

Measuring the Affordances of Studying in a Virtual World

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Abstract There has been much interest at the University of Hertfordshire in the teaching and learning in virtual worlds such as Second Life. The School of Computer Science has established a virtual campus within this system where a broad range of learning and teaching activities take place. These include presenting textual, audio and video learning and teaching materials, delivering virtual lectures, providing simulations and group working areas. Recently there has been a great deal of controversy over such initiatives, for example at my own university lecturers are divided as to the efficacy of such an approach. Some see the initiative as an interesting addition to the range of teaching and learning strategies available, likely to motivate learners. Others see it as a trivial attempt to jump on the latest band wagon, with little pedagogical benefit or justification. My own past research in this area, over several years has related to an estimation of the cognitive load imposed by desktop virtual environments and how this affected learning. Several important variables have been identified in several years of research and their effects measured. In the study presented here, a group of 80 final year computer science students used the Second Life virtual environment in order to support their practical project work. Groups of four learners used the university virtual campus especially modified for this purpose to hold meetings and to manage their software development projects. This study reports on how the group areas were established and used by the learners, the types of activities that took place and the effectiveness of the approach in this context. Quantitative and qualitative research was undertaken and it was found that there were benefits to be had by the use of such virtual environments. Recommendations are made as to the affordances of the Second Life virtual environment for teaching and learning in this context and also discussed are the potential problems inherent in this initiative related to individual differences and the cognitive burden imposed on learners.

Introduction

In recent years, advances in information and communication technology and lower hardware prices have made it possible for three-dimensional (3D) virtual environments (VEs) and particularly computer desktop VEs to become popular (Li & Ting, 2000; Mills & Noyes, 1999) and be used for commercial, social and educational applications. These technologies and their applications are used in a variety of areas such as entertainment, engineering, architecture, medicine and science. A fairly recent development has been the use of the Second Life virtual environment (<http://secondlife.com/>) in education and training. Since its establishment in 2003, many hundreds of organisations have become involved in setting up educational and training applications using this system.

For example, the University of Hertfordshire has recently established a virtual campus within the School of Computer Science, which is currently being used in order to support the learning of campus based students. In consideration of the investment necessary in terms of development cost and staff time to set up and manage these systems, it will be important to provide pedagogical justification for the use of such systems. It will also be important to consider the potential risks inherent in such initiatives. These considerations are discussed more fully in the concluding section of this paper.

It seems clear that there is a strong rationale for the increased use of virtual systems in education and training. We live and use our senses in a 3D real world environment and are adjusted to interact effectively in one. It has therefore been claimed that, 3D interfaces and VEs, which enable 3D interaction, provide a more natural manner of interaction with computer applications (Crossley et al., 1997). Whilst VEs, non-immersive virtual environments (NIVEs) and 3D graphical users interfaces (3D GUIs) such as Second Life are becoming more widespread and have many application areas, they contain problematic design and human factor issues that have to be addressed (e.g. Mills & Noyes, 1999; Stanney et al., 1998). In particular, navigation in 3D GUIs and NIVEs is one of the most important factors directly affecting task performance in these environments.

Previous Research

In the following section is presented a summary of some of the findings a four year investigation into the factors that affect task performance in virtual worlds (Barker et al., 2008; Haik, 2005). It is argued that in order to justify the widespread use of such systems in education and training, it is necessary to understand at the very least, task performance and learner attitude to working in such spaces.

Method

Initially it was necessary to identify those factors likely to be important in working and learning in virtual environments. Based on the review of the literature, several factors were selected as being potentially important in the context of this study:

- **Navigation** – The ability to move efficiently in the environment is an important factor for 3D GUIs and NIVEs. However, navigation in these environments is often difficult.
- **Mouse** – The use of the mouse, a 2D device, to navigate in the 3D space is known to be problematic, where users often experience difficulties. The user's concentration could be distracted by problems experienced with the mouse.
- **Task** – This refers to the overall difficulty in performing the tasks. This could be related to different factors such as difficulties with orientation and use of the mouse.
- **Orientation** – The users' ability to know their location with regard to the environment is an important issue that can affect various factors. Users

- often experience problems with orientation. This could clearly affect the ability to find information and perform tasks effectively.
- **Finding** – The ability to find information in the environment is crucial to successfully completing tasks. How efficiently one can find information could be affected by the efficiency of other properties such as orientation, navigation and use of the mouse.
 - **Freedom** – The degree of sensation of freedom or constraint that the users experience is part of the 3D navigation experience that could affect performance. Sensation of freedom could be affected by other factors such as the orientation and navigation. For example, when users experience frustration with navigation they might feel more constrained.
 - **Preference** – This is concerned with the overall users' subjective preference and attitude regarding the ease of the different conditions.
 - **Time** – The time taken for users to complete the tasks directly reflects general effectiveness of navigation. When users experience problems, efficiency in performing the tasks is reduced and task performance time is increased.
 - **Remembering** – This refers to the users' ability to remember the location of the information after finishing the tasks in each condition. This provides some information about the users' cognitive load.

Experiments were performed over a considerable period using a VRML based system and the factors presented above (Barker et al., 2008; Haik, 2005). Effective navigation was tested based on widely accepted metaphors, such as maps which are commonly used for navigation, and arrows, which are commonly used to direct users to a destination. Some ideas from several previous works (Darken & Silbert, 1993; Li et al., 1999 & Stoakley et al., 1995), along with new ideas such as use of different metaphors, were employed and investigated. It was suggested that the main problems caused with navigation are due to difficulties with movement, orientation and use of the mouse in the environment. It was hypothesised that guided and targeted navigation would result in faster performance. It is possible to summarise the hypotheses as follows:

- Any difference in task performance and user attitude would be related to the navigational method used
- Environments with navigational assistance would result in quicker task performance and more positive user attitude compared with the control condition.
- The navigation map would result in the fastest task performance and most positive user attitude

Four experimental conditions were employed:

1. Environment-only, navigation is enabled by mouse movements (control)
2. Environment with a 3D view map, navigation is enabled by mouse movements
3. Environment with a 3D view map and with the navigation arrows.

Navigation is enabled by mouse movements and by clicking on the arrows that animates the viewpoint accordingly

4. Environment with the 3D navigation map. Navigation is enabled by clicking on the map that animates the viewpoint accordingly.

In each condition, subjects were required to navigate to locations within a virtual world in a pre-defined order. They were required to undertake tasks, remember features of the rooms and of the environment.

Results

Table 1: Attitude to environment and Friedman Test results from users' feedback (1-5 Likert scale) in the four experimental conditions

Variable	Mean Rank				Chi-Sqr.	Df	Sig.
	Condition I (control – env. – only)	Condition II (method 1 – simple map)	Condition III (method 2 – simple map and arrows)	Condition IV (method 3 – navigation map)			
Navigation	3.46	3.04	2.42	1.08	24.88	3	0.00
Mouse	3.33	3.29	2.13	1.25	25.87	3	0.00
Task	3,25	2.83	2.75	1.17	23.11	3	0.00
Orientation	3.33	2.67	2.83	1.17	21.28	3	0.00
Freedom	3.00	2.50	2.29	2.21	3.18	3	0.37
Finding	3.04	2.67	2.71	1.58	10.62	3	0.01
Preference	3.54	2.88	2.17	1.42	20.27	3	0.00
Overall easiest	3.75	2.92	2.25	1.08	27.40	3	0.00
Overall preference	3.75	2.83	2.17	1.25	24.10	3	0.00

(Env. = Environment, Likert 1-5 rating: 1 = V. good; 2 = good; 3 = average; 4 = poor; 5= V. poor)

Figure 1 below shows how the time variable was related to each of the four experimental variations in the environment.

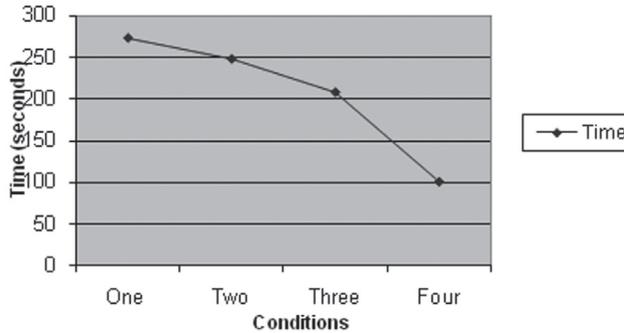


Figure 1: Task completion time and experimental condition

There was a significant difference ($p < 0.01$) found for task completion time between the environments tested. Fig. 2 below summarises the effect of environment on the non-parametric variables tested in the study.

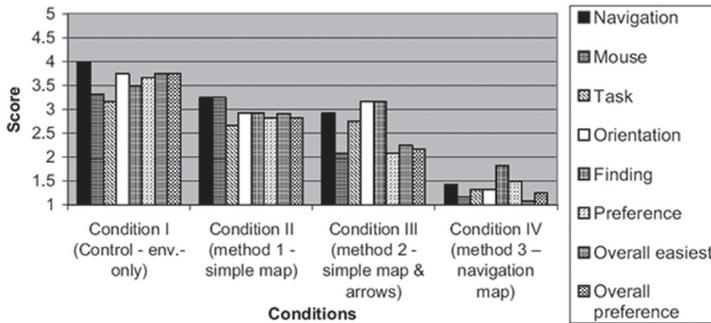


Figure 2: Non-parametric variables and experimental condition

There were significant differences at the 1% level in attitude to the task performance also due to the effect of the experimental condition ($p < 0.01$). It is interesting to note that, despite significant differences in task completion time and attitude to the navigation method employed, there was no significant difference in the ability to remember information related to locations ($p > 0.05$). This is despite tasks performed under the control condition (i.e. no assistive features) taking almost three times as long to complete as the fastest task completion (navigation map). This is interpreted as being related to the additional cognitive load placed on learners due to the difficulty of navigation in the control condition compared to other conditions. Increased time was spent dealing with the difficulties involved in navigation, rather than performing tasks and remembering. It is also likely that in the conditions with less cognitive load, features of the environment were not better remembered because learners experienced less of the environment, due to the assistive measures removing them from it, leading to decreased task completion times. This finding has interesting implications for learning in such

environments. Although assistive measures decreased task completion times and improved attitude to the environment, they did not assist in learning about the environment ($p=0.53$). We argue that there is a trade-off between how much assistance learners are provided with in difficult environments and their ability to engage with and learn about the environment. This was supported by our findings. Environments such as Second Life provide several assistive methods intended to decrease task completion times and improve attitude, such as 'flying' and 'teleporting'. Although these may improve attitude to the environment by speeding up interaction and navigation, they are not likely to help in remembering the environment. Needless to say, the actual *environment* itself is central to what takes place in virtual *environments* otherwise we may ask, why have them? The benefits claimed for such spaces relate in part to the motivational aspects of such worlds. It is indeed paradoxical that in order to overcome the cognitive overhead placed on learners by the complex virtual environment, assistive measures to help navigation remove learners from a large part of the environment itself. Even with such assistive measures, there is a considerable learning curve for even experienced computer users before navigation and task completion become easy in virtual worlds. This is also true for teaching staff who may lack confidence when interacting with student experts in such spaces. Navigation in *fully* immersive worlds is simplified to some extent by our worldly experience. In NIVEs, mouse navigation requires that we keep still and the world moves as we move around in such spaces. This is not natural to us and it is difficult if not impossible for us to obtain the benefits claimed by (Crossley and colleagues, 1997) related to the naturalness of virtual spaces. We are not able to benefit from a more natural environment, indeed we are hampered by it. Learners, despite the assistive measures, faster task completion and improved navigation did not feel less constrained because of this ($p=0.37$). This shows that the feeling of constraint and freedom users experience relates more to the frustration of poor navigation than to the ability to roam unhindered. The control environment allowed users to wander freely, yet there was no difference in this dimension from the most physically constrained environment with guided navigation.

It is reasonable then to ask *what exactly the pedagogical benefits of learning in NIVEs are?* The ability to provide realistic simulation is an important feature of 3D worlds. However, the amount of realism provided by Second Life is quite minimal. In almost all respects it is an artificial world with keyboard navigation, low resolution graphics, anonymous users with strange names, poor physics, for example lack of gravity, poor collisions etc., users flying and teleporting and rather strange abilities such as walking through walls and typing as they talk. The possible benefits related to motivation and the feeling of presence in such space however is of interest to us.

The author and colleagues have also found in our other studies that individual differences such as gender ($p<0.05$) and approaches to learning ($p<0.05$) have significant effects on attitude and task completion (Barker et al., 2008; Haik, 2005). It will be important to continue to understand how such factors affect learning performance in such worlds. Should learners be disadvantaged by such

environments, it will be important to understand and to allow for it in some way, possibly by induction measures or the provision of greater assistance.

Group working in Second Life

An important component of software development is the requirement to work in teams. Team working has always proven difficult in software development, not least due to difficulty in arranging face to face meetings. In the past we have tried video conferencing and synchronous messaging with some limited success in managing team meetings. The following example is taken from the final year Computer Science B.Sc. module where learners of differing abilities were required to work together in small groups to solve real-life problems related to the design and production of a complex software application. The project involved four learners working in groups. The intended learning outcomes for the project were as follows:

Knowledge and understanding of:

- a range of theoretical issues in Human Computer Interaction, including, at a suitable level, relevant research activity;
- the complexities of designing large scale multimedia and interactive systems involving a wide range of physical and human resources, including the roles of stakeholders in relation to the technical and other information necessary for the system design task.

To be able to:

- develop an advanced multimedia computer system in response to a brief setting the requirements in a real context, choosing among and deploying a range of tools and techniques appropriate to the task;
- work as part of a team in the development of design specification documents for a multimedia system which will reflect the interests of all stakeholders in the system.

In order to support this, the following support system was established in Second Life:

- Induction sessions in which each learner underwent a course of induction prior to the start of the group working stage of the module. This included lectures and demonstrations, online help systems and the use of specially prepared training materials which all learner were required to follow.
- A secure area for group working and studying was established in Second Life (Figure 3). Here, learners would be able to meet in a private secure environment. This area was restricted so that only members of the module could enter.
- Note taking and recording facilities were provided within the environment so that a single record of minutes of meetings etc. could be taken online, without the need to use paper or third party applications.



Figure 3: Group meeting taking place in Second Life

Online resources within study areas in Second Life were provided so that all course materials were available. These resources included:

- Lecture notes
- Audio files of lectures
- PowerPoint presentations

Online lectures took place in Second Life. It was important that the virtual system was seen to be equivalent in many respects to the 'real-life' system. In this way it would be possible to ask learners to make comparisons between the various support systems used, including face to face lectures, the Managed Learning Environment (MLE) and Second Life. Lectures were provided in several formats:

- Asynchronous, where learners could view a recording of the lecture at any time. This included lectures provided in the Elluminate system (www.eluminate.com).
- Synchronous lectures took place in real-time. Learners could choose whether to attend the lecture in a lecture theatre at the university, or attend a virtual presentation, although they were required to attend a minimum of one lecture in each format.
- Avatar based lectures where the lecturer was present in the Second Life environment as an avatar and gave the lecture directly to learners in the environment. PowerPoint slides were projected onto a virtual screen and the lecturer used the voice function in Second Life to communicate to the students. These lectures were sometimes broadcast directly from a lecture theatre with some students present and on other occasions from a private office in isolation.
- Video-based lectures took place in a lecture theatre and were streamed to Second Life. The video was presented on a screen where students could view. Learners could choose whether to attend the real-life or virtual presentation.

Examples of the interactions in Second Life are shown in Figures 3 to 6

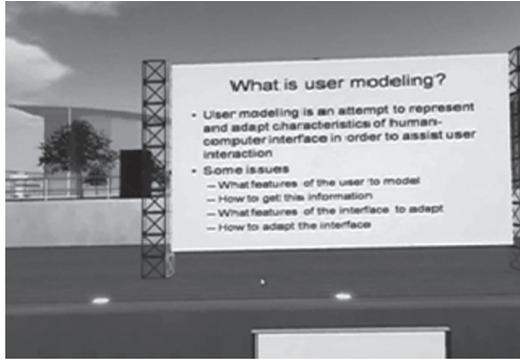


Figure 4: Asynchronous lecture in Second Life



Figure 5: Lecture taking place in a lecture room and Second Life simultaneously

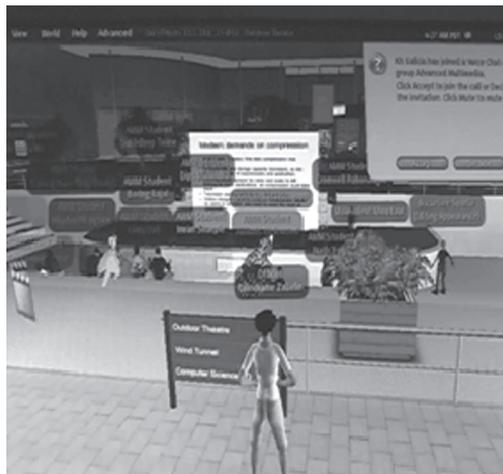


Figure 6: Lecture taking place in Second Life, delivered by an avatar

Data Collection

Learners followed the module, undertaking their project work and related studies using a combination of support systems, the MLE including group discussion areas and e-mail, face to face meetings and lectures and the Second Life environment features as presented above. In order to measure and compare the affordances of these systems in supporting studies and group working, a range of data collection methods were employed.

Individual and group reflective reports were collected as part of the assessment for the module. Learners were required to assess their individual and group performances and how well they were supported in their group work by the systems provided. This included a ranking exercise for common functions undertaken in their projects on these systems and a heuristic assessment of the systems. This provided a wealth of data, especially as final year computer science students are trained in the evaluation of such systems. Learners also produced an audio recording of a focus group session where they discussed the affordances of Second Life as a support system for their project work.

Screen capture and data logging was undertaken so that group interactions in Second Life could be monitored. It was possible to record the duration of meetings, the interactions and communications between participants and what was discussed. In this way it would be possible to compare with the records of face to face meetings undertaken by the groups. Questionnaires were developed to measure learners' attitudes to the support systems provided. These were useful in conjunction with focus group sessions in obtaining qualitative data. The results of group projects were also collated in order to assess the quality of the product as well as the process. In this way, direct comparison with the work of previous cohorts could be measured.

Findings

Although in the initial stages of data analysis it is possible to provide a summary of the findings to date. Qualitative evidence suggested that virtual lectures were not as highly regarded by students as the face to face lectures on the course. Video lectures were preferred to avatar lectures and Elluminate lectures were preferred least of all ($p < 0.01$). My personal reflection was that in a Second Life lecture the teacher has less control than in face to face lecture and that this can be a problem. It is difficult to know the identity of any of the students in the lecture due to Second Life's insistence on anonymity of its users. Despite claims that anonymity is an advantage to learners (Hollins & Robbins, 2008) this was considered to be a major limitation in interacting with students in Second Life. It was also difficult for learners to recognise the tutor, which led to some confusion. In Second Life lectures feedback from learners is poor and slow. In a face to face lecture an experienced teacher is able to gauge his or her performance and to interact with learners even in quite large groups. It was impossible to ask questions and to respond to students' questions, which were few. It was not possible in Second Life to interact

at all well with learners. Where public access was permitted in our environment, it was difficult to keep out unwanted guests. This was especially problematic when using the large lecture theatre in Second Life. As this area was used by other groups and the general public for University events, unwanted guests sometimes appeared and on occasions were disruptive. In general learners behaved well and appropriately in the learning environment. My conclusion was that Second Life is perhaps not the best way to deliver lectures to large groups of learners. Group working was much more successful. Learners engaged well in the group activities and although they in general preferred face to face meetings, Second Life scored well in terms of online access. It was considered to be better than the asynchronous group areas of the MLE and better than email and phones.

It will be important to measure what is the true cost and benefit of using such spaces for teaching and learning. It is often said that Second Life is a reasonably cheap virtual environment, costing little for an island and a small yearly rental. This of course does not take into account the cost of training staff, technical support, developing resources, increased network demand and hardware costs such as improved computers, graphics cards and file servers for streaming video. While small scale developments on a more or less individual basis may indeed be cheap, it requires a great deal of investment to undertake this kind of work in larger groups.

There are enormous problems with accessibility and the possible exclusion of learners in Second Life. It is not yet clear exactly which stakeholders if any are likely to be disadvantaged by the system including teachers, students, technical staff, administrators and university manager. Not only are staff and students with disabilities likely to have accessibility and usability problems, but also there will be teachers and learners who will be subjected to additional cognitive load and this might interfere with their work and studies.

Given that there are good pedagogical reasons for using 3D environments such as Second Life in learning, there may still be problems of undertaking formal learning in such spaces. The use of web 2.0 technology in learning is a fairly recent innovation that seeks to capitalise on the rapid growth of the social aspects of the internet and apply them to learning. Second Life may be grouped under the web 2.0 banner. Often such services are provided 'free' to learners, and teachers are keen to integrate them into formal programmes. The true cost of this to institutions may be high, including training and support, as well as materials development.

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"..in violation of the terms of service. These problems include incidents of grid attacks, racism and intolerance, persistent harassment of other residents, and crashing the Woodbury University region itself while testing their abusive scripts. Due to the ongoing problems, Linden Lab has no option but to immediately close the Woodbury University region"
The Herald (2007)

The high development cost of creating your own virtual world and the loss of true 'social networking' in university developed systems may be too high for many organisations. Despite much research over the last couple of years, there are few good examples of the pedagogical benefits of web 2.0 in education. Most examples stress the motivational benefits of such systems with little regard to the true cost, the risks, or the actual benefits to learners. It is also important to understand the part that context plays in learning. Distance learners, for example already have significant overhead on their learning. It will be important to ensure that learning in a wide range of contexts and personal situations is not made more difficult by the use of difficult environments with little pedagogical benefit. Our research will centre on finding the pedagogical benefits of such systems and also on the best sorts of assistive measures to provide for learners to ensure a successful and motivational learning experience.

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