



**UNIVERSITY OF LEEDS**

This is a repository copy of *The Virtual Worlds Project: geological mapping and field skills*.

White Rose Research Online URL for this paper:

<http://eprints.whiterose.ac.uk/92115/>

Version: Accepted Version

---

**Article:**

Houghton, JJ, Lloyd, GE, Robinson, A et al. (2 more authors) (2015) The Virtual Worlds Project: geological mapping and field skills. *Geology Today*, 31 (6). pp. 227-231. ISSN 0266-6979

<https://doi.org/10.1111/gto.12117>

---

**Reuse**

Unless indicated otherwise, fulltext items are protected by copyright with all rights reserved. The copyright exception in section 29 of the Copyright, Designs and Patents Act 1988 allows the making of a single copy solely for the purpose of non-commercial research or private study within the limits of fair dealing. The publisher or other rights-holder may allow further reproduction and re-use of this version - refer to the White Rose Research Online record for this item. Where records identify the publisher as the copyright holder, users can verify any specific terms of use on the publisher's website.

**Takedown**

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing [eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk) including the URL of the record and the reason for the withdrawal request.



[eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk)  
<https://eprints.whiterose.ac.uk/>

## **The Virtual Worlds Project: Geological Mapping and Field Skills**

**Jacqueline J. Houghton<sup>1</sup>, Geoffrey E. Lloyd<sup>1</sup>, Annabeth Robinson<sup>2</sup>, Clare E. Gordon<sup>1</sup>  
and Daniel J. Morgan<sup>1</sup>.**

**<sup>1</sup>School of Earth and Environment, University of Leeds, Leeds, UK.**

**<sup>2</sup>Leeds College of Art, Leeds, UK.**

**Abstract-**The Virtual Worlds Project is a collaboration between the School of Earth and Environment, University of Leeds, and the Leeds College of Art to build a virtual environment in which to learn and practice basic geological mapping skills. Using the Unity™ game engine, a virtual landscape populated by rock outcrops with associated notebook entries has been created. This approach is not a replacement for field map work. Rather, it represents an in-class tool with the appearance of a computer game with which to enhance basic mapping skills taught in the field in a virtual environment.

### **Introduction**

Game-based learning has come to the fore in recent years for its potential to engage students by allowing them to be active participants in the learning process. Our aim with the Virtual Worlds Project is to create effective learning environments with the appearance of computer games that allow students to learn basic skills through exploration of virtual landscapes (Figures 1 and 2).

Geological mapping, recording the spatial distribution of different rock types and their associated structures across an area, is a fundamental skill for any geologist. Traditionally, mapping skills are taught in the field, where the relationship between rocks in outcrop, the landscape and the underlying geology can best be interpreted. However, the field with its

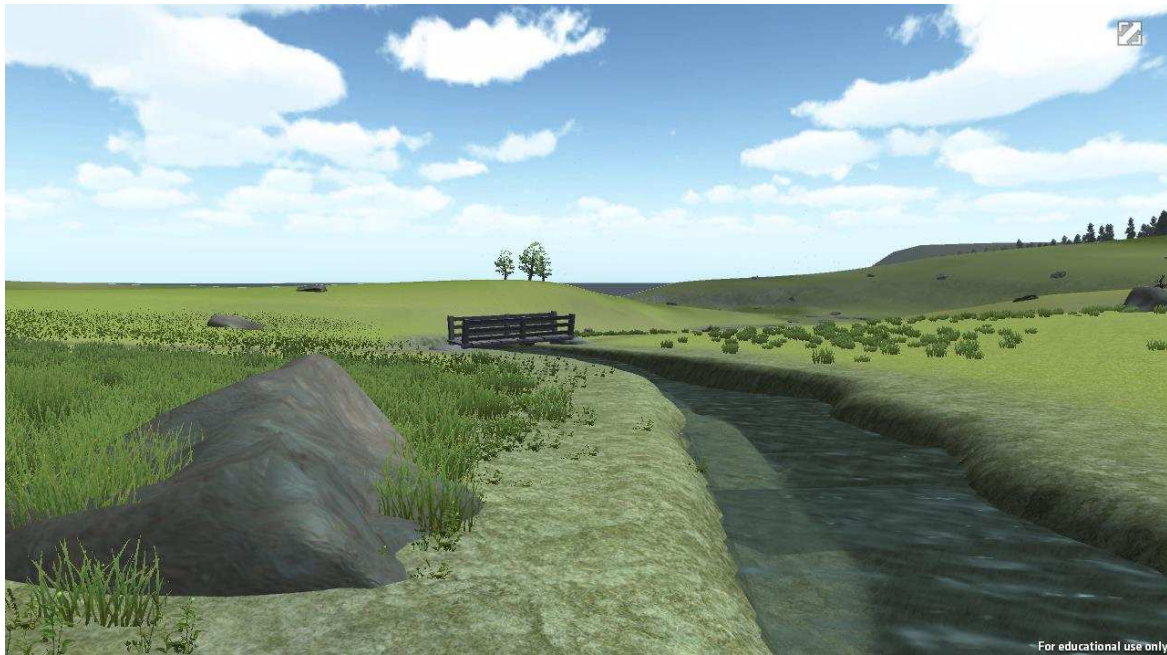


**Figure 1.** Screenshot of the virtual mapping area (looking east towards ‘The Gorge’ – see Figure 5).

unpredictable weather and myriad distractions is not always the ideal learning environment to reinforce basic field skills, such as plotting data on maps, etc. The Virtual Worlds Project (Geological Mapping Skills) has created a virtual training environment (VTE) that provides a virtual space between the class room and the field in which these skills can be learned and practiced in the comfort and control of a class room environment. It is available at: [http://www.see.leeds.ac.uk/virtual\\_worlds/demo/](http://www.see.leeds.ac.uk/virtual_worlds/demo/). We emphasise it is not a replacement for field (map) work but can recreate aspects of field mapping relevant to basic skills not otherwise reproducible in a classroom setting.

### **Background to project**

The Virtual Worlds Project grew from an existing web-based mapping resource (<http://www.see.leeds.ac.uk/structure/virtualmapping/index.htm>). Our initial plans were to improve the appearance and to increase the interactive nature of this exercise. However,



**Figure 2.** Screenshot of the virtual mapping area, with an outcrop in the foreground (left), adjacent to a stream that can only be crossed via the bridge in the background.

during the earliest stages of redevelopment, we met a colleague from the Leeds College of Art who works in ‘serious games’ software programming (i.e. how video games can be used in education). In particular, she is an expert in the Unity™ game engine, software designed for building video games, and a collaboration was born.

Unity™ is a game development ecosystem. It represents software designed especially for building video games. The basic version is free and the plug-in necessary to play the games is easily downloadable (<http://unity3d.com/webplayer>).

### **Approach: creating an effective learning environment**

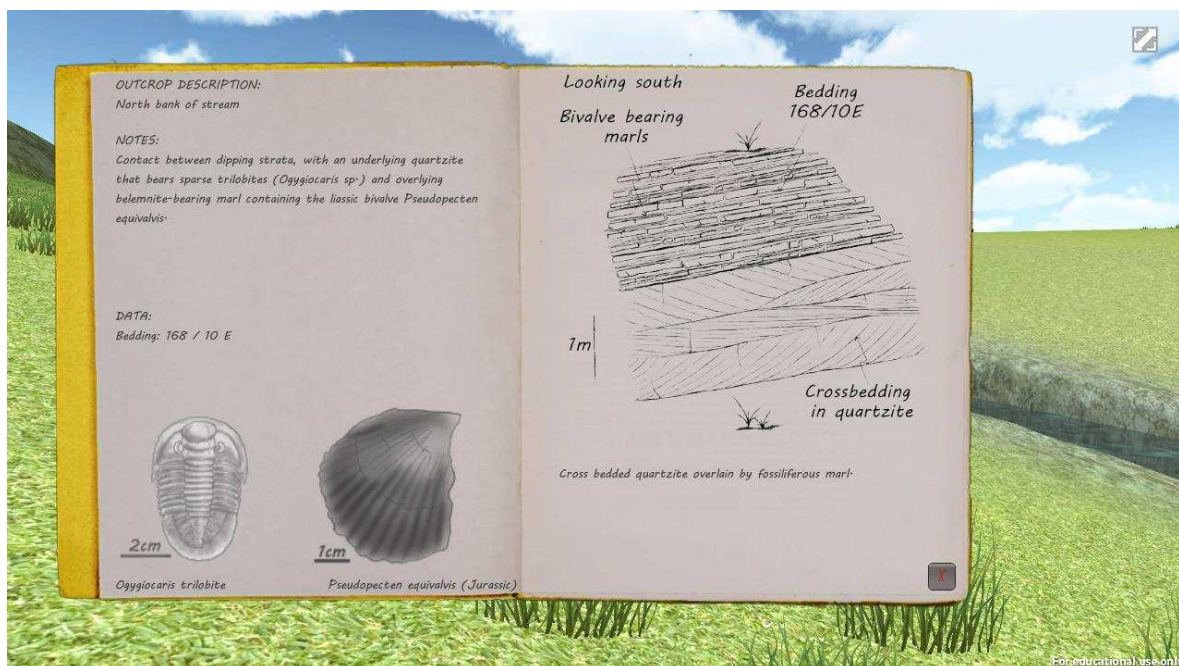
In the real field, students visit individual rock outcrops, describe and identify the rock type(s) and take readings of the orientations of specific features. Observations are recorded in notebooks and relevant measurements plotted directly on to field maps. The observations at one location are then used to determine where to go next.



As it is not possible to replicate all of this experience in a virtual world, we chose to disseminate information via a notebook entry linked to each outcrop (e.g. Figure 3). The notebook information includes: a description of the outcrop; rock type(s) present; lithological, structural and/or palaeontological characteristics; orientation measurements; and any necessary field sketches. To enhance good practise, the notebook is laid out in the manner expected of a real field notebook. A 'pop-up' GPS provides location data (e.g. grid references) and a 'pop-up' compass aids navigation (Figure 4).

Students are expected to evaluate the virtual notebook, record relevant information in their own real notebooks and plot the lithological and orientation data provided on to real field map slips. Finally, they use this information to decide in which direction to proceed for the next appropriate outcrop, where the process is repeated.

A fundamental aspect of geological fieldwork is the development of an understanding of the geology in three dimensions. Again, this is a skill students often struggle with and computer simulations have already been identified as a useful tool in aiding three



**Figure 3.** Screenshot of a typical notebook entry.



**Figure 4.** Screenshot of the GPS and compass (note dead sheep in background!).

dimensional thinking. In the VTE, students use this mapping process to create a geological map and from it to construct appropriate cross-sections, thus enhancing their understanding of the three dimensional nature of the geology.

The speed at which it is possible to move across the virtual landscape has been restricted to a brisk walk, whilst rivers can only be crossed at bridges. This approach introduces time and hence planning elements to the virtual mapping procedure. Unlike many existing educational games, the VTE is a free-form experience; there is no proscribed route through the landscape and students can achieve their aims as they see fit.

To map the whole of the virtual area takes about a working day in real time. This is longer than most practical classes. Obviously, the 'mapping' can be extended over several classes to complete the whole map. Alternatively, sub-areas can be selected to emphasise and/or practice specific skills and/or tasks. For example, the western (coastal) area with its simpler geology is good for learning how to map boundaries, observing how boundaries

interact with the terrain and also how to erect a stratigraphy, whilst the eastern (hilly) area has a more complicated geology that can be used for structural mapping and interpretation (e.g. involving stereonet, etc.).

Overall, the desired learning outcomes for the VTE are as follows. (1) To enable students to become confident in plotting and interpreting data on geological maps. (2) To enable students to understand and plan decision-making skills involved in constructing geological maps in the field in a time efficient manner. (3) To enable students to practice constructing three-dimensional geological relationships, including drawing cross sections.

### **Approach – Creating a realistic experience**

A memorable experience linked with learning aids recall. We wanted to make the experience of mapping in the virtual world reflect that in the real world. Consequently, we gave particular thought to the level of realism. This, however, has to be balanced with the technical requirements and demands involved (e.g. web connections, computer graphics capabilities, etc.). Details that provided a sense of scale and context include: a person sat on an outcrop; a wind farm; and flocks of sheep (including, see Figure 4, a dead sheep complete with buzzing flies - a nod to a common fieldwork experience). Early tests showed it was quite easy to lose a sense of direction, including an awareness of locations already visited; therefore, we added trees to increase the individuality of locations. This remains an area we plan to develop further, including the addition of stone walls, ruined buildings, etc.

Although our virtual world is primarily visual, overall realism is enhanced by the inclusion of sound. We added sounds triggered by proximity to localities. For example, the sound of running water increases as streams are approached. On the high ground, the sound of the wind increases. Animal sounds, such as sheep 'baaing' and birds singing/calling are also evident. There is also the sound of a jet fighter plane flying overhead - again, a common

noise experienced during field classes.

Currently, the actual geological outcrops are somewhat generic grey lumps; this is due to practical restrictions and considerations. However, those testing the experience have been tolerant of this limitation. In future versions we plan to use more realistic shapes and textures for the outcrops that reflect more closely actual geology.

### **Creating the geology of the VTE**

The geology of the VTE is based on an original web-related exercise (Virtual Mapping) devised in 2002. This web exercise was in turn based on field mapping training classes to various parts of the Moine Thrust Zone, NW Scotland. The web-based exercise was inherently structural in conception and formed part of a Level 2 Structural Geology module. As such, the geology in the east is relatively complex.

After adoption of the Unity™ game engine approach, our initial plan was to transfer the original web-related exercise and its geology directly into the virtual landscape. However, we soon discovered problems and the resulting procedural development has been something of an evolutionary experience. Whilst the original web-based version worked well on paper, Unity™ provides a highly visual 3D world into which the more descriptive paper world struggled to fit.

An initial problem we faced involved topography. Whilst this appeared reasonable on the original web-based paper map, for some reason it turned out to be ‘Himalayan’ in proportion in the virtual world. Reducing the overall topography (e.g. Figure 5) had a major impact on the dips of the lithological units, all of which had to be recalculated. Although it is possible to use real topography and indeed real geological maps in the virtual world, made-up maps are simpler as they can be targeted at particular learning outcomes; the answers cannot

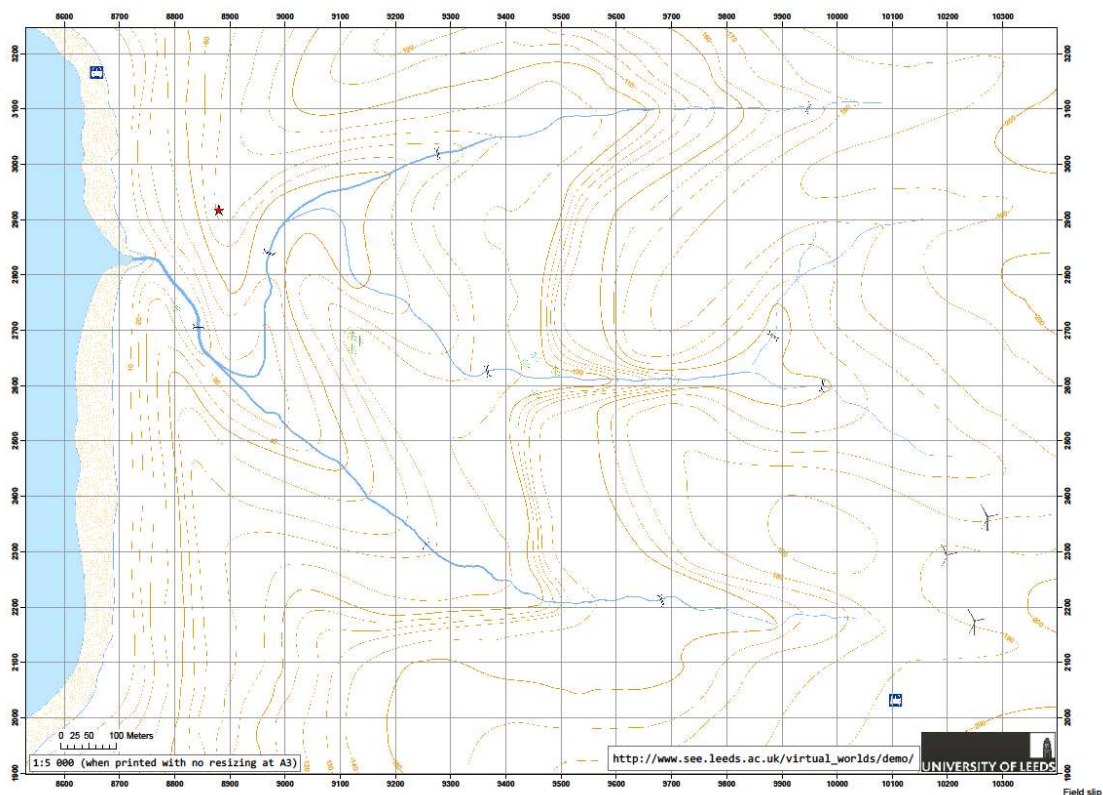


be found on the internet; and real field classes are not compromised by incorporation in to a virtual environment. For more details on how the field slip was converted into topography and the landscape was created see Robinson et al, this volume.

## How to use the Virtual Training Environment

First, download the Unity™ plug-in, then visit the Virtual Worlds site at [http://www.see.leeds.ac.uk/virtual\\_worlds/demo/](http://www.see.leeds.ac.uk/virtual_worlds/demo/). Unity™ plug-in works on Windows and Apple computers and laptops but not on mobile devices. Once installed, make sure the sound is turned up to get the full benefit of the environment.

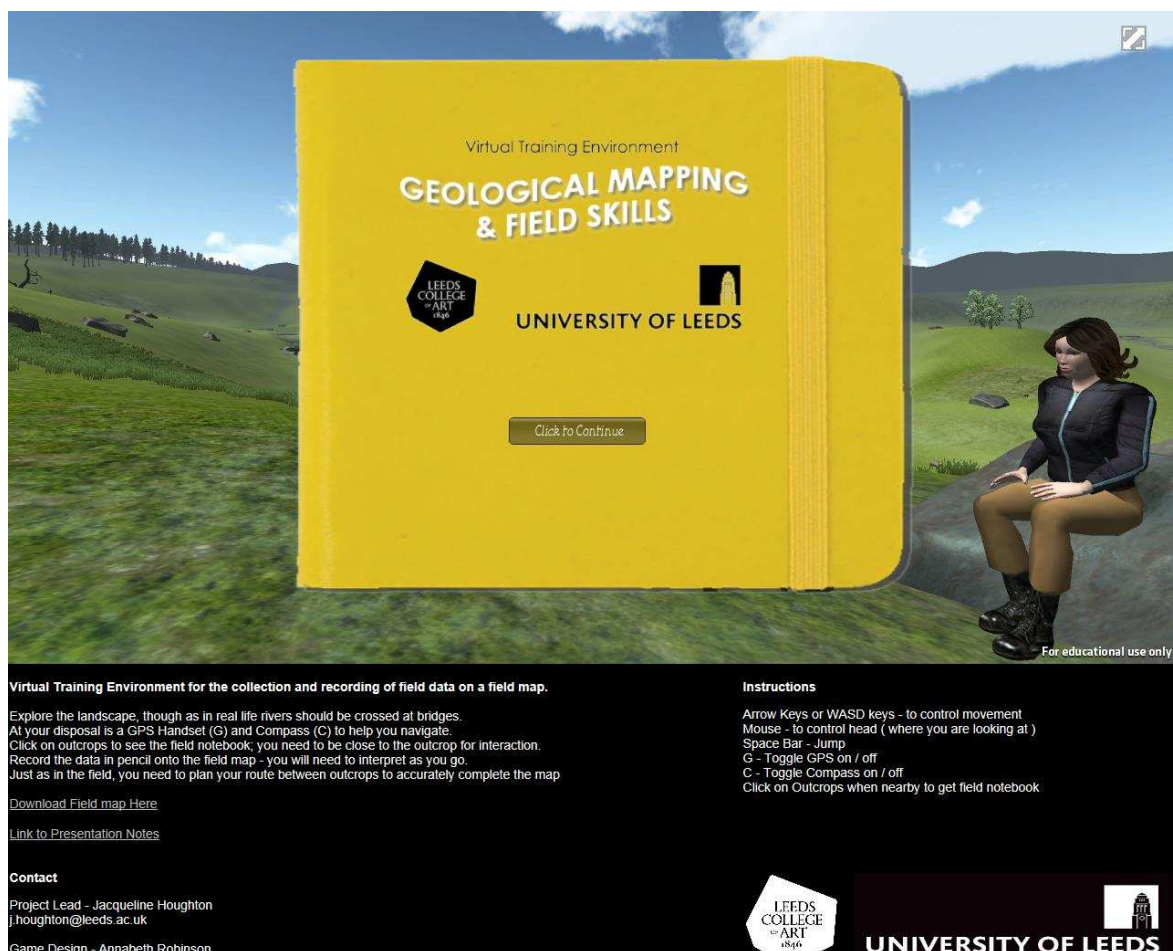
Next, download and print out the A3 field slip topographical base map (Figure 5) from the link of the VTE title page (Figure 6). Ensure that it is printed actual size on A3 paper.



**Figure 5.** Topographic base map field slip of the virtual field environment – printed actual size on A3 the scale is 1:5,000.

The VTE title page also provides basic instructions for moving round the virtual landscape, and advice on how best to plan your work. WASD letter keys or Up/Left/Right/Down arrow keys allow forward, left, right or backward movements respectively, whilst the Space Bar allows a jump move. The mouse controls the direction in which you are looking. The GPS and compass devices are engaged/dismissed via the G and C keys respectively. The figure sitting on the rock is for outcrop scale only and is not interactive.

There are two minibuses in the virtual environment (Figure 7). One is located on the coast in the NW part of the field area. The other is located by the windfarm in the SE corner.



**Figure 6.** Screenshot of the opening page of the Virtual Worlds mapping environment.



**Figure 7.** Screenshot of the minibus on the beach (note the seagulls).

Entering a minibus allows you to travel to the other minibus and is the only means of a quick route across the field area.

Clicking the double headed arrow in the top right hand corner of the screen enables full screen, which is the recommended mode. Clicking the escape button or the double headed arrow disables full screen mode.

The point of entry into the landscape is indicated by an asterisk on the A3 field slip. Once in the virtual landscape, walk up to an outcrop and, when close to it, click on it to bring up the notebook entry for that outcrop. To get the most accurate grid reference from the GPS, jump on top of the outcrop. With the outcrop data collected, use your geological skills together with the field slip to decide where to go next, using the compass to help you get there. Look out for the dead sheep!

### **Initial experiences**

At the time of publication, we have conducted two trials of two hours each, involving



**Figure 8.** Students testing out the VTE in class – one took the experience seriously!

~50 Geological Sciences students (e.g. Figure 8) and ~25 Level 2 Geophysical Sciences students, both at the Level 2 stage of their University careers. The Geological Sciences students had already attended a field mapping training field class in NW Scotland and so had practical experience of field mapping. The Geophysical Sciences students had received only a basic training in field geological skills.

The students' initial response was more enthusiastic than we expected. Comments included: *"I'm enjoying this way more than is natural..."*; and *"Can we go on this at home? I want to do the whole of it"*. However, initial interest was more in exploring the virtual world than deciphering the geology. For example: how far is it possible to walk out to sea (only a short way); and what happens at the edge of the mapping area (there's an invisible 'force field' beyond which it is not possible to pass). Once the initial novelty had worn off, most students settled down to the task at hand and we were able to gauge the practical realism of the exercise.

A common student problem in field mapping is so-called 'outcrop capture' - get the outcrops marked on the map and worry about the geology later. This approach leads not only to problems in data interpretation once the students have left the field but also failure to use



geological knowledge as it is acquired in the field to guide the move to the next location. Interestingly, many students did exactly the same in the virtual mapping world: they plotted the outcrops on the map but did not consider the cross-section until they had covered the whole traverse. In the field, we cannot often send students back to work out where they went wrong. In the virtual field environment we can and we did!

The mistake of recording, but not understanding geological field data is very common. It is difficult to persuade students, often in trying conditions in the field, they need to think as well as measure and that it will pay big dividends in the quality of their work. We hope and anticipate that by making this mistake in the virtual world they will learn from it and not repeat it in the field.

Another common, and related, problem is students often make comprehensive observations in their notebooks but are reticent to complete a field map slip in the field. They prefer to construct their field slips from the notebook entries, either back at base, or even worse, after the field mapping exercise has ended. This approach is referred to as 'notebook mapping'. The consequence is a serious reduction in the quality of map and field report produced.

In our trials, we found students were more inclined to plot readings directly on to their map than they are in the field, which is good. When asked why, they said 'it was easier being at a desk'. However, we encountered the reverse issue of students not collecting other information available from outcrops in their notebooks, which then created difficulties in interpreting the more complex areas of the geology. We suspect students are tempted to take whatever they considered the easiest path.... Again, we hope the experience of using the VTE will encourage good practice in the field and reinforce the use of both notebooks and field map slips whilst in the field.



Overall, the benefits for the students included being able to work at their own pace without the pressures of needing to keep up with a group and to be able to ask questions quickly and easily. From a teaching point of view, staff found it easier to observe what students were doing and to correct (basic) mistakes.

### **Diversity implications**

Using a virtual world to do field work has clear potential for students unable to go in to the field due to mobility issues. We are creating a new geology for the VTE based on the Assynt area, NW Scotland, where our Level 2 undergraduates are taken for their introduction to field mapping training. To replicate more closely the field experience, the rock types, which are currently listed and described in the location notebooks in the virtual mapping world, will be replaced with specimen numbers that refer to a collection of hand specimens and thin sections. The students will make their own rock descriptions. In addition, actual field photographs and data (e.g. sedimentary logs, palaeocurrents, etc.) will add to the variety of data to be interpreted. The overall aim is for the students to produce both field and fair copy (using ArcGIS™) geological maps and cross section(s), incorporating a stratigraphic column, and a field report, in the same way as the students attending the Assynt mapping training class.

### **Future plans**

The concept of creating a virtual landscape within the Unity™ game environment and linking data to flags (outcrops) is easily replicable for other subjects that require the teaching of basic field skills. We are looking currently to create new VTEs in Engineering Geology and Environmental Sciences. We are producing also a simplified version for schools to show how geological maps are created.

## **Conclusions**

The Virtual Worlds Project is already used at Leeds and two other institutions of which we are aware. It has been well received by students and staff and we continue to monitor feedback and 'tweak' the game accordingly. Going forward, the potential for developing field skills using VTEs is huge, not just in geology and not just within university settings. There is potential for its use in Outreach, Widening Participation and creating training exercises for continuing professional development. However, it is important to choose projects with clear learning outcomes and for which the virtual world is well suited and not just of novelty value.

## **Further reading**

Jong, M., Shang, J., Lee, F.-L. & Lee, J. 2008. Harnessing computer games in education. *International Journal of Distance Education Technologies*, 6(1), 1-9.

doi:10.4018/jdet.2008010101

Mountney, N. 2009. Improving student understanding of complex spatial-temporal relationships in Earth Sciences using computer animation and visualization. *Planet*, 22, 72-77

Pringle, J.K. 2013. Educational environmental geoscience e-gaming to provide stimulating and effective learning. *Planet*, Volume 27, Issue 1, DOI: 10.11120/plan.2013.27010021

Quinn, C. 2005. *Engaging learning*. CA:Pfeiffer.