Fieldscapes – Creating and Evaluating a 3D Virtual Field Trip System

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Fieldscapes – Creating and Evaluating a 3D Virtual Fieldtrip System

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Abstract. This paper describes the concept of the virtual field trip and presents a taxonomy of virtual field-trip approaches. Building on the Virtual Skiddaw project between Daden Limited and The Open University, UK, the InnovateUK funded Virtual Fieldstrips as a Service project is described. The resulting Fieldscapes system is then presented, along with how it addresses the technical, pedagogic and commercial challenges of creating a virtual fieldtrip system. This is followed by an initial evaluation of the system, and areas for future development and research are identified.

Keywords. Virtual Field Trips, Immersive Learning, eLearning, Virtual Reality

1 Virtual Field Trips

Fieldwork, which involves leaving the classroom and engaging in teaching and learning through first-hand experience of phenomena out-of-doors, has a long tradition in geography and in certain sciences, notably biology and environmental science/studies. The concept of a virtual field-trip is well established [1,2] as a way of providing students with some knowledge (and virtual experience) of a location and how it demonstrates a topic under discussion without requiring them to physically visit the location, as well as being able to support and augment a physical field trip. However, there is a wide variety of technology which can be used to create a virtual field trip, and as a result there are differing perceptions as to what constitutes a proper (or effective) fieldtrip [3,4]. The range of technologies which can be used to create a virtual fieldtrip may include:

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- A set of images and video, used with a paper map
- A web based map linked to text, images, video and audio (e.g. Google Maps)
- A Geographic Information System with similar features to the above (e.g. ESRI - http://edcommunity.esri.com/)
- A video stream or recording of someone at the location (e.g. FieldTripZoom – www.fieldtripzoom.com)
- A set of 180° or 360° panorama photos
- A set of 360° "photospheres", (e.g. Google Expeditions - https://www.google.co.uk/edu/expeditions/)
- A 3D model examined from an objective perspective (e.g. Google Earth)
- A 3D model examined from a subjective perspective – i.e. the user represented as an avatar (e.g. Second Life – www.secondlife.com)

To provide a better framework for considering virtual field-trips the authors have developed the landscape presented in Figure 1 below. This identifies the two most important features of virtual field trips, as identified by the authors, as being:

- The extent to which the landscape is modelled in 3D in order that the true morphology and spatial relationships on the ground can be presented and understood.
- The extent to which the student has the same degree of agency as they do in a real field trip – e.g. can they go off-script and just run up the nearest hill?

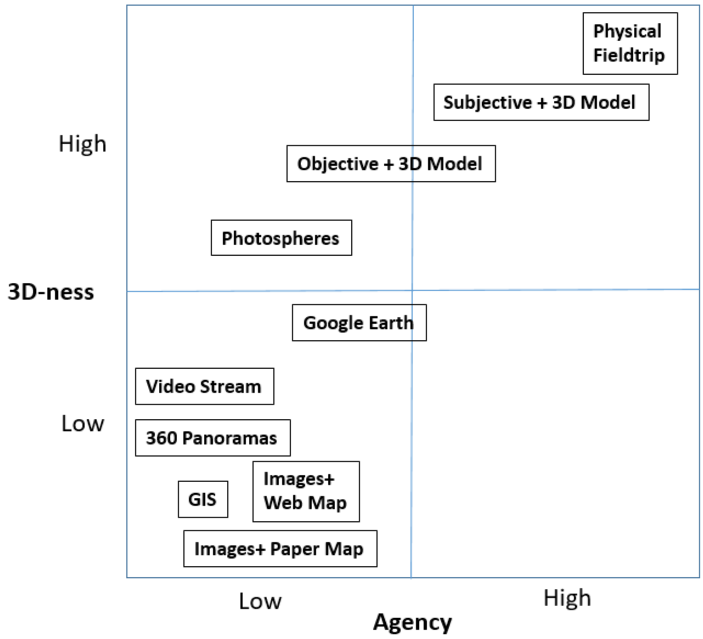

Fig. 1. A Virtual Fieldtrip Landscape

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Interactivity is assumed to be incorporated within agency – although there is not a strict correlation. Other possible dimensions which could also be considered include:

- Whether the virtual fieldtrip system supports multi-user use (as with a physical field trip).
- Ability of tutors to create their own content (as with a physical field trip).
- Level of immersion.

Within the project team there has always been a keen interest in the subjective experience within 3D modelled environments. This has come from using subjective 3D environments such as Second Life (www.secondlife.com) in a range of learning situations [5,6]. This interest, and a desire with The Open University (OU) to move beyond an images and paper map model for their own geology virtual field trips led to the Virtual Skiddaw project (http://www.open.ac.uk/researchprojects/open-science/3d-virtual-geology-field-trip).

2 Virtual Skiddaw

The aim of the Virtual Skiddaw project [7] was to create a subjective, multi-user 3D virtual field trip of the Skiddaw area in the English Lake District which could be used by OU staff and students to conduct synchronous, group-based, virtual fieldtrips – and therefore conducted in a very similar way to physical field-trips. This would help the OU move from an Images+Map approach (bottom left quadrant in Figure 1) to a Subjective 3D Model (top-right quadrant). Daden Limited created the Virtual Skiddaw system using the Unity game engine, and with commercially sourced digital elevation data and aerial photography. Six specific sites (and hand samples at each site) were digitally captured using photogrammetry. The resulting 3D model gave accuracies of around 2-5m across the whole 10km x 10km area, and of around a few centimeters in the sample sites, and of millimeters for the hand samples. Pedagogically, the application provided the students with a text and audio overview of the location and its geology, a simple kit selection task, and then guided activities at the 6 sites which included: sketching the location, examining rock outcrops, examining and assessing the hand sample, and considering the location context. Virtual Skiddaw has been (and continues to be) used successfully on OU Geology courses since its development.

3 Virtual Fieldtrips as a Service

Whilst Virtual Skiddaw was an undoubted success the project team were keen to explore how the system could be moved from one institution/one location/one lesson to multiple institutions/multiple locations and multiple lessons.

In 2014, InnovateUK (the Innovation Agency of the UK Government) launched a Design for Impact competition to fund feasibility, and possibly development, of education technologies which had been proved on a small scale but which if scaled-up could benefit UK education (at all levels) as a whole. Daden led a consortium consisting of

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the Open University, the Field Studies Council (FSC, who host over 140,000 students on physical field trips each year), and DesignThinkersUK (a service design consultancy) and were successful at winning both 6 months Phase 1 Feasibility funding and then 12 months Phase 2 development funding. This paper presents the results of both these phases.

During both phases the project team actively involved a wide range of stakeholders, including schools, universities, field study operators, heritage organisations, mapping agencies, educational publishers and awarding bodies. DesignThinkersUK facilitated service design workshops in schools and with the FSC - to identify customer journeys. Workshops were also held at universities and even in Second Life.

The activities were broadly grouped into 3 main areas: pedagogy, technical development and commercial planning.

3.1 Pedagogical Challenges

In order to ensure that the virtual field-trip system was going to be of interest and use to teachers and students it was vitally important to understand what physical field-trips consisted of, how they were managed and experienced from both the teacher and students' viewpoint, and the role that a virtual field-trip could play in enhancing them. It should be noted that an over-riding feature of the project was that virtual fieldtrips should be seen as enhancing physical field-trips rather than replacing them.

From the workshops the team identified that a field-trip could be considered as having three main phases: before the trip, during the trip, and after the trip. Table 1 shows the different ways in which a virtual field-trip could be used to support the physical field-trip which were identified at these workshops.

Before	**During**	**After**
Teacher planning/skills Student skills/planning – maximise time-on-site On site meeting with field tutors Parent briefing Risk assessment General map skills Context setting	Next-day planning "Virtual drone" on site Where we didn't get to…. Wet-weather programme Day review	Data review Students who missed trip Students who didn't do all tasks Comparative sites Translation tasks Revision

Table 1. The Before-During-After roles of a Virtual Field Trip

Whilst the discussions were focused around "environmental" field-trips (including geology, geography, earth sciences, environmental studies, biology) almost all educators identified the wider opportunities that such a system could offer to the teaching of history, Science, Technology, Engineering and Maths (STEM) subjects, and even languages.

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In addition, it became apparent that the technology itself needed to be pedagogically neutral – allowing educators to create the sort of lesson they wanted – whether structured or unstructured, directed or action learning etc. Most of the field trip systems described earlier embed the pedagogy within the technology application – resulting in systems that are inflexible when it comes to meeting individual educators' needs and approaches.

3.2 Technical Challenges and Development

In terms of the technical development of the system the workshops helped identify several challenges that any service needed to address, including how the system could:

- Deliver a wide variety of complex 3D terrain models.
- Operate on a variety of computing devices, including PCs, tablets and smartphones.
- Operate both in a "traditional" 3D mode (e.g. with the student represented as an avatar and viewed in first or third person), and with the new generation of virtual reality headsets (such as Google Cardboard and Oculus Rift).
- Enable teachers to create lessons without a high level of IT or 3D skills.

These represent the core requirements of the system, and the resulting Fieldscapes system developed as part of the project and described below has been designed to address and deliver against each of these challenges and requirements.

In order to gain some early technical feedback and experience the team created two demonstrator virtual field-trip applications and placed them on the Android Play Store and sent them to participating schools. Both ran on Android smartphones and were designed to be used with the Google Cardboard mobile Virtual Reality (VR) headset. The applications were:

- A 3D model of CardingMill Valley, a popular physical fieldtrip site in Shropshire, England, which allowed the user to walk and fly around a 2km x 2km area centered on the fieldtrip site. This let students see the context of the valley (which they do not typically leave during a trip) by flying all around it and the surrounding ridges and moors, and could even be used when physically on the field-trip in the valley itself. An image of the system is at Figure 2.
- A set of 3 photospheres (360° photos) which gave students an all-around photorealistic view of the valley at 3 key points, and the ability to "jump" between the points. The graphic quality was significantly better than the 3D model, but the student was significant limited in terms of where they could go – just 3 locations. An image of the system is at Figure 3.

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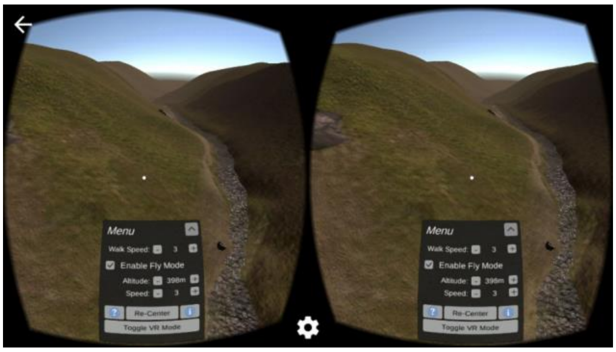

Fig. 2. The 3D Model of CardingMill VR Application

Fig. 3. The Photosphere CardingMill VR Application

It should be noted that neither application had any authored learning content beyond the location itself. The results of an evaluation of each is presented below.

In terms of system design the key decision was to separate the system out into 3 main elements:

- A “player “ application which initially contains no location or learning content, but includes an “engine” to deliver the learning content.
- The 3D files for each location, and any objects needed by the lesson, which are served to the player application when the student needs them, and then cached for off-line access.
- The learning content, defined in a platform neutral XML format, with a supporting what-you-see-is-what-you-get (WYSIWYG) and form based editor, and which again is served to the student as required.

This approach gives the system the flexibility it needs to meet the differing demands of student devices, the use of VR headsets, and to deliver a wide variety of pedagogical approaches for subjects from across the whole curriculum.

The resulting Fieldscapes system is described in more detail below.

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3.3 Commercial Planning

In the discussions with educators it was apparent that in order to be useful a virtual fieldtrip system had to be able to deliver content that was specific to the curriculum being studied (rather than a "general" geology field-trip), and had to be applicable across the whole-school if the money was to be made available to purchase it.

Commercially there is no way that Daden (or most other small companies) can afford the investment to create such a wide variety of lessons up-front. The only feasible route, and the one adopted by Fieldscapes, is to create a sharing culture of User Generated Content. The Times Education Supplement TES Resources site (https://www.tes.com/teaching-resources) has shown just how readily educators will create and share quality content.

The other key commercial consideration was pricing. The teams' experiences with the educational users of Second Life have shown how educators like to be able to "play" with a technology and experiment before using it in class. The Second Life pricing model also showed how the high cost of subscriptions put off small-scale use of the platform – which may have in due course led to whole-institution use. For that reason Fieldscapes is being developed with both a "educator access free" model to encourage experimentation and then a tiered "per student" charging model to enable the system to be economically viable for any size of class or institution.

It should also be noted that the team was well aware that child-safety concerns around Second Life restricted its use in schools and Fieldscapes has been designed to address these concerns and provide a safe environment for 3D immersive education.

4 Fieldscapes

The Fieldscapes system developed through the project is shown in Figure 4. The main elements of the system are:

- The Fieldscapes service (centre of Figure 4), which runs on the Internet and is used to host locations, inventories and exercises
- 3D location and equipment models (top of Figure 4), created by anybody with suitable technical skill and developed with industry standard tools such as 3D Studio Max, SketchUp and Unity3D.
- Exercises (right of Figure 4), which almost any IT-literate teacher should be able to create. Exercises are defined within a location simply by moving around, placing objects (called "props" in Feldscapes, and defining how the user interacts with those props. The authoring tool provides variables, logic tests, timers, grouping of props and media integration by URL to create a relatively rich authoring environment.
- The Explorer application (bottom of Figure 4), which lets students undertake the exercises and comes in versions that run on Smartphones and Tablets (iOS and Android), and on standard PCs (and shortly Macs). In terms of virtual reality (VR), the iOS and Android versions support Google Cardboard, and the PC/Windows version supports Oculus Rift. The Explorer application can also work in single user or hybrid

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multi-user mode, and also provides class management tools for a tutor – such as recalling the class from across the landscape (and then locking them in position!)

- The Lesson Manager application, which as well as allocating students and exercises to assignments also tracks student completion and success on each assignment, and interfaces to a Virtual Learning Environment (VLE) (left of Figure 4).

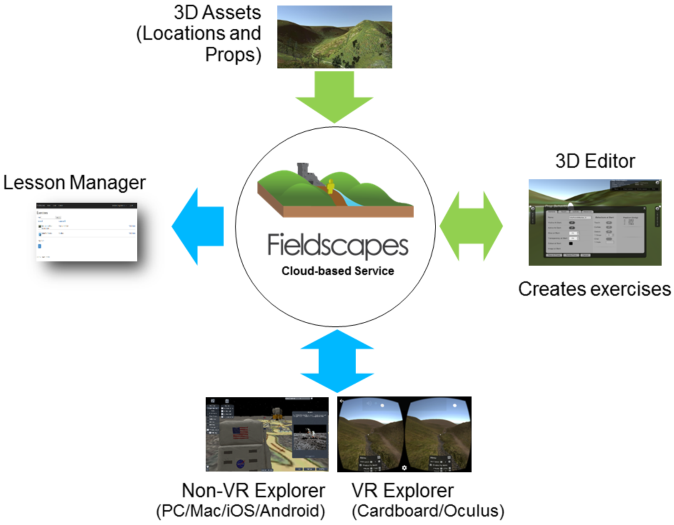

Fig. 4. The Fieldscapes System

An image of the Fieldscapes authoring environment is shown in Figure 5, and Figure 6 shows the user experience during a river measurement exercise. A video introduction to the Fieldscapes system is at https://www.youtube.com/watch?v=vCrstN4tlFg, and there is more information on the system at www.fieldscapesvr.com.

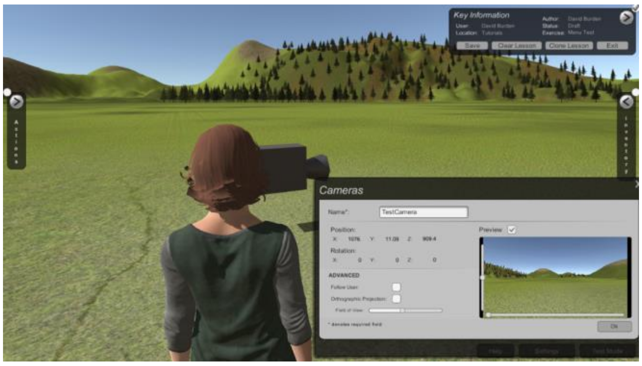

Fig. 5. The Fieldscapes Editor

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Fig. 6. The Fieldscapes User Experience

5 Initial Evaluation

During the Phase 2 activity the project team undertook a variety of very initial qualitative and quantitative assessments of Fieldscapes as part of the school, university and stakeholder engagements to help prove that a virtual field trip can aid learning, and, in particular, support students going on a physical trip. Further work is on-going but the initial results are presented here.

5.1 Qualitative Assessment

From the workshops and trials session the following quote give an idea of how well the Fieldscapes concept and application were received:

“This is ridiculously exciting. People have been using the term virtual fieldwork for a while but this is the first actual virtual fieldwork I've seen. Mind blowing!” – Geography Teacher, Melbourne, Australia

“I presented to 3 other earth science teachers, the head of science, and the administrator in charge of science this morning. They all loved Fieldscapes.” – Geology & Paleontology Teacher, Virgina, USA

Negative comments tended to dwell on the lack of visual realism in comparison to photospheres, current lack of avatar choice, and current lack of browser access.

5.2 Quantitative Assessment

As an example of the quantitative assessment undertaken the results presented here are for a workshop held at a girl’s secondary school in Northampton. During a one-hour

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session 20 students took part in a round-robin of 4 stands with each student having the chance to try out:

- The Photosphere VR of Carding Mill Valley (CMV) running on Google Cardboard (top left quadrant of Figure 1).
- The 3D Model VR of CMV running on Google Cardboard (top right quadrant).
- A lesson on Apollo 11 running on a PC using Fieldscapes (top right quadrant).
- A lesson on tourism in CMV on a PC using Fieldscapes (top right quadrant).

Students were then asked to rate each system by:

- How much they felt they learnt (self-assessed on a scale of 1 to 5).
- How much they felt that it prepared them for a physical field-trip to Carding Mill Valley that they were undertaking the next week (self-assessed on a scale of 1 to 5).

The charts at Fig 7 show the results for each of the 4 systems against these two measures (N=20, HPS=5).

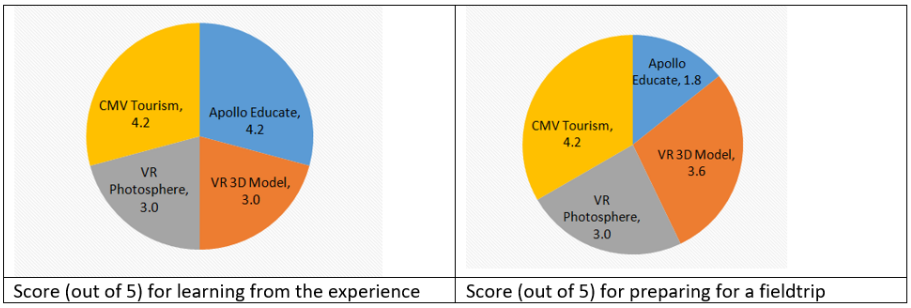

Fig. 7. Average efficacy ratings for different virtual fieldtrip models

The key findings were:

- Students felt that they learnt well, from the Apollo and Carding Mill Tourism exercises, and with equal performance.
- The students gave two Cardboard VR applications lower learning ratings – but it should be noted that neither had an explicit learning layer.
- The Tourism exercise scored highly for preparation for a field trip – the expected result as it combined a full 3D model, a high level of agency, and a structured learning layer.
- The VR 3D model scored more highly than the more photo-realistic VR photosphere – again not surprising as the 3D model enabled the students to better place the valley in context, and to visit any part of the valley.
- The field-trip to the moon was poor preparation for a physical fieldtrip to Shropshire!

Overall, the results of this quantitative assessment confirmed the validity of the design approach for Fieldscapes and the focus on a good quality 3D model and high student

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agency in order to place the virtual field trip as close to the physical field trip experience in the top-right quadrant of the earlier Figure 1 as possible. As the use of Fieldscapes grows we would hope to complete a fuller evaluation of this type with more students and a wider set of questions.

6 Future Directions

With the completion of the InnovateUK funded work in October 2016 the development of Fieldscapes is now being undertaken as a self-funded activity by Daden, and the project partners are continuing to provide active support.

6.1 Commercial Development

Fieldscapes is currently in beta, with beta-testers already coming from across 3 continents. Beta testing and content development is planned to continue until Feb 2017 when the system will be formally launched for live use.

6.2 Technical Development

The initial launch system will support all the key features that the project has shown are needed in a baseline virtual fieldtrip system. It will run on PC and Android systems, and Oculus Rift VR headsets. Further development will be driven by user demand and feedback and is likely to include versions for the Mac, support for other VR headsets, and support for data visualization within locations, and possibly web browser access.

The team is also considering the publication of the XML standard used for exercise definition as an open standard which may open up alternate uses for the system, and the ability for third parties to create editors and players for Fieldscapes exercises in environments not being directly supported by Daden.

6.3 Research

The project team is keen to conduct further research into the efficacy and longevity of education and training within immersive 3D environments, and comparison between avatar-driven and “VR” style approaches to virtual fieldtrips and immersive learning, the efficacy of different pedagogic approaches within 3D and VR immersive learning environments, and the strength of encoding specificity [8] in simulated environments.

7 Conclusions

Fieldscapes represents the culmination of over 10 years of experience in both Daden-Limited and the Open University in the development of immersive learning experiences and environments. To us the fully realized 3D model of an environment, together with the highest level of user agency (and ideally a multi-user setting) provides the closest

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possible experience to a physical field-trip – and as such is ideally positioned to complement and extend physical field-trips, and to allow students to undertake trips and exercises which are just not practicable in real life. This is certainly not to say that a 3D model based field-trip is better than other forms, and educators should always be aware of the affordances of the different approaches (GIS/Google Maps, Photospheres/Google Expeditions) and use them accordingly.

There are undoubtedly challenges in deploying such technology in the classroom – from technical issues such as PC graphics power, locked down desktops and network bandwidth, to issues of staff training and time to just experiment with new approaches with their classes. Certainly, from our experiences over the last 12 months, the technical issues have much reduced over the last decade, but the latter "soft" issues are as challenging as ever.

Through separating the technically challenging task of creating the 3D environment models from the pedagogically creative task of authoring exercises and experiences, and by providing a child-safe learning environment, we also believe that Fieldscapes could help to significantly democratise the adoption of 3D (and VR) immersive learning within the classroom.

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