TOWARDS EFFECTIVE BLENDED LEARNING WITH 3D MUVE

An Analysis of Use Case Implementations for 3D MUVE Learning

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Keywords: Blended learning, Learning in 3D MUVE, Learning use cases, Blended learning challenges, Learning environment integration, Second Life, Open Simulator, Moodle, Sloodle.

Abstract: Technology enhanced learning has been a mainstream educational process, which has introduced a variety of techniques to use in different contexts to fulfil learning objectives and goals. E-Learning has been widely used to fulfil various learning requirements from primary education to university and research based education. However, criticisms on the existing learning methods on competence to cater for societal and human needs within the context of learning are not rare, associating the constraints of behavioural, cultural, and pedagogical. 3D Multi User Virtual Environments (MUVE), in contrast, show a promising future for dynamic learning activities, complementing blended learning methods with high collaboration and user engagement, in which some of those would not have been possible with existing learning practices. This paper, nonetheless, shows that the present 3D MUVE learning use cases are not well defined, yet educationalists tend to practice and expect the conventional e-Learning use cases in 3D MUVE, creating inconsistencies and losing the significance of 3D MUVE for learning. It also proposes a novel approach to consider effective 3D MUVE learning use cases. The use case analysis has been done on a blended perspective. Moreover, the paper critically argues about the effectiveness of learning activities designed with 3D MUVE and e-Learning through selected case studies.

1 INTRODUCTION

In various segments of our society, 3D Multi User Virtual Environments (3D MUVE) can be seen as useful applications. In effect, 3D Learning Environments based on Multi-User Virtual worlds are a growing feature of UK education (Kirriemuir 2010). Virtual worlds with simultaneous interactions of thousands of people in a shared 3D space, show frontier and critical implications for business, education, social and technological sciences, and society at large (Messinger, Stroulia *et al*. 2009). Leading universities are interested in, and have been researching on, applications of this novel technology for their learning needs. 3D MUVE support more intuitive activities for learning complex and advanced concepts. They are particularly appropriate for educational use due to their alignment with Kolb's (Kolb, Boyatzis *et al*. 2001) concept of experiential learning, and learning through experimentation as a particular form of exploration (Allison, Miller *et al*. 2008). Interactive 3D virtual environments demonstrate a great educational potential due to their ability to engage learners in the exploration, construction and manipulation of virtual objects, structures and metaphorical representations of ideas (Dalgarno, Bishop *et al*. 2009).

Virtual worlds provide new opportunities and challenges for technology-enhanced learning (Allison, Miller et al. 2010). Consequently, many higher education courses with novel and engaging approaches to conduct practical coursework have been virtual worlds in academia. The knowledge on appropriate learning use cases is essential for the success of learning in 3D MUVE, as many educationalists are interested in. Therefore, in this research, we have focused on identifying key use cases for learning with 3D MUVE support. For our research and learning activities, we choose Second Life - SL (Linden_Labs 2003) and Open Simulator (The_Open_Simulator_Project 2007) as 3D MUVE and, we consider Moodle (Moodle 2004) as an e-Learning platform. More details about the work we have done with these environments will be discussed later. A significant point of interest for users of 3D virtual worlds as learning environments is that this paper considers popular public domain, open source

Perera I., Allison C., McCaffery J. and Miller A..
TOWARDS EFFECTIVE BLENDED LEARNING WITH 3D MUVE - An Analysis of Use Case Implementations for 3D MUVE Learning.
DOI: 10.5220/0003339500460055
In *Proceedings of the 3rd International Conference on Computer Supported Education* (CSEDU-2011), pages 46-55
ISBN: 978-989-8425-50-8

platforms OpenSim, Moodle and Sloodle for learning activities, which are capable of providing a complete blended learning environment with 3D virtual world support.

It is important to distinguish between virtual worlds, such as Second Life, and massively multiplayer online role playing games (MMORPG) such as World of Warcraft (WoW), as many commentators still seem to regard them as belonging to the same genre. In virtual worlds all the content, building and terra-forming is the result of user activity. There are no goals per se. Unlike MMORPGs the client does not hold a model of the entire world. As avatars move around, their immediate environment is downloaded dynamically to the client. Consequently, virtual worlds require significantly more network bandwidth than 3D games. For example, WoW has been measured as using as little as 7 Kbps (Sheldon, Girard *et al*. 2003), whereas Second Life and OpenSim will readily use more than 500 Kbps. This can be an issue for a limited resource blended learning environment that looks for 3D MUVE engagement. Appropriate learning use cases should be designed considering 3D MUVE network bandwidth requirements as well. Delivering the desired Quality of Service to a virtual world is a live and challenging subject (Oliver, Miller *et al*. 2010).

This paper is arranged into the following sections: in section 2 we describe background details along with our experiences on learning in 3D MUVE; section 3 explains the high level model that we use to analyse 3D MUVE supported learning in the context of existing learning methods. Section 4 elaborates appropriate learning use cases for 3D MUVE learning while considering the research environments we have used. Sections 5 and 6 briefly present two case studies we have worked on to examine the proposed model while presenting the use case mapping challenges and domain specific comparisons, respectively. The section 7 describes the relevance of research findings for security policy development on 3D MUVE learning as the future research work, before concluding.

2 BACKGROUND AND RELATED WORK

E-learning gives many advantages, but there have been criticisms on using it as a mainstream method of education. In fact, this concern was examined by Graf and Kinshuk in their work on e-Learning adaption to standard learning styles (Graf and Kinshuk 2009). A study on e-Learning impact for successful learning activities was done using an approach of task-technology fit (McGill and Klobas 2009). It was found that the perceived benefits of e-learning utilization are higher than that of the actual outcome in the form of student grades, in light of the argument that the technical constraints and underutilization of the possible use cases could have resulted in such observation, through poor collaboration and irrational learning methods, due to overwhelming technology perception of the users. Additionally, technological limitations on providing learning content and activities without 3D rich formats can be a significant cause for a failure of a learning activity. Moreover, trying to map traditional models of learning into e-learning has resulted in weaknesses that we experience in some available e-learning applications (Teo and Gay 2006). Importantly, monotonous ways of interacting students, without their preferred personalization has resulted in poor engagement on learning activities, as well.

Blended learning refers to instructional approaches with multiple learning delivery methods, including most often face-to-face classroom with asynchronous and/or synchronous online learning. Rich collaboration and user friendliness are expected norms on multiple platforms in blended learning (Brenton 2009). Blended learning is characterized as maximizing the best advantages of face-to-face and online education (Wu, Tennyson *et al*. 2010). As a result, the possibility of incorporating 3D MUVE as a complementary learning platform with existing learning environments has been widely used in this work. However, we insist that the new blended learning paradigm should only consist of productive learning use cases of 3D MUVE to avoid redundancies and suboptimal practices. Weippl's extensive set of factors and use cases for e-Learning security management (Weippl 2005), has been used for this analysis in a blended approach.

The University of St Andrews has ventured in a diverse set of educational and research projects incorporating 3D MUVE. The educational projects mainly include the course delivery and assessment in 3D MUVE with a significant success. The Laconia Acropolis Virtual Archaeology (LAVA) (K. Getchell, Nicoll *et al*. 2007), a joint project between schools of Classics and Computer Science, allows students to engage with a simulated archaeological excavation, and then explore a recreation of the site in Second Life. The WiFi Virtual Laboratory in Second Life project (WiFiSL) (Sturgeon, Allison *et* *al*. 2009) is used as a learning aid for wireless networking. It facilitates collaborative explorations and visual simulations of wireless traffic using 3D virtual world interfaces. Another computer networking related research project is to examine Second Life network traffic. It has been a validating study of previous researchers' findings whilst offering new insights of SL traffic management, as a client end measurement analysis (Oliver, Miller *et al*. 2010). Teaching Human Computer Interaction (HCI) to honours students has been a successful effort, once with Second Life (Perera, Allison *et al*. 2009) and another instance with OpenSim (Perera, Allison *et al*. 2010). Figure 1 shows some of the creative mechanisms students have developed.

Figure 1: Students' coursework for HCI in Second Life and OpenSim – Dijkstra's shunting algorithm, and interactive door systems for enclosures.

The Module Management System (MMS) interoperates with Second Life in order to maintain an association of institutional and virtual world identities while being a learning management system. The university is in the process of introducing Moodle in place of WebCT, which provide a Single-Sign-On based Moodle-MMS e-Learning platform for a seamless course management service. Therefore, with the experience on using 3D MUVE for teaching, we suggest that incorporating 3D MUVE along with existing e-Learning environments would generate better blended learning results for students and teachers.

3 BLENDED LEARNING WITH 3D MUVE – STRATEGIC VIEW

The following abstract model indicates learning environment approaches and possible technology applications with a high level perspective. The model is used to analyse how 3D MUVE fit into the existing learning environments, and to evaluate feasible solution stacks to form a productive learning environment. This model analysis will be considered for the use case analysis, later in this paper.

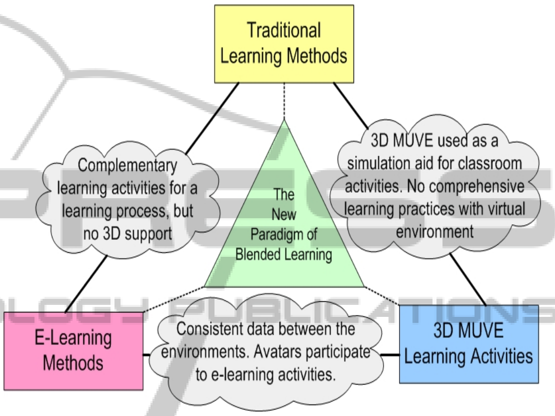

Figure 2: High level model to analyze 3D MUVE integration with learning practices.

The model uniquely identifies three core areas of learning methods: traditional learning methods, e-Learning methods and 3D MUVE learning activities. According to the model, for a productive blended learning experience, 3D MUVE should be introduced in a complementary nature to the existing e-Learning and traditional learning system suites. Let us briefly discuss typical characteristics and issues on each of the different combinations that teachers can practice along with selected system environments. Moreover, for this analysis, we presume the individual methods, i.e. traditional learning or e-learning or 3D MUVE learning alone, would only provide suboptimal learning experience.

Another important consideration made with this model analysis is that the role of mobile learning or commonly known as m-learning. There is no doubt that the portability and the ubiquity presented by hand held devices such as PDAs and mobile phones add a significant value to the existing learning activities. Many researchers tend to consider it as a sub category of broad e-Learning application domain. Lefrere (Lefrere 2009) has examined activity based scenarios for ubiquitous mobile e-Learning. In his findings, he concludes that prevailing resource constraints of mobile infrastructure and complex nature of existing e-Learning use case scenarios have prevented mobile learning being considered as a broad and independent learning technology, but a supportive rich extension for existing e-Learning practices. Moreover, learning with the mobile device support does not replace existing learning practices, but it offers a way to extend the support of learning outside the classroom, to the conversations and interactions of everyday life, as a value addition to e-Learning (Boja and Batagan 2009). We also understand that considering mobile learning as a part of e-Learning for this model analysis would not affect negatively the accuracy of the model, but provide a summative and straightforward insight on the arguments being presented.

Most of the present virtual environment supported learning activities can be seen as complementary approaches of e-Learning and traditional learning combinations. Apart from a pure e-Learning based distance learning activity, all the other learning practices have traditional learning methods such as classroom teaching, in person interactions, practical and laboratory projects, assessment and feedback. Even though e-Learning methods provide learning process optimization through automation and usable content reusing approaches, it cannot entirely replace traditional learning activities that require user collaboration and physical engagement. On the other hand, beyond video content support, e-Learning does not provide simulation facilities to streamline 3D aspects in the learning experience. A learning environment with Moodle support can be considered as an example scenario for this category.

Undoubtedly, the traditional learning has benefited by using 3D MUVE as a supportive tool for 3D simulations and user engagement. Specially, when it comes to explaining complex concepts such as computing algorithms, natural and physical science phenomena and 3D modelling, 3D MUVE provide unequal value additions for traditional learning. Moreover, 3D MUVE can be used as an alternative simulation tool to train students virtually, before their actual laboratory experiments. In some instances, this can be the only possible option due to various constraints on real experiments. However, we do not see a comprehensive integration with the learning processes, as 3D MUVE are merely used as supportive tools. Isolated learning activities that use Second Life or Open Simulator virtual regions can be considered as example scenarios for this.

The combination between 3D MUVE and e-Learning also show better results, but it misses the important aspects of traditional learning such as classroom participation, examination and physical engagement. The data consistency and content integration between the two environments have made this option the most effective out of the three, yet it is not the optimal scenario. Sloodle (Sloodle 2007) integration between Moodle and Second Life/OpenSim is the best example for this type. However, we will further discuss certain inappropriate use cases designed in Sloodle, which could be practiced productively with e-Learning systems than in 3D MUVE.

Therefore, it is understandable that for a successful learning experience, there should be complementary facilitation of these three learning environments. The proposed new blended learning paradigm facilitates straightforward analysis on the learning processes and the degree of their dependence upon e-Learning, traditional and 3D MUVE domains. Moreover, the finer granular functionality analysis derived from this abstract model would help to fine-tune the existing learning methods and models to avoid potential redundancies and functional gaps, when systems are in use. For that, we further analyse effective use cases for 3D MUVE learning in the context of existing blended learning environments in the next section.

4 USE CASE ANALYSIS – 3D MUVE LEARNING

Comprehensive use case analyses on learning with virtual environments have not been performed in a larger scale, so far. The main reason for that may be the intrinsic properties of learning use cases that directly map with the pedagogical and traditional learning processes, which have resulted in researchers considering those as they are for virtual environments. However, this lack of analytical understanding on appropriate use cases for a given learning environment creates difficulties for integrating 3D MUVE with existing learning environments. Furthermore, it results in educators to expect inefficient use cases from 3D MUVE, and often makes them to practice those meaninglessly.

Table 1 summarises the default user roles in the Moodle e-Learning environment while indicating the appropriate corresponding roles from Second Life and OpenSim 3D MUVE. It shows the abstract user role definition in 3D MUVE, compared to Moodle or similar e-Learning systems, results in poor granularity on defining learning use cases in 3D MUVE. Learning activity management for complex use cases with distinct roles can be a challenging task to achieve in 3D MUVE. As a result, a revision of complex e-Learning scenarios is needed for an effective learning experience with 3D MUVE support. Furthermore, access control and permission models in 3D MUVE are designed for 3D content and land access (Perera, Allison *et al*. 2010), which may not be possible to map directly with access control models of e-Learning systems. This creates further discrepancies when users expect exact e-learning use case behaviours in 3D MUVE.

Table 1: The comparison of default user roles in Moodle with the 3D MUVE Second Life (SL) and OpenSim (OS).

Moodle Role	Description	SL	OS
Administrator	system administration (all courses)	Linden Labs	System Owner
Course creator	create courses, teach in them	Land owner / Resident user	Land owner / Resident user
Teacher	teach in and modify assigned courses	Land owner / Resident user	Land owner / Resident user
Non-editing teacher	teach in assigned courses	Resident user	Resident user
Student	resource access and course participation	Resident user	Resident user
Guest	observation only	Visitors	Visitors

Although we can consider all major user roles in the table 1, due to the limited space, let us consider only the student role for the use case analysis, here. In fact, for 3D MUVE, beyond administration tasks of the system and the virtual environment, most of the other use cases are common to different roles; hence the common user role would be the 'Resident User' in the virtual region. Therefore, default student role is taken as a resident user, and considered the common use cases available for a resident user in default, which are compared in the figure 3 with the Moodle student role.

With the system support for rich text based content management and integration, e-Learning environments such as Moodle can incorporate a diverse set of student activities as shown in the figure 3. Moreover, these activities can be extended easily with additional functions to form comprehensive end-to-end learning processes. On the other hand, 3D MUVE user activities are more abstract and emphasis on 3D simulation and dynamic nature through programming than advanced textual features. The 3D MUVE student use cases shown in figure 3, indicates this abstract nature and gives a clear view on how difficult to achieve e-Learning use cases as they are, in 3D MUVE.

This validates the proposed blended learning model and the arguments, as 3D MUVE should be incorporated with its competent learning use cases, whilst e-Learning and traditional learning practices being considered for the rest. Moreover, inappropriate use case integration between e-Learning systems and 3D MUVE can result to inconsistent data and critical security issues on the role based access control. The next section elaborates the use case mapping challenges considering a set of unproductive learning feature implementations in 3D MUVE through the one-to-one mapping of e-Learning use cases.

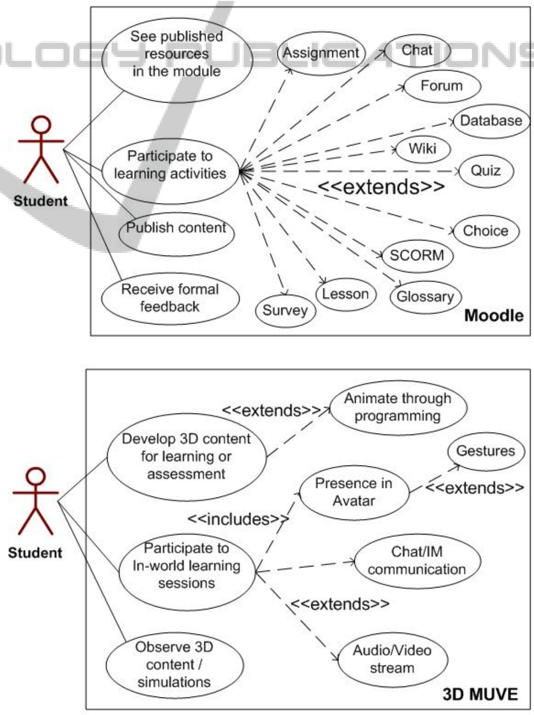

Figure 3: The comparison of learning use cases for the student role in Moodle (version 1.9.9) and generic 3D MUVE. (UML 2.0 use case standard).

5 CASE STUDY I – USE CASE MAPPING CHALLENGES

Use case mappings can be seen in two types. The first type accounts for the popular activities of using

3D MUVE for trivial learning activities such as mere gatherings or to impose 3D flavour on existing 2D learning contents. These activities do not induce additional inefficiencies to learning process, but add variety and dynamism, although the learning activities may be not practiced to the optimum potential. On the other hand, the second type of learning use case mapping seems crucial for learning environments since it can introduce a set of complimentary uses with 3D MUVE instead of major Web based e-Learning activities. Although these practices are becoming popular, they are yet to provide productive learning use case implementations for a complete replace of selected 2D Web tasks.

For this case study, we have installed and tested a prototype learning environment. We have used Moodle (version 1.99) as the e-Learning platform, Sloodle (version 1.0) and OpenSim (version 0.68) as the 3D MUVE. Another important fact with this arrangement is all these systems are free and open source; the most complete open solution available present for academia to work with on this regard. Therefore, this system suite based learning activities should be thoroughly studied in order to optimise the proposed blended learning with 3D MUVE.

Sloodle learning features include 11 activities to map selected Moodle activities such as chat, forum, glossary, choice, content display and limited support of quiz and 3D content submissions for assignments. A summary of main Sloodle tools for learning, their functional descriptions along with the corresponding Moodle task, is mentioned in table 2.

Table 2: The comparison of default user roles in Moodle with the 3D MUVE Second Life (SL) and OpenSim (OS).

Sloodle tool	**Functionality description**	**Moodle**
Webintercom	Synchronize chat	Chat
Presenter	Display media files	Content display
Toolbar	Blog, Gestures, Avatar list display	Forum
Quiz chair	MCQ question support	Quiz
Pile on quiz	MCQ question support	Quiz
Prim drop	Submit prim for assignment in Moodle	Assignment
MetaGloss	Access glossary in Moodle	Glossary
Sloodle Choice	Synchronize choice	Choice
Vending machine	Distribute SL objects	--
Awardsystem	Connects Sloodle points with Moodle Gradebook	Gradebook
Picture Gloss	Connects texture from glossary to prim	Glossary

Synchronised user communications and Moodle content display in 3D MUVE are rational features that add value to learning. However, using 3D MUVE chat channels to publish student compositions in Moodle forum, glossary and wiki, can be a question as those entries are supposed to feature rich text and content, which cannot be supported through 3D MUVE chat or IM channels, at present. Furthermore, asking students to participate in quizzes, assignments and text based learning activities in 3D MUVE instead of Moodle can introduce further difficulties to student work. In most of the instances, students require re-login to Moodle afterwards of their initial submission, to enrich the entries that have been done through raw chat interfaces while they were inside 3D MUVE. By accessing Moodle through in-world media browser directly would allow a certain level of rich text support as shown in Figure 4. However, due to JavaScript support issues with the present in-world media browsers, students can try external browsers of their systems for advanced text compositions while being inside the 3D MUVE.

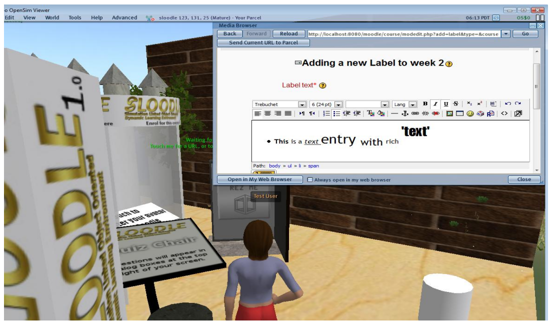

Figure 4: Publishing rich text entries through direct access of Moodle without Sloodle support.

Another important fact to consider is the accurate map of user collaboration facilities provided in 3D MUVE with the e-Learning environment. Specially, Web based learning activities by their nature are not designed for rich collaboration in real time, but a user session based individual browsing. Some argue that confining certain 3D virtual world learning activities to the in-world browser, would eventually hinder the advantages of 3D MUVE for collaborative learning. A collaborative web browsing (‘co-browsing’) tool support is being developed as an extension to the Sloodle system (Crowe and Livingstone 2009). However, it is too early to evaluate such a tool for seamless web browsing on serious learning activities with 3D MUVE. For the time being, accessing textual content through the in-world browser or external browsers (Firefox, Safari, IE, etc.) would be advised, and it provides better results for rich and comprehensive composition tasks (Figures, 5 and 6). Moreover, Sloodle mediation only supports MCQ questions! Therefore, accessing Moodle directly in 2D form is essential for formal assessment and feedback.

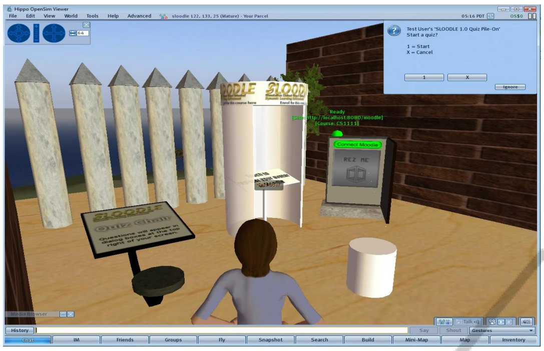

Figure 5: Attempting a quiz, published on a Moodle course, in OpenSim with Sloodle mediation through in-world Note-cards.

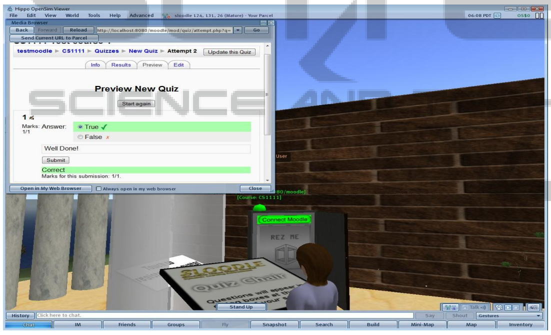

Figure 6: Attempting the same quiz mentioned in fig. 5, through the OpenSim in-world media browser. Here the avatar accesses the quiz directly without Sloodle support.

However, when it comes to mediating the 3D content ownerships, their associations and avatar identity registration with Moodle course modules, Sloodle does reasonably well through its tools. 'Prim drop' and 'Vending machine' are important tools for this purpose and unarguably implements essential use cases for 3D MUVE integration with e-Learning. Moreover, 'Registration Booth', 'Access Checker' and 'Login Zone' functions are effective for platform integration with accurate identity and access control mapping between 3D MUVE and Moodle.

Therefore, trying to achieve all learning use cases of e-Learning systems in 3D MUVE is not advised for serious learning requirements. With the case study, we have identified that the textual and 2D based learning content and activities are not yet fully supported for effective use in 3D MUVE. Educationalists should rationally decide appropriate learning use case implementations according to the learning domain requirements. We have further studied on such a specific implementation of a domain requirement and will be discussed in the next section. Moreover, students should be encouraged to use the e-Learning environment for its competent functions while the 3D MUVE for its best, in a mutually independent manner. The system infrastructure should ensure the seamless data integration between the environments underneath for a smooth learning experience, without forceful implementations of inappropriate practices.

6 CASE STUDY II – A DOMAIN SPECIFIC COMPARISON

For this, we have selected to compare two distinctive implementations of the link state protocol OSPF (Open Short Path First) simulations as learning aids. OSPF uses Dijkstra's Shortest Path algorithm as its mechanism to build and calculate the distances to all known destinations. Importantly, understanding Dijkstra's Shortest Path algorithm can be a challenging task for an unaided student due to its complex nature. Like many algorithms, it can leave some students bored and disengaged, so the goal was to demonstrate a user-friendly learning resource to help students who would otherwise lose interest.

The first attempt was to implement a Web based public accessible learning resource with animation support to indicate the algorithm behaviour. Also this implementation facilitated a certain level of interactivity with feedback to self assess user's understanding on the algorithm behaviour. A working instance of the Dijkstra's algorithm animation with highlighting the relevant step is shown in Figure 7.

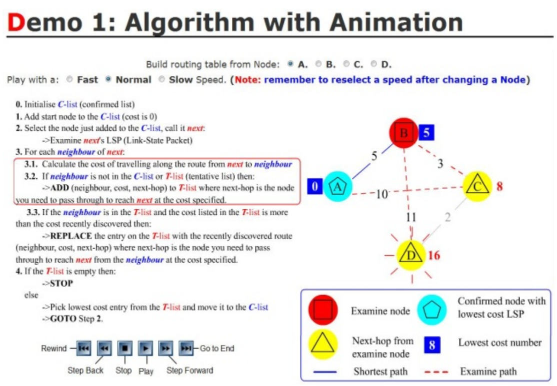

Figure 7: An operational instance of the interactive Web based OSPF algorithm simulation learning resource.

Although this Web based OSPF learning resource was a better alternative to the static textual explanations of OSPF algorithm, we have identified several obstacles associated with its domain limitations, which are challenging to overcome for an engaged and collaborative learning participation. Moreover, the Web based OSPF learning aid could only provide the dynamism within a pre arranged set of graph topologies to indicate the algorithm behaviour. If a student wants to practice own network topology with varying constraints to examine the algorithm, it is not possible with this. However, with the intrinsic support for textual content of the platform, this version of OSPF animation provides usable text based learning content and dynamic activities such as formatted routing table, node – arc summary at each step and textual user input and feedback for self assessments. It also provides additional resources (external) for an enthusiastic student to refer and further study.

Alternatively, an OSPF simulation learning resource has been developed in a locally installed OpenSim island (McCaffery, Miller *et al.* 2010). The Web based OSPF learning resource demonstration has been replicated with the 3D content and scripting for the required animation (Fig 8). Further extensions and attractive learning use cases have been associated with this learning aid beyond the basic preset algorithm simulation.

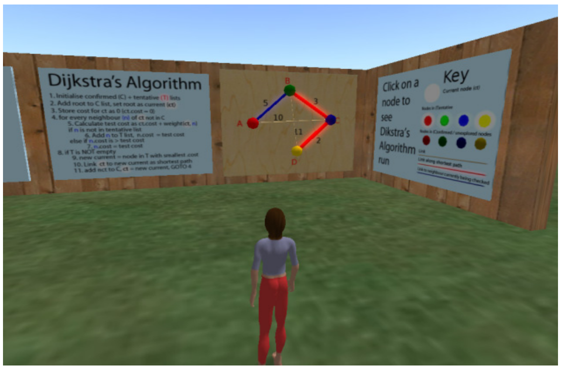

Figure 8: An avatar observes the Dijkstra's algorithm simulation example.

The implementation of OSPF algorithm simulation in OpenSim has several additional functions when compared with its Web based predecessor. Importantly, one of the key use cases of this learning resource is the truly dynamic network topology creation at students' preference. Student avatars can create various complex network architectures using routers and end nodes as they wish (Fig. 9). This is an excellent opportunity for students to reflect on what they have learnt and to self examine individual concerns to overcome liminal spaces related to a threshold concept of their learning. A threshold concept lets students into transformational liminal states(Meyer and Land 2005). Indeed a complex algorithm related concept such as OSPF can be a threshold concept for some students, in which if we could not provide adequate dynamic learning aids as liminal states emerge when students are in the process of understanding, they easily tend to mimicry the algorithm flow shown in the static demonstrations, without a thorough knowledge. While creating their own desired network topologies, it is obvious that students think a shortest path by reflecting their knowledge. However, instantaneous observation of the correct answer through intuitive simulation would help students to reinforce their learning accurately. Had they anticipated an erroneous answer, their curiosity would let them reinvestigate their answers once the simulation indicated the correct path of the packet flow, as shown in the figure 10.

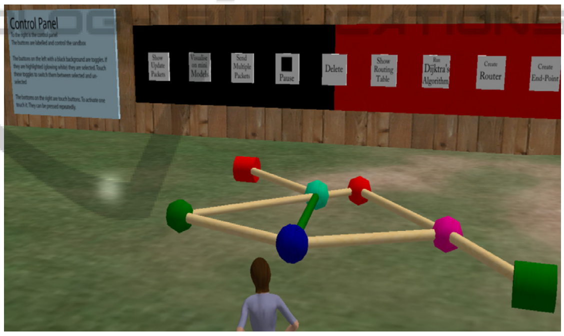

Figure 9: A student avatar creating a dynamic network topology with routers and end nodes.

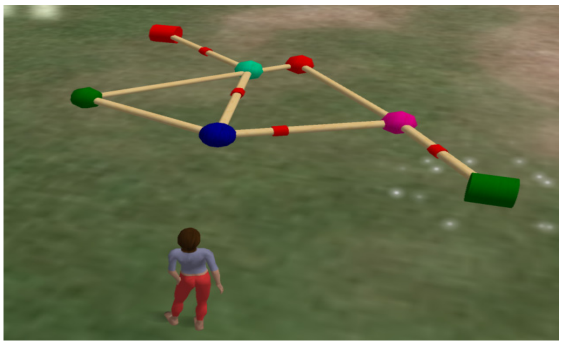

Figure 10: Observing the packet flow in the shortest path of the user created network topology.

Another important advantage with this implementation is the extensive facilitation for collaborative group activities. Certainly, it is due to the intrinsic trait of the 3D MUVE platforms; the learning resources should be carefully designed to exploit it, however. Students' collaboration on network topology creation, setting various weights and resources, and observing and commenting others' use of the learning aid are new use cases that have been introduced compared to 2D Web version. In fact, these use cases of learner collaboration are essential for a broader understanding of a complex concept, which would otherwise be limited with individual insights. User collaboration occurs through interaction between learners while interacting with the 3D MUVE, through the learning interface that provides supports rather than barriers to learning (Girvan and Savage 2010). Students have been given the opportunity to use 3D MUVE communication channels (chat, voice, IM) to share their ideas while being engaged with their learning. This was not possible with the previous Web based animation, either.

The main emphasis given on this OSPF simulation implementation was to depict the associated concepts in 3D visuals as much as possible instead of the textual alternatives. Although the learning experience could be implemented on other platforms without 3D MUVE support, the learner experience would be lost, and users feel contrived (Girvan and Savage 2010). Therefore, a reasonable amount of textual content and activities have been appropriately redesigned and mapped to 3D content to exploit the 3D MUVE benefits to the fullest. By doing so, however, certain learning use cases that are primarily associated with the textual contents and could not completely mapped to 3D content, seem to be deprived when observed along with the rich 3D visuals. Using 3D MUVE raw text channels to display routing information or algorithm simulation updates may not be aesthetic without rich formatting. Indeed, this strengthens our argument of using complement systems for a blended learning on what they are competent of. An appropriately designed Web based e-Learning resource to provide rich textual content and user activities would complement the 3D MUVE with sufficient integration. Moreover, as we discussed in the previous section, such a resource could be accessed interactively through the in-world or external browsers, while participating in the 3D MUVE learning activities.

Another challenge, with 3D MUVE learning resources, is the provision of external resources of the same calibre for further studies. Being a novel and growing technology for learning, 3D MUVE do not yet possess a reasonable amount of 3D learning resources to be referred for a particular area of study. Even if there are 3D contents available from external sources, accessing and execution of those content objects is not a straightforward activity, as we access Web based public resources. This is primarily due to the heterogeneous content ownership management policies and platform constraints. However, we can expect for a brighter future as 3D MUVE systems further develop and are widely used in blended learning environments.

7 CONCLUSIONS AND FUTURE WORK

This paper has rationalized the use case issues associated with learning in 3D virtual worlds, when users expect identical use cases as they practice with e-Learning activities. Either the situational approaches for utilizing 3D MUVE for learning, or forceful integrations of inappropriate use cases of e-Learning systems with 3D MUVE, would not furnish sustainable solutions; this paper has introduced a strategic model to analyze these issues considering prime aspects. The analysis on use case implementations and selected case studies in this research would only guide the pathway, but further research is encouraged for standardising and applying productive use cases for various blended learning requirements with 3D MUVE.

3D virtual worlds have a great potential for engaging students in innovative, immersive learning environments. Identifying appropriate use cases for learning in 3D MUVE will facilitate the future work of this research. With this research, we are looking forward to provide comprehensive security management policies for generic learning requirements in 3D MUVE. For a sustainable security management policy definition on 3D MUVE learning, it is essential to consider every associated main platform of blended learning. Not only it allows us to develop policy models for 3D MUVE learning in a holistic manner, but also provides an efficient set of complimentary learning use cases that has been already filtered for redundancies from other platforms. The proposed security policy models will then be implemented as prototypes to evaluate and optimize for large scale deployments. These will be done at the application level, independent of the underlying platform constraints to ensure seamless customization and reuse, as required.

ACKNOWLEDGEMENTS

This research is supported by the UK Commonwealth Scholarship programme and the *Scottish Informatics and Computer Science Alliance* (SICSA). Second Life region rental was supported in part by the University of St Andrews *Fund for Innovations in Learning, Teaching and Assessment* (FILTA). The *Higher Education Academy for Information and Computer Sciences* (HEA ICS) supported part of the work on OpenSim.

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