037/0022-0663.98.3.583

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemporary Educational Psychology*, *36*(1), 36–48. https://doi.org/10.1016/j.cedpsych.2010.10.002

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, *37*(2), 91–105. https://doi.org/10.1207/S15326985EP3702_4

Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In S. Christenson, A. Reschly, & C. Wylie (Eds.), *Handbook of Research on Student Engagement* (pp. 259–282). Bosten MA: Springer.

Peña-Ayala, A. (2013). *Intelligent and Adaptive Educational-Learning Systems: Achievements and Trends (Smart Innovation, Systems and Technologies)*. https://doi.org/10.1007/978-3-642-30171-1_6

Peña-Ayala, A., Sossa-Azuela, H., & Cervantes-Pérez, F. (2012). Predictive student model supported by fuzzy-causal knowledge and inference. *Expert Systems with Applications*, *39*(5), 4690–4709. https://doi.org/10.1016/j.eswa.2011.09.086

Puentedura, R. R. (2006). Transformation, Technology, and Education.

Reich, B. J. (2015). Rebooting MOOC Research. Improve assessment, data sharing, and experimental design. *Science*, *347*(6217), 34–35.

Riel, M. M. (2000). Education in the 21st Century : Just-in-Time Learning or Learning Communities Education in the 21 st Century : Just-in-Time Learning or Learning Communities Margaret Riel Center for Collaborative Research in Education, (March).

Roblyer, M. (2004). *Integrating Educational Technology into Teaching* (3rd ed.). Pearson Education. https://doi.org/10.1177/016264341102600108

Ryan, R., & Deci, E. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *The American*

Psychologist, *55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Sawang, S., O'Connor, P., & Ali, M. (2017). Using Technology to Enhance Students' Engagement in a Large Classroom. *Journal of Learning Design*, *10*(1), 11–19. Retrieved from http://www.creatividadysociedad.com/articulos/19/La influencia de las vanguardias artisticas en los videoclips de Michel Gondry.pdf

Scherer, K. R. (2005). What are emotions? and how can they be measured? *Social Science Information*, *44*(4), 695–729. https://doi.org/10.1177/0539018405058216

Schmid, R. F., Bernard, R. M., Borokhovski, E., Tamim, R. M., Abrami, P. C., Surkes, M. A., … Woods, J. (2014). The effects of technology use in postsecondary education: A meta-analysis of classroom applications. *Computers and Education*, *72*, 271–291. https://doi.org/10.1016/j.compedu.2013.11.002

Shadish, W., Cook, T., Campbell, T. (2005). Experiments and generalized causal inference. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*, *100*(470), 1–81. https://doi.org/10.1198/jasa.2005.s22

Shuman, V., & Scherer, K. (2014). Concepts and Structures of Emotions. In *International Handbook of emotions in education* (pp. 13–55). New York, NY: Talor & Francis.

Stein, N. L., & Levine, L. J. (1989). The causal organisation of emotional knowledge: A developmental study. *Cognition and Emotion*, *3*(4), 343–378. https://doi.org/10.1080/02699938908412712

Stockwell, B. R., Stockwell, M. S., Cennamo, M., & Jiang, E. (2015). Blended Learning Improves Science Education. *Cell*, *162*(5), 933–936. https://doi.org/10.1016/j.cell.2015.08.009

Tadlaoui, M., Chikh, A., & Bouamrane, K. (2013). Chapter 2 ALEM : A Reference Model for Educational. In *Intelligent and Adaptive Educational-Learning Systems* (pp. 25–48).

vanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, *46*(4), 197–221. https://doi.org/10.1080/00461520.2011.611369

Waddoups, G. L., & Howell, S. L. (2002). Bringing online learning to campus: The hybridization of teaching and learning at Brigham Young University. *International Review of Research in Open and Distance Learning*, *2*(2), 197–216. https://doi.org/10.19173/irrodl.v2i2.52

Weiner, B. (1985). An Attributional Theory of Achievement Motivation and Emotion. *Psychological Review*, *92*(4), 548–573. https://doi.org/10.1037/0033-295X.92.4.548

Wood, W. B., & Tanner, K. D. (2012). The role of the lecturer as tutor: Doing what

effective tutors do in a large lecture class. *CBE Life Sciences Education*, *11*(1), 3–9. https://doi.org/10.1187/cbe.11-12-0110

Wu, H., & Bra, P. De. (2001). Sufficient Conditions for Well-Behaved Adaptive Hypermedia Systems 2 The Adaptation Rule Language. *In Proceedings of the First Asia-Pacific Conference on Web Intelligence: Research and Development*, 148–152.

Xu, Z., Wijekumar, K., Ramirez, G., Hu, X., & Irey, R. (2019). The effectiveness of intelligent tutoring systems on K-12 students' reading comprehension: A meta-analysis. *British Journal of Educational Technology*, *50*(6), 3119–3137. https://doi.org/10.1111/bjet.12758

Young, J. C., Rose, D. C., Mumby, H. S., Benitez-Capistros, F., Derrick, C. J., Finch, T., … Mukherjee, N. (2018). A methodological guide to using and reporting on interviews in conservation science research. *Methods in Ecology and Evolution*, *9*(1), 10–19. https://doi.org/10.1111/2041-210X.12828

Young, J. R. (2002). Hybrid Teaching seeks to end divide between traditional and online instruction. The Chronicles of Higher Education.

Young, M. R. (2010). The Art and Science of Fostering Engaged Learning. *Academy of Educational Leadership Journal. 2010 Supplement*, *14*, 1–18.

Zeidner, M. (1998). *Test anxiety. State of the art*. New York: Plenum.

Annexe 1: Ethics Approval Documentation

PRIVATE
Mr Oran Devilly
Computer Science
University of Warwick
Coventry
CV4 7AL

8 November 2017

Dear Mr Devilly

Study Title and BSREC Reference: *The impacts on engagement of an Adaptive Educational System as an integrated part of a classroom environment* REGO-2017-2113

Thank you for submitting the revisions to the above-named study to the University of Warwick's Biomedical and Scientific Research Ethics Sub-Committee for approval.

I am pleased to confirm that approval is granted and that your study may commence.

In undertaking your study, you are required to comply with the University of Warwick's *Research Data Management Policy*, details of which may be found on the Research and Impact Services' webpages, under "Codes of Practice & Policies" » "Research Code of Practice" » "Data & Records" » "Research Data Management Policy", at:
http://www2.warwick.ac.uk/services/ris/research_integrity/code_of_practice_and_policies/research_code_of_practice/datacollection_retention/research_data_mgt_policy

You are also required to comply with the University of Warwick's *Information Classification and Handling Procedure*, details of which may be found on the University's Governance webpages, under "Governance" » "Information Security" » "Information Classification and Handling Procedure", at:
http://www2.warwick.ac.uk/services/gov/informationsecurity/handling.
Investigators should familiarise themselves with the classifications of information defined therein, and the requirements for the storage and transportation of information within the different classifications:

> *Information Classifications:*
> http://www2.warwick.ac.uk/services/gov/informationsecurity/handling/classifications
> *Handling Electronic Information:*
> http://www2.warwick.ac.uk/services/gov/informationsecurity/handling/electronic/
> *Handling Paper or other media*
> http://www2.warwick.ac.uk/services/gov/informationsecurity/handling/paper/.

Please also be aware that BSREC grants **ethical approval** for studies. **The seeking and obtaining of *all* other necessary approvals is the responsibility of the investigator.**

These other approvals may include, but are not limited to:

1. Any necessary agreements, approvals, or permissions required in order to comply with the University of Warwick's Financial Regulations and Procedures.
2. Any necessary approval or permission required in order to comply with the University of Warwick's Quality Management System and Standard Operating Procedures for the governance, acquisition, storage, use, and disposal of human samples for research.
3. All relevant University, Faculty, and Divisional/Departmental approvals, if an employee or student of the University of Warwick.
4. Approval from the applicant's academic supervisor and course/module leader (as appropriate), if a student of the University of Warwick.
5. NHS Trust R&D Management Approval, for research studies undertaken in NHS Trusts.
6. NHS Trust Clinical Audit Approval, for clinical audit studies undertaken in NHS Trusts.
7. Approval from Departmental or Divisional Heads, as required under local procedures, within Health and Social Care organisations hosting the study.
8. Local ethical approval for studies undertaken overseas, or in other HE institutions in the UK.
9. Approval from Heads (or delegates thereof) of UK Medical Schools, for studies involving medical students as participants.
10. Permission from Warwick Medical School to access medical students or medical student data for research or evaluation purposes.
11. NHS Trust Caldicott Guardian Approval, for studies where identifiable data is being transferred outside of the direct clinical care team. Individual NHS Trust procedures vary in their implementation of Caldicott guidance, and local guidance must be sought.
12. Any other approval required by the institution hosting the study, or by the applicant's employer.

There is no requirement to supply documentary evidence of any of the above to BSREC, but applicants should hold such evidence in their Study Master File for University of Warwick auditing and monitoring purposes. You may be required to supply evidence of any necessary approvals to other University functions, e.g. The Finance Office, Research & Impact Services (RIS), or your Department/School.

May I take this opportunity to wish you success with your study, and to remind you that any Substantial Amendments to your study require approval from BSREC before they may be implemented.

Yours sincerely

pp. E Digby

Professor John Davey
Chair
Biomedical and Scientific
Research Ethics Sub-Committee

Biomedical and Scientific
Research Ethics Sub-Committee
Research & Impact Services
University of Warwick
Coventry, CV4 8UW.
E: BSREC@Warwick.ac.uk

http://www2.warwick.ac.uk/services/ris/research_integrity/researchethicscommittees/biomed

WBS ETHICS REVIEW FEEDBACK

[Semester 2, 2017]

Dear Oran

Re: The impacts on engagement of an Adaptive Educational System as an integrated part of a classroom environment

Thank you for submitting this project for review by the WBS committee. The committee has now undertaken a peer review of the project work and would be happy to recommend this project be granted ethical approval to proceed.

Kind regards

Rebecca

Rebecca Jones
Ethics Chair, Worcester Business School
wbsethics@worc.ac.uk

BIOMEDICAL AND SCIENTIFIC RESEARCH ETHICS COMMITTEE CONSENT FORM

Study Number: 13363801

Patient Identification Number for this study: N/A

Title of Project: The impacts on engagement of an Adaptive Educational System as an integrated part of a classroom environment

Name of Researcher(s): Researcher : Oran Devilly / Academic Supervisor : Jane Sinclair

Please initial all boxes

1. I confirm that I have read and understand the information sheet dated **[23/10/2017 Version Number 2]** 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 at any time without giving any reason, without my education rights being affected. ☐
3. I understand that relevant sections of data collected during the study, may be looked at by individuals from The University of Warwick, from regulatory authorities where it is relevant to my taking part in this study. I give permission for these individuals to have access to my records. ☐
4. I have agreed to an interview and I agree to have my interview recorded ☐
5. I agree to the use of [anonymised quotes/aggregated results] in publications ☐
6. I agree to take part in the above study. ☐

Name of Participant	Date	Signature
Name of Person taking consent	Date	Signature

Biomedical and Scientific Research Ethics Committee (BSREC):

Application Form for Research Ethical Approval

SECTION 1. APPLICANT DETAILS	
1.1 RESEARCHER	
Researcher's Title:	MR.
Researcher's Forename:	Oran Zane
Researcher's Surname:	Devilly
Researcher's Faculty/School and Department:	Computer Science
Researcher's Status:	
Undergraduate Student	☐
Taught Postgraduate Student	☐
Research Postgraduate Student	☒
Staff	☐
Other	☐
Please specify:	
If Student:	
Name of course/qualification:	P/G Student Computer Science PhD
If Staff:	
Researcher's Post:	
1.2 RESEARCHER'S CONTACT DETAILS	
Warwick e-mail address:	O.Z.Devilly@warwick.ac.uk
Daytime telephone number:	07895082553
Postal address:	59 Monarch Drive, Worcester, WR26ES
1.3 SUPERVISOR (COMPLETE FOR ALL STUDENT PROJECTS)	

Supervisor's Title:	Associate Professor
Supervisor's Forename:	Jane
Supervisor's Surname:	Sinclair
Supervisor's Post:	Faculty
Supervisor's Faculty/School and Department:	Computer Science
Supervisor's Warwick e-mail address:	J.E.Sinclair@warwick.ac.uk
Supervisor's daytime telephone number:	024 7652 3193

SECTION 2. PROJECT DETAILS	
2.1 Project Title:	The impacts on engagement of an Adaptive Educational System as an integrated part of a classroom environment
2.2 Estimated Start Date of Project:	October 2017
2.3 Estimated Completion Date of Project:	May 2019
2.4 Sponsoring Organisation: (for University of Warwick staff and students, undertaking non-commercial projects, this will be the University of Warwick)	University of Warwick
2.5 Funder: (e.g. unfunded student project, unfunded Departmental project, Medical Research Council (MRC), Economic & Social Research Council (ESRC), EU)	unfunded student project

2.6 TYPE OF PROJECT

Is the project:

Primary Research	☒
Research limited to the use of previously collected identifiable data	☐
Research limited to the use of previously collected anonymised data	☐
Clinical Audit	☐
Service evaluation or Development	☐

Please specify:

2.7 LINKS WITH OTHER BSREC APPLICATIONS

Is the project linked to any other BSREC application? No
If yes, detail:
Project title:
Chief Investigator:
BSREC Reference (if known):

Nature of linkage:

2.8 LOCATION

Will any part of the project be undertaken overseas? No

State all of the locations at which the project will be undertaken, whether in the UK or overseas e.g. public place, school (a), school (b) etc., in researcher's office:
University of Worcester

2.9 PARTICIPANTS

State the total number of planned participants: 50

BREAKDOWN OF PARTICIPANTS
Where applicable, state the breakdown of participants by type and number of each type of participant, e.g. children, parents, teachers, etc.:

Type of Participant:	**Number:**
Students	50

SECTION 3. TRAINING	Yes	No
Have you successfully completed the Research Integrity online training module? https://www2.warwick.ac.uk/services/ldc/researchers/opportunities/development_support/research_integrity/	☒	☐

SECTION 4. RISK AND ETHICAL CONSIDERATIONS CHECKLIST

Complete the checklist ticking '**Yes**' or '**No**' to all questions.
Note that, where you have ticked '**Yes**' to a question below, you will need to specifically address the ethical issues raised by that point in the study protocol.

		Yes	No
A	Does the study involve **participants who are particularly vulnerable** or **unable to give informed consent** or **in a dependent position** (e.g. children, your own students, over-researched groups, people with learning difficulties, people with mental health problems, young offenders, people in care facilities, prisoners)?	☒	☐

B	Will participants be taking part in the study without their consent or knowledge at the time, or will **deception** of any sort be involved (e.g. covert observation of people in non-public places)?	☐	☒
C	Is there a risk that the highly sensitive nature of the subject might lead to **disclosures** from the participant concerning their involvement in illegal activities or other activities that represent a threat to themselves or others (e.g. sexual activity, drug use, or professional misconduct)?	☐	☒
D	Could the study induce **psychological distress or anxiety**, or produce **humiliation**, or **cause harm**, or lead to **negative consequences** beyond the risks encountered in normal life?	☐	☒
E	Does the study involve **substantial physical exertion**?	☐	☒
F	Does the study involve the **administration** of any substance?	☐	☒
G	Does the study involve **physically intrusive procedures**, use of **bodily materials** or **human tissue**, or **DNA/RNA analysis**?	☐	☒
H	Is any **reward**, apart from travelling and other expenses, to be given to participants?	☐	☒
I	Does the study involve **collaboration with any company** or **organisation** external to the University of Warwick?	☐	☒
J	Could the proposal give rise to researchers having any **conflicts of interest**?	☐	☒
K	Will the researchers go to any areas where their **safety may be compromised**?	☐	☒
L	Will **pregnant women** be participants in the study?	☐	☒
M	Will the study involve children **under 5 years** old?	☐	☒
N	Is the research commissioned by the **military**?*	☐	☒
O	Is the research commissioned under an **EU security call**?*	☐	☒
P	Does the research involve the acquisition of **security clearances?***	☐	☒
Q	Does the research concern **terrorist or extreme groups**?*	☐	☒

*Please refer to the University webpages on Prevent Duty

SECTION 5. SIGNATURES AND DECLARATIONS

5.1 RESEARCHER/APPLICANT

I undertake to abide by the University of Warwick's Research Code of Practice in undertaking this study.

I understand that BSREC grants ethical approval for projects, and that the seeking and obtaining of all other necessary approvals and permissions prior to starting the project is my responsibility.

I understand that I must not begin research and related projects with human participants until I have received full approval from the relevant Research Ethics Committee of the University of Warwick.

I understand that any changes that I would like to make to this study after receiving approval from BSREC must follow BSREC procedures as detailed on the BSREC web pages.

Name of Researcher: Oran Zane Devilly

Signature: .....
Date: 11/02/17

Send a signed copy of the form to the BSREC Administrator, A010, Medical School Building, Warwick Medical School, University of Warwick, Coventry, CV4 7AL. bsrec@warwick.ac.uk

5.2 SUPERVISOR SECTION

I confirm that I have read this application and will be acting as the student researcher's supervisor for this project.

The proposal is viable and the student has the appropriate skills to undertake the research. Participant recruitment procedures, including the Information Leaflet(s) to be provided and the process for obtaining informed consent, are appropriate, and the ethical issues arising from the project have been addressed in the protocol.

I understand that BSREC grants ethical approval for projects, and that the seeking and obtaining of all other necessary approvals and permissions prior to starting the project is the responsibility of the student.

I understand that research and related projects with human participants must not commence without full approval from the relevant research ethics committee of the University of Warwick.

Name of Supervisor:

Signature: .....
Date:

NB: An e-mail from the Academic Supervisor that states the above, in lieu of a signature on this form, may be sent to: bsrec@warwick.ac.uk

BIOMEDICAL AND SCIENTIFIC RESEARCH ETHICS COMMITTEE CONSENT FORM

Study Number: 13363801

Patient Identification Number for this study: N/A

Title of Project: The impacts on engagement of an Adaptive Educational System as an integrated part of a classroom environment

Name of Researcher(s): Researcher : Oran Devilly / Academic Supervisor : Jane Sinclair

Please initial all boxes

1. I confirm that I have read and understand the information sheet dated **[23/10/2017 Version Number 2]** 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 at any time without giving any reason, without my education rights being affected. ☐
3. I understand that relevant sections of data collected during the study, may be looked at by individuals from The University of Warwick, from regulatory authorities where it is relevant to my taking part in this study. I give permission for these individuals to have access to my records. ☐
4. I have agreed to an interview and I agree to have my interview recorded ☐
5. I agree to the use of [anonymised quotes/aggregated results] in publications ☐
6. I agree to take part in the above study. ☐

Name of Participant	Date	Signature
Name of Person taking consent	Date	Signature

Annexe 2: Self-Reporting Survey Questions

Classroom engagement questions

1. I enjoy being in class
2. I am confident when I go to class
3. I am proud of the work I do in class
4. I feel angry in class
5. Thinking about class makes me feel uneasy
6. I get embarrassed in class
7. I feel hopeless in class
8. I get bored in class

Learning Engagement Questions

1. I enjoy acquiring new knowledge
2. I have an optimistic view towards studying
3. I am proud of my capacity to learn
4. Studying makes me irritated
5. I get tense and irritated while studying
6. I feel ashamed when I can't absorb simple details
7. I feel hopeless when thinking about studying
8. The materials make me feel very bored

Styles of Engagement

1. I feel confident in my ability to learn
2. I feel I have control over my learning (which tasks I do and how and when I do the tasks is in my control)
3. How would you rate the level of difficulty of these tasks
4. How would you rate your level of enjoyment of these tasks
5. How would you rate your level of motivation in these tasks
6. I feel supported with my learning
7. I feel comfortable in the classroom environment
8. Another other information you feel would be valuable to this journal or help inform the structure of the module

Adaptive System Based Questions

1. I feel supported by the adaptive system
2. I find it easy to use the adaptive system
3. The adaptive system gives me control over my learning
4. The adaptive system helps me find the information I need to proceed in tasks
5. I feel more capable of making progress on my own while using the adaptive system as opposed to asking for support from the tutor

Open Ended Questions: (System refers to the Adaptive Educational System students will use during workshops)

Do you feel the system gave you more control over you learning, explain?

Did the system support you in your learning, explain?

What worked, what didn’t when using the system?

What do you feel was the main difference between lecturer support and the support from the system?

Annexe 3: Semi-Structured Interview Guiding Questions

Individual Interview Topic Guide

("System" refers to the Adaptive Educational System students will use during workshops)

("Engagement" refers to the emotional aspects of engagement being explored in this study)

Research goals of the interviews:

- What are the impacts of the system in the classroom on the learners classroom engagement
- What are the impacts of the system in the classroom on the learners learning engagement
- What impact does the system have on aspects of the learner's style of engagement such as confidence, demand, control and support.
- In what ways does the system impact the learners' perception of learning and emotionally engaged state.

(a) Introduction, overview of research and interview process (5 minutes)

- Researcher will recap the research objectives around exploring the impacts of an adaptive system on emotional engagement. Outlining the process of the interview, that it will be recorded and that all data will be kept secure and anonymous. Then describe the concept of open ended questions which allow the participant to discuss their experience.
- As participants discuss their experiences, the research will explore various emotions related to the questionnaire filled out in earlier sessions and how they have been impacted by having or not having the system in place

(b) Discussion on emotional engagement (35 minutes)

All the questions here are aligned with areas explored in the quantitative data, these relate to classroom engagement, learner engagement and styles of engagement. There are also some questions to explore various impacts of the system directly on this elements of engagement. The following questions will lead the discussion:

1. Did your attitude / feeling towards class differ when the system was in place vs when it wasn't?
2. Did your attitude / feeling towards your learning differ when the system was in place vs when it wasn't?
3. Did you feel you could make more individual progress when using the system

4. Do you feel the system gave you more control over you learning, explain?
5. Did the system support you in your learning, explain?
6. What worked, what didn’t when using the system?
7. What do you feel was the main difference between lecturer support and the support from the system?

(c) Conclusion (5 minutes)

- Sum up what has been discussed, and thank the participant, asking if there is anything else of importance that the participant wishes to discuss in relation to this study.
- The participants will be reminded of their option to withdrawn from the study if they so choose and that data in such a case would not be used for the study.