
MATHEMATICS EDUCATION IN SECOND LIFE

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Introduction

In this paper we consider various ways to use virtual realities, such as Second Life, in mathematics education at the tertiary level. Virtual realities carry the potential to address the social problems associated with virtual learning. Students studying online courses using their computers lack social interaction with their fellow students. If they attend virtual classes as avatars, they can, at least, see other avatars, and talk to them between classes. This has enormous potential and is likely to play an instrumental role in e-education. These remarks apply, naturally, to any discipline, and almost everything that we express below applies generally to all virtual learning in Second Life.

While it is rather clear how this setting may help train students in real life pretend situations (Michael Begg, 2005), it is not as clear how it can be used to enhance learning of abstract subjects such as mathematics. Therefore it is also necessary to take a critical stand and to try to answer the question whether such environments support new features which may contribute effectively to better learning in comparison with the tools which are used conventionally and for which we already have developed legacy educational materials. Any new technological development considered as educational tool ought to be backward compatible with the technologies that are already in use since producing technology enhanced courseware is very costly.

There are several virtual realities platforms, most notably a new open source effort called OpenSimulator (<http://www.opensimulator.org/>) devoted to developing a functioning virtual worlds server platform capable of supporting multiple clients and servers in a heterogeneous grid structure. Second Life (ref) is a privately developed virtual reality that has received a lot of media attention because of investments by large corporations like IBM, ABN-AMRO, Intel and by government institutions like a Swedish Embassy and several national parties. The education community has also been looking into SL and conferences and surveys aim to establish it as a platform for teaching and distance learning (Second Life Best Practices in Education: Teaching, Learning, and Research 2007 International Conference, 2007). Its main contribution to distance learning programs is the provision of an enriched social environment where the familiar discussion forums and chat-rooms become actual 3D inhabited spaces in which both textual and voice communication is possible. The virtual learning environment Moodle is presently being “contaminated” by Second Life in the mixed learning environment Sloodle (Sloodle) (Kemp) which will automatically create a 3D classroom in Second Life populated with the resources that are stored in any of the Moodle classes and each tool is re-created as an interactive or a metaphorical object. There are, however, limitations in the type of media that can be used within Second Life. Foremost the commonly used HTML pages currently cannot be browsed directly and other formats commonly used to distribute lecture notes and slides, such as pdf and PowerPoint, need to be converted to images and uploaded at a cost.

A different view is offered by looking at the history. The first browser, Gopher (1991) allowed the link of text files to other text files. Gopher offered one dimensional browsing. Mosaic, a two dimensional browser, was released only two years later, and Gopher experienced an almost sudden death. Gopher is still supported by some servers, but for all practical purposes, Gopher is dead already.

Second Life is a three dimensional browser. It has the same potential power to render two dimensional browsing obsolete as what Mosaic had over Gopher. This has not happened yet, however, mostly because Second Life requires new computers with powerful graphics capabilities. A large part of computers used to access the internet cannot be used to run Second Life. It is interesting to see how long it will take until two dimensional browsing follows the way of Gopher.



Figure 1 Lars Ahlfors Exhibition in Second Life

Mathematics in Second Life

Searching for *mathematics* in Second Life yields surprisingly - or possibly not surprisingly at all - very few locations dealing with mathematical subjects. Public Institutions offering support in mathematics are very few, one is Warwick University Maths Department (Kirriemuir, 2007) that has its own island.

Exhibits are a popular initial approach to developing in Second Life. They are relatively easy to setup and the results are remarkable. As an experiment, we have replicated, in Second Life, the Lars Ahlfors Exhibit that took place for the centennial celebration of the first Fields medallist. The exact same electronic resources were used for the posters that hang at the University of Helsinki and for those that were shown in the Millenium Tower on EdTech Island, see Figure 2.

We have also created an office and exhibit space for the JEM, Joining Educational Mathematics, thematic network where we held a mixed reality seminar: speakers were presenting to the audience live in the auditorium and their avatar was simultaneously speaking to attendees gathered in the JEM office in Second Life as shown in . The major technical difficulty was synchronizing the display of slides on the virtual board with those projected in the auditorium. Slides of the presentations, converted to images, had to be uploaded to the virtual board before the meeting and were updated synchronously by an “assistant” avatar while the voice was directly streamed.



Figure 2 Mixed reality JEM seminar

A good starting point for searching learning resources in Second Life is the SaLamander wiki (SaLamander wiki), which to date lists only 4 locations with mathematical content: a gallery of fractal art and one of mathematical sculptures, a hypercube, and the math playground¹. This last place is specifically geared to exploring how 3D virtual environments can enhance children's understanding of K-12 basic mathematics concepts.

¹ <http://slurl.com/secondlife/Eduisland%20II/27/90/22>

Learning Mathematics in Virtual Realities

A virtual reality environment such as Second Life can be viewed as a powerful simulation framework providing primitives that students may use to create 3D objects. By carrying out any kind of construction or scripting activity, a user experiences concepts such as translation, rotation, scalar transformations, and as a result, learns about vector calculus. By interacting with other avatars in the economy of buying and selling items, a student can practice the kind of financial mathematics that is needed in day to day life, including computing discount percentages, and checking the money transactions on one's own budget. These are learning outcomes which are a by-product of becoming active in the virtual platform itself. However, it is also possible to create specific learning activities, within Second Life, that promote mathematics learning.

Educational Gaming

EduFrag (EduFrag: Educational Gaming) employs a modification of Unreal Tournament, a popular first-person shooter video game, to setup a maze whose doors opens only if the student answers to a question in a quiz correctly. Quiz questions, chemical reactions or statements are posted on doors within maps. Correct answers lead to further exploration of map. Incorrect answers lead to starting over in a study room. A quiz is composed of multiple maps or rooms interconnected by teleporters. Each map is a single room (a decision point) with 4 doors, one door for each choice in the multiple choice questions. One of the doors bears a correct statement and leads to the next room. Three other doors are incorrect and lead to a study room, or to the beginning room in the maze. There can be more "doors" that have no associated teleporters and lead to study rooms with material that should be helpful to the student.

This model is not hard to adopt in a virtual reality world such as Second Life and work to do so is in progress.²

Even though EduFrag has been used to teach chemistry (Bradley & Lucci), the same kind of tests is ubiquitous also in mathematics. At the University of Helsinki, we have developed a large collection of interactive exercises that can be delivered online by systems for automated testing and assessment such as MapleTA. At present it is very difficult to make these exercises available to avatars in Second Life without the support of in-world browsing since the architecture for computer-supported testing and assessment is strongly based on web technologies. An additional problem is the issue of input and display of mathematics: a picture of a formula is a poor representation of the mathematical object since it cannot be manipulated by computational software nor understood by a search engine. To overcome these limitations, which most likely will be removed with time, we have designed a mixed approach game to take place partly online in a conventional web browser and partly in the virtual world. In the JEM sample treasure hunt (Caprotti) each instruction is handed out only upon the correct completion of a practice exercise (selected from our collection). Completing the whole assignment produces the entire collection of instructions which contain the directions for the scavenger hunt in Second Life.

Experiential Learning

Experiential learning is "learn by doing" and by reflecting on the experimental activities which in mathematics may include hands-on laboratories and practice sessions.

The experiential learning cycle of (Kolb, 1975): concrete experience, observation and reflection, formation of abstract concepts and testing in new situation is crucial in mathematics: the process of analysing some object, making a conjecture about it and proving an assertion about some property of the object is what a mathematician is trained to do. For certain abstract objects, a virtual reality may offer a concrete and immediate way of visualizing a model for the objects in which the avatar can move, and experience in a very vivid fashion for instance the geometry as in **Error! Reference source not found.** Exploration can be guided by additionally providing a notecard with a number of questions and pointers to where to learn more. Ideally, the interested student will go on to attempt the construction of other regular polytopes to further the understanding. Furthermore, all these activities can be carried out in groups or alone.

² <http://slurl.com/secondlife/Eduisland%20II/191/188/22>

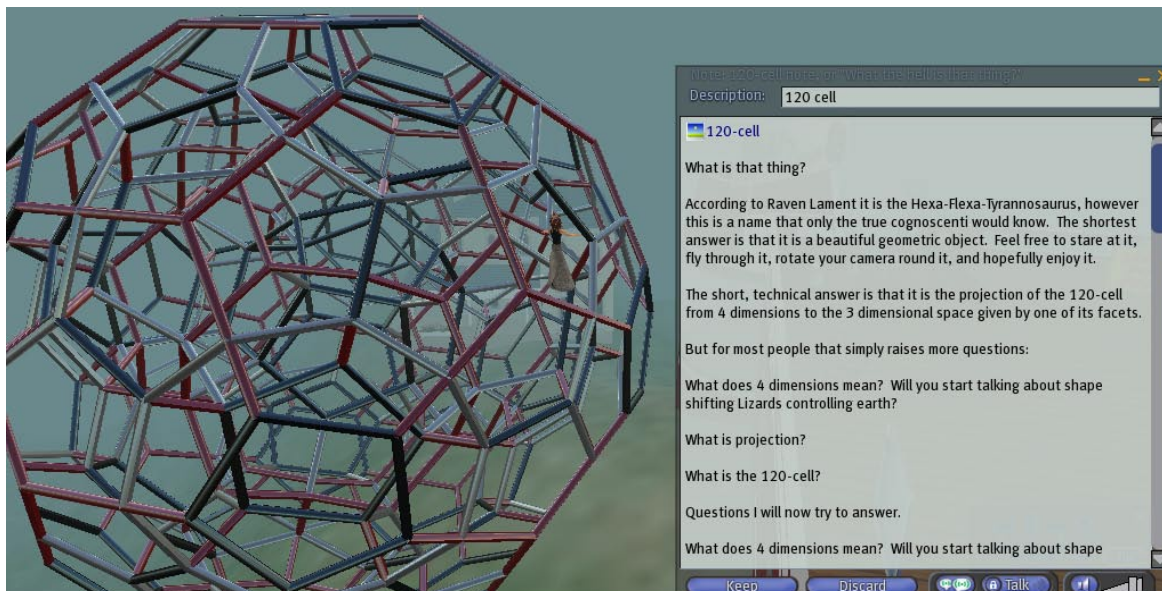


Figure 3 Dodecaplex with avatar flying inside

Concluding Remarks

The power of three dimensional browsing enables the users of systems like Second Life to develop educational games in all disciplines. This is important for all initiatives in e-learning. This is also the way the current students, digital natives, have learnt to get a big part of their information. YouTube rules for most teenagers today. We have to acknowledge that and take-up the opportunity offered by emerging technology. Virtual realities offer also concrete ways to visibly recognize students' achievements. They can brag to their friends by showing off their medals or other rewards they have obtained for good performance. We, the developers of e-learning content and services, on the other hand, can also brag, to our peers, about our solutions to virtual learning. There is a nice promise of rewards to everybody concerned.

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