Experimentation Not Simulation: Learning About Physics in The Virtual World

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Abstract

This paper reports on the evaluation of a study to explore the use of the virtual world Second Life™ for conducting real physics experiments, completed as a pilot activity for a new course development at The Open University. All HEIs within the UK are currently engaged in some level of activity in virtual worlds. However in such a young field there is a relatively scarce literature, and so small scale pilot projects are vital for exploring the pedagogical framework as well as the practical tools for supporting specific subjects within such an immersive environment. This study gave ten participants access to a small range of tools that enabled them to create experiments to explore the physics of Second Life using a cognitive learning approach. Data on their inworld activity was collected and compared against their input to a survey at the conclusion of the two-week study period. These results were triangulated using detailed follow up interviews with a smaller sample of two participants. The research found that students look for context and indicators of stability and reassurance during the experience. The majority of respondents indicated that they would be happy to participate in course-embedded Second Life activities of this type, albeit also expressing a range of reservations, providing valuable feedback for further development of the pilot tools and module framework.

Key Words: Virtual worlds, science, physics, experiments, immersive environments, cognitive learning.

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1. Introduction

The Open University is a pioneering institution for distance learning in the UK, supporting 200 000 part-time undergraduate students. Courses in the Science faculty traditionally blend distance and e-learning methods with optional face-to-face tutorials, supplemented with weeklong residential schools. Currently, only one third of the target group attend residential schools in science and so, from 2012, the residential options will be replaced by a single module, Practical Science (S288).

S288 will offer subject-specific pathways in physics, biology, chemistry and geosciences, with recommended practical units and an additional mix of online or residential options.

Much of the basic practice of being a scientist is in knowing how to formulate a hypothesis, design an experiment to test and investigate that hypothesis, make observations and process data with rigour and consistency, all skills that translate easily into learning outcomes. Students who are unable to physically attend residential schools will be offered alternative activities as options within S288 that support these learning outcomes through immersion rather than simulation.

The S288 Course Team identified SL as a potential venue for one stream of student activities, with a key emphasis on exploiting the physics engine within the environment to conduct genuine experiments rather than simulations. This paper reports on pilot activity for this inworld module, where students were provided with a small set of tools for experimentation, and their experience was assessed through automated observation and a critical pedagogy of survey and interviews. The course team requested that the experiments in this pilot should be exploratory, enabling students to use tools to investigate their environment, rather than follow a directed series of actions.

The objectives of this study were as follows:

- Collect quantitative data on time spent on tasks, number of returns within experiment period, comparison between science and other students/gender etc
- Collect survey responses from each user
- Record interviews with selected users
- Triangulate and analyse data, survey and interview responses

The results are encouraging, finding that despite reservations all the students who responded would be happy to participate in course-embedded SL activities. The paper provides a discussion of these results, paying particular attention to the reservations expressed, and summarises the outcomes with recommendations for further work in the area.

2. Background

Whilst The National Physical Laboratory's SciLands region promotes scientific activity in SL and a number of universities have explored some of the potential in teaching physics in SL, there is little or no literature to disseminate the transferable learning from these specific subject experiences.

There is however a more general body of literature emerging on the wider potential of teaching and learning in VWs. Warburton (2009) reflects on a review of multi-user virtual environments, in particular SL (Warburton and Perez-Garcia, 2009), to identify:

> where components of the SL experience can facilitate innovations in pedagogy through:
>
> - Extended or rich interactions: opportunities for social interaction between individuals and communities, human–object interaction and also intelligent interaction between artefacts
> - Visualisation and contextualisation: the production and reproduction of inaccessible content that may be historically lost, too distant, too costly, imaginary, futuristic or impossible to see by the human eye
> - Exposure to authentic content and culture
> - Individual and collective identity play
> - Immersion in a 3-D environment where the augmented sense of presence, through virtual embodiment in the form of an avatar and extensive modes of communication, can impact on the affective, empathic and motivational aspects of the experience
> - Simulation: reproduction of contexts that can be too costly to reproduce in real life with the advantages that some physical constraints can be overcome
> - Community presence: promoting a sense of belonging and purpose that coheres around groups, subcultures and geography
> - Content production: opportunities for creation and ownership of the learning environment and objects within it that are both individual and owned.

Whilst there is arguably potential in all these areas for S288 support, it is specifically the combined potential for authentic content, immersion and content production that we explore in this pilot activity. Creating content and giving students ownership of that content, working immersed in an individual space, drives a cognitive approach to formalized learning that makes “learning more conscious in order to enhance it” (Rogers 2003: 27).

Cognitive theorists view learning as creating associations through inference, expectation and repetition, involving the acquisition or restructuring of the cognitive structures that we use to process and store information (Good and Brophy, 1990). The experiments are provided as tools to be used in multiple instances, in the anticipation that participants will use them to explore and make sense of the physics of their virtual environment. In so doing they will acquire strategies and knowledge that translate directly to the physical world.

By seeking to understand the processes that lead to the acquisition of knowledge from the tools that we offer students in this pilot study, we are moving towards an informed position from which to develop deeper activities linked directly to course learning outcomes.

3. Methodology

Using the graphical user interface and inbuilt Linden Scripting Language, tools were developed specifically for two groups of experiments to explore SL physics within this pilot study. Details of the experiments are available on request.

Participants were provided with access to these tools in a dedicated space on Open University island in SL, with entry restricted to study participants – see Figure 1: Inworld Study Space. The space was bounded by posters with instructions for using the tools and suggestions for activity. The content on these posters were also provided to each participant in the form of inworld notecards.

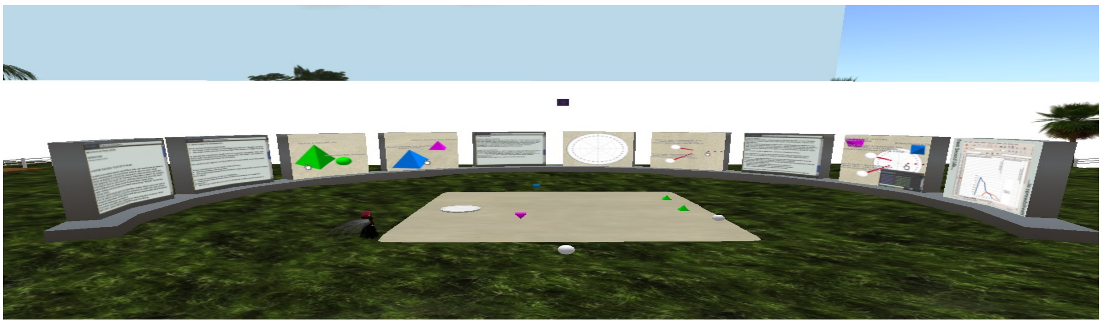

Figure 1: Inworld Study Space

All participants agreed to wear a device for capturing a range of data relating to their inworld activity during the period of the study.

It is anticipated that the greater number of future S288 students will be following a science pathway, but many will also be taking the course as part of a wider learning experience: At any time approximately 40 000 students with the OU are registered on an Open Degree, allowing them a range of choice between qualifying courses. Therefore the pilot study was not restricted to science students.

In order to focus on the experience of engaging with the experiments in SL, an invitation to participate was issued to the Open University UK inworld group in the expectation that most members of this group would have a core set of basic skills. The ten participants were drawn from respondents to this invitation.

4. Results

Due to imposed word limits, the detailed results are available in an appendix on request from a.peachey@open.ac.uk

5. Discussion

For most students the survey data tallied with their inworld activity. Student 9 is highlighted as an exception, with an activity log that shows he did no more than click on the large ball drop once and the small ball drop once. He used no measuring apparatus and made only one visit to the study area. However in his survey responses he marks *Not at all* or *A little* to every question about the experiments, despite having no interactions at all with the momentum tools. Only registered participants wearing the data capture HUD had access to the experiments, so it is not possible for him to have engaged under the guise of another avatar, or to have engaged without his data being captured. This student identified his computer skills as average, but has previously opted in to a group offering OU tutorials in Second Life and has sufficient experience within the environment to engage with the simple tools on offer. He did not approve access to his student record for purposes of the study so his wider study history is unknown. When asked what he found difficult about the experiments he commented *Having access*, so it is possible to surmise he was restricted by access issues.

Generally the survey charts suggest that the momentum experiment was better received than the gravity experiment, and the interview respondents both reason that the latter allowed more interaction and unstructured investigation, which provides a sensible explanation for this comparison. The lowest result for all quantitative charts was shared by the first two questions for the momentum experiment. Both interview respondents felt that they might be doing something wrong with the ball drop experiment as they lacked a theoretical and instructional context for what they observed to be happening, and their interaction with the tool was limited. Neither went beyond the environment, e.g. to the web, to look for an explanation for their results but both were offered the follow up of an email explanation during the interview and both accepted, with Student 4 being so keen as to email a reminder about this as soon as the interview closed. This suggests a limit on how much we might expect students to investigate unsupported, aligning with the cognitive pedagogy and with other practical OU course activities that are embedded in a framework of theoretical material. Both students made excellent observations, but a lack of confidence meant that they didn't follow through to explore the theory independently, and so found the experiment unfulfilling

The most positive quantitative response to the ball drop experiment was to the statement: "The ball drop experiment helped me think about the differences and/or parallels between running an experiment in Second Life, and running an experiment in the physical world." Only one participant, Student 3, responded *Not at all*.

Student 3 is both a student and tutor, and her qualitative responses are generally supportive of and enthusiastic about using SL for study, but express her personal reservations about studying science. Student 3 answers *Not at all* or *A little* to all the quantitative questions, and it seems that the experiments were too far outside her comfort zone with the subject matter rather than the context and/or environment, as in response to "How would you feel about using Second Life to access/work with core learning material for an OU course" she replies:

> *I think using SL to access core learning material is an excellent idea. Fun and non-threatening. It would be good to use with a tutor group, so there is more peer input. (as well as tutor guidance)*

The statement "The […] experiment helped me think about the differences and/or parallels between running an experiment in Second Life, and running an experiment in the physical world", also has a positive response for the rolling ball. Taken together, Student 3 answers the only *Not at all*, with 7 responses for *A little* (omitting Student 9's contribution), 5 *Reasonably well*, 1 *Very well* and 1 *Completely*, that last being from Student 1 for the rolling ball. As we aimed to test the more general sense of how students could relate SL experiments to physical experiments, this result is encouraging and suggests that ironing out practical issues with the experiments themselves would translate well to this wider context. This is supported by Student 4's comment that

> *I think I realised how you could use inworld experiments to 'show' people a concept that they may only be able to read about in a book.*

Participants expressed concern over the stability of the environment, understanding instructions and over the time required for them to participate in the research. As S288 students will have selected to follow this module, time will not be an issue in the way that it relates to volunteering in a research study (although they may have concerns over the time needed to gain SL skills). Those who anticipated that they would have trouble understanding instructions went on to comment in response to other questions that they found the instructions clear and easy to follow, so these concerns were abated. Stability of the environment is, however, significant.

Student 1 commented again on the potential for problems in her response to the question about expectations, but generally responses here were blank, said that there were no expectations (these two being arguably the same answer), or indicated positive anticipation. Student 9 said that his expectations were higher than the actual experience, again a difficult comment to rationalise against his interaction log. Student 2 said I thought it would take longer than it actually did, *perhaps because I rapidly bored with what seemed very simplistic experiments*, although like 6 other participants he did not register any interactions with the protractor tool. Student 1, who also missed out this tool completely despite an otherwise regular interaction pattern, addressed this in her interview by saying that she used one that had been 'left out' by another participant, so it is feasible that other participants did likewise and it was an omission on the part of the data capture to record interactions with an object not rezzed or owned by the avatar. It is also feasible that, like Student 7, they perceived that there were no instructions for use of the protractor.

When asked what they found easy about the experiments participants all responded with predictable variables such as good instructions or comments on tools, for example Student 5: *Activating the objects and experiments* and Student 7: *The green pyramid is straightforward*. The most negative comment was from Student 8, who said: *So a large extent i did not find it easy. I think because i was not really sure of the context of the experiments*. This can be linked back to the earlier comments from the interviews, and would be addressed by experiments embedded in a course framework.

Fifty percent of all reasons given for the participants' regular use of SL could be grouped as social and 8 out of the 9 participants who responded gave this as their primary or secondary reason for being in SL, the exception being Student 9. SL itself is primarily a social tool; an open VW with no game narrative, bringing together multiple users in a shared space. Participants 1, 3 and 5 reference this social interaction, categorized by Warburton and Perez-Garcia as Community Presence and Extended Interactions, when asked about using SL for learning. Students 1 and 4 both talk in their interviews about bringing social content into future developments, although for Student 4 this is about using a context of forums to share ideas and reflections. Previous OU research in SL has explored how well the environment supports community (Peachey, 2010) and a socially constructivist pedagogy (Peachey and Withnail, in press). Sfard (1998), argues for the wisdom of respecting a variety of perspectives rather than leveraging acquisition and participation metaphors to enforce a single standpoint.

Five of the 9 respondents expressed reservations about technical issues with the environment should it be adopted for further activity. It is noted that although anticipated these reservations are well-founded and should of course be given due weight and consideration when planning how a full range of SL activities might be developed into an S288 module.

Student 1 identifies herself as a visual learner and talks about visiting other locations in SL to support science learning on other courses, referencing Warburton and Perez-Garcia's category of Visualisation and Contextualization.

6. Conclusions

This research set out to explore participants' understanding and experience of using the tools provided to test SL physics. Evaluation found a mix of responses, highlighting specific shortfalls with the experiments (quantitative) but indicating a positive approach overall to using SL for formal learning activities (qualitative).

The following results are presented with acknowledgment that this is a study of only ten participants, offering a step forward in development for S288 VW activities, but with limited extrapolation value to a wider context other than raising issues that might benefit from further research.

Students are open to relating SL experiments to physical world experiments. Students like activities that encourage them to explore and investigate freely but are more confident when activities are set in a theoretical and instructional context, with a range of supporting materials. This aligns well with the cognitive learning approach for activities carried out independently. Students might gain confidence from sharing results and discussing outcomes and there is significant potential for developing SL activities into a VLE-based course framework.

Potential use of SL for S288 need not be restricted to cognitive-driven Immersive, Content-rich activities. Students use the environment regularly as a social tool and they are comfortable working within a socially constructivist pedagogy. Community Presence and Extended Interactions therefore present viable options, and use of existing content on virtual field trips as well as bespoke development may be explored for purposes of Visualisation and Contextualization. A milieu of activities, leveraging a range of pedagogies, would offer a richer learning experience.

This study specifically excluded issues regarding access and SL skills in order to focus on the experience of the science activities. However participants still raised a number of reflections on these issues, reinforcing the significance that should be accorded in wider planning for S288 inworld developments.

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