EFFECTIVE POLICY BASED MANAGEMENT OF 3D MULE

An Exploratory Study Towards Developing Student Supportive Policy Considerations

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Abstract: Learning environments that are based on 3D Multi User Virtual Environments (3D MUVE) can be referred as 3D Multi User Learning Environments (3D MULE). 3D MULE used in various educational and research activities show proven success sufficient to warrant their consideration as a mainstream educational paradigm. They introduce a platform for diverse learning activities with a novel set of challenges for teachers and students. Without suitable learning management practices, 3D MULE users can encounter difficulties during their learning interactions through 3D MUVE functions, although the learning environment is dynamic and engaging. To overcome this challenge, we researched learner supportive policy considerations for 3D MULE management. This paper presents an exploratory study with student engagements (*N=32*) that identifies key factors, self-regulation and environment management, for policy considerations. Moreover, the paper critically examines the importance of constructive alignment of learning activities with the 3D MULE features for useful learning experiences.

1 INTRODUCTION

3D virtual worlds provide unique features for enhancing technology supported learning through intuitive activities for learning complex and advanced concepts. They are particularly appropriate for educational use due to their alignment with the Kolb's (Kolb *et al*., 2001) concept of experiential learning, and learning through experimentation as a particular form of exploration (Allison *et al*., 2008). For our research we use Second Life (Linden Labs, 2003) and Open Simulator (2007) MUVE; a trend towards open 3D MUVE such as OpenSim can be seen recently (Allison *et al*., 2011), however.

Lack of awareness on 3D MUVE system functions can cause significant challenges of learning management for an educationalist, which can deteriorate the value of 3D MULE and student motivation for learning. Furthermore, if adequate management policies are not followed, students may also find difficulties in adhering to the best practices when engaged in learning. Managing 3D MULE and achieving usability and trust in learning can be a challenge as student interactions may be influenced by the varying levels of self-regulation practices. With the interest for extensive use of 3D MULE, we believe that the use of learner supportive management policies would positively contribute to student learning engagement. Therefore, we have focused on identifying key policy areas for managing 3D MULE.

Section 2 of this paper describes background details and our experiences with 3D MULE; section 3 reveals the research methodology and design. Sections 4 and 5 elaborate the results, analysis, contributions and study limitations. Section 6 presents future work and conclusions.

2 BACKGROUND AND RELATED WORK

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 (*et al*. 2009). Although the learning experience could be implemented on other platforms without 3D MUVE support, the learner experience would be lost, and

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users feel contrived (Girvan & Savage, 2010). Various successful studies for enhancing education with 3D MULE can be found, recently. However, most of these studies assume the fact that 3D MUVE implicitly facilitate learning needs. Since 3D MUVE are not specifically designed for educational needs, users have to consider system and user role based management for successful learning experience (Perera *et al.*, 2011). Weippl (2005) has considered a set of factors for e-Learning system management policy considerations. Previous study on use case analysis of 3D MULE compared to e-Learning has identified the significance of environment management for successful management policy considerations (Perera *et al*., 2011).

Technology supported learning environments, can help to develop specific self-regulatory skills related to successful engagement in learning (Dabbagh & Kitsantas, 2004). Pintrich, (2000) defines self-regulation as "*an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the learning environment contextual features*". Students with better self-regulatory skills tend to be more academically motivated and display better learning (Pintrich, 2003). Schunk (2005) suggests the need of more research aimed at improving students' self-regulatory skills as they are engaged in learning and to examine how learning environment contexts affect the amount and type of self-regulation displayed. In this study, we examine self-regulation and system management for 3D MULE learning.

Several research and educational projects with 3D MUVE are used in the University of St Andrews as 3D MULE such as, The Laconia Acropolis Virtual Archaeology (LAVA) (Getchell *et al.*, 2010), Wireless Island (Sturgeon *et al.*, 2009), Network Island (McCaffery *et al.*, 2011) and Human Computer Interaction (HCI) student projects (Perera *et al.*, 2009). Research on integrating 3D MUVE with e-Learning infrastructure is conducted (Perera *et al.*, 2011), which initiated this study.

3 RESEARCH METHODOLOGY AND EXPERIMENT DESIGN

Student behaviour and system administration have been widely considered aspects for effective learning environment design. Based on our previous studies on 3D MUVE use cases and role analysis (Perera *et al.*, 2011) and the 3D MUVE function behaviours, we hypothesised these two parameters to be the most influential factors for successful policy considerations for 3D MULE management. Furthermore, we decided to extend the study to investigate the impact of these two factors on student engagement with the 3D MULE. Therefore, we examine three factors: student behaviour, system (environment) management and student engagement with the environment as the research variables. Importantly, the engagement with 3D MULE may not necessarily represent the student engagement with the learning, although there can be a positive correlation if the learning tasks are constructively aligned (Biggs, 1996). However, the opposite; i.e., if the student engagement with the 3D MULE is low, so it is with the learning tasks that depend on 3D MULE, obviously. There are unique advantages of using 3D MUVE for teaching and learner support, which we may not achieve from the other methods. Deductively, if students do not engage with 3D MULE, there is a high tendency of them having less engagement with their learning as well. Hence, our policy considerations for 3D MULE management should not negatively affect the student engagement.

The following research hypotheses were defined to examine the supposed variables and their impact.

H1: Student behaviour with self-regulation is a major factor of the successful 3D MULE management

H2: System environment management is a major factor of the success of 3D MULE management

H3: Student self-regulatory behaviour has a positive and significant effect on student engagement with 3D MULE

H4: System environment management has a positive and significant effect on student engagement with 3D MULE

3.1 Experiment Design

We followed a two phase study; first, students from two course modules experienced the 3D MUVE supported learning environment (in OpenSim) as a part of their studies. In contrast to Second Life, OpenSim gives several advantages (Allison *et al*, 2010). It is important that students participate in a credit bearing learning session designed with 3D MUVE for the data accuracy than following an artificial task. Further, it helps students to consciously associate the experience they had. The two modules have different learning objectives levels in Scottish Credits and Qualification Framework (SCQF, 2007). This study focused on student engagement with the environment; although students had different levels of the same learning task, both samples were similar with respect to our measures. The differences in the modules did not affect the experiment; hence can be considered as a single sample of 59 students for the data analysis.

Table 1: Considered module information.

Module Information	SCQF Level
CS3102 *Data communication and Networks* - 31 Students	10- Hons. Degree
CS5021 *Advanced Networks and Distributed Systems* - 28 Students	11-PG Degree(MSc)

The learning environment, Wireless Island (Sturgeon *et al.*, 2009), is a dedicated region for facilitating learning and teaching wireless communication through interactive simulations with configuration settings and supplementary learning content for exploration. To facilitate small group learning with a less competitive environment interaction, we set up 5 identical Wireless Islands (256x256 m^2 virtual space; 6 students per island) in the OpenSim environment. Students were assigned to regions as their home place to start their learning.

For the second phase, a questionnaire with 15 questions, divided into two sections: avatar behaviour–7 questions, and 3D MULE management –8 questions, was used. The 8 questions in the 3D MULE management section had some relevance on the two factors that we are investigating, self-regulation and environment management; however, the questions did not directly portray the variables. We decided to confirm through the statistical analysis, therefore, included as 8 related questions.

4 RESULTS AND ANALYSIS

4.1 Observed Student Engagements

Avatar appearance change can be a fun, although creating attractive appearances within a limited time can be challenging. OpenSim with Hippo viewer gave an additional step on changing user appearance compared to Second Life. Users first have to create a body-part, edit it and then wear it to change the shape of the default avatar. However, few students spent long enough to create more sophisticated shapes, clothes and even change the avatar gender (default avatar shape is shown in the top-left image of Fig. 1). Postgraduate students were less keen on changing their avatar, whereas many undergraduates went to a further step by comparing the avatar appearances with their friends'. However, the student commitment for making their avatars look good should not be underestimated as it can take substantial portions of their learning time.

Content creation is one of the fundamental interactivity mechanisms available in 3D MUVE. Allowing students to create attractive 3D shapes makes them engaged with the environment passionately. As observed, students tried a range of constructions and editing of the existing objects.

Figure 1: Observed student interactions.

Some of the alterations directly affected the learning experience; activities such as wearing the control buttons of the media displays, moving and changing the internal arrangement of the lecture theatre, and creating constructs on the simulation area (Fig. 1), introduced some disturbances. These can be discouraged through usable policy considerations. A student interaction caused the learning environment to be significantly altered compared to its original layout (Fig.1 last row). This observation was a one-off incident, as the majority of students refrained from changing land settings. Compared to the postgraduate (Masters) students, the undergraduate (Honours) students showed high interactivity, resulted in a range of user-created objects, altered content and changed land terrain. The undergraduates were keen on exploring game-like features, and associate their friends for collaborative activities, although those activities were not related with the learning. Students that were keen on completing their tasks may have had less motivation to explore the 3D MUVE, however.

Students were allowed to follow their preferred behaviour and environment interactions as a mean of learning through exploration (Kolb *et al.*, 2001) without any restriction. In this exploratory study, we wanted to examine these actions as empirical evidence; an assurance was given that their behaviour does not affect their grades, but the completion of the learning tasks.

4.2 Analysis of Questionnaire Data

We received 32 completed questionnaires (54.28%), [20 (71.4%) from postgraduate and 12 (38.7%) from undergraduate students]. An initial observation of the question characteristics and the descriptive statistics helped to understand the user responds and possible classifications. Analysis of the question and responds resulted in preliminary clustering of the questions into two major categories: (Q1-Q7) *user engagement* and (Q8-Q15) *3D MULE management*.

The questions in user engagement section, based on different student behavioural activities in the environment, indicated a higher internal consistency (Cronbach's α = 0.802). The internal consistency validated the combined use of questions to represent the associated variable. The 3D MULE management section was designed to examine the two prime variables associating the research hypotheses. We have statistically analysed for accurate variable identification as a method to test the hypotheses.

Exploratory Factor Analysis (EFA) used to test the Q8-Q15 question set. Pre-tests were conducted for the fitness of data to be used for EFA. Bartlett Test of Sphericity, a strict test on sampling and suitable correlations, was performed using PASW (18.0), and obtained $\chi^2 = 155.257$, $p < .001$, suggesting that the correlation matrix (*R-Matrix*) items can be clustered based on relationships; the null hypothesis of *R-Matrix* being an Identity Matrix can be rejected with significance indicating a higher level of fitness for EFA. Additionally, the Kaiser-Meyer-Olkin (KMO) test to examine the accuracy of using the data sample for the EFA; KMO value =0.714(>0.7; Field, 2006) validated the fitness. The sample size to variable, *N:p* was higher and meets the guidelines given by Costello & Osborne (2005).

We used EFA to test H1 and H2. Principal Component Analysis (PCA) was used to extract factors; two factors (*Eigenvalues>1.0*) was obtained. These highest two factors contribute nearly 72% of the total variation of the aspect 3D MULE Management. Further, we employed Orthogonal Verimax Rotation with Kaizer Normalization and obtained the rotated factor loadings (Fig. 2).

To remove weak loadings, we followed Stevens (1992) and Field (2006) suggestions, and used .6 as the cut-off, considering the exploratory nature of the analysis. The Orthogonal Verimax Rotation seems accurate as the two factors relatively equally contribute (37.13% and 34.74%) to the underlying aspect. The Component Transformation Matrix showed symmetry over the diagonal, indicating the Orthogonal Rotation is accurate, and the rotated factor loadings are correct. As the rotated factor loadings indicated, questions Q9, Q15, Q10 & Q8 were considered as a one variable. The objectives of the questions suggested a common parameter. We concluded it as the student behaviour with Self-regulation, as expected. The second factor represents Q11, Q14, Q12 & Q13 questions and strongly relates the student preference and impact on the system control, administration and management of

Table 2: Questionnaire items and the descriptive statistics on item scores.

No	Question	Mean	Mode	Std. Dev.	Std. Error
Avatar Engagement					
Q1	I changed my appearance as I like to appear	3.09	3	0.466	0.082
Q2	I created content objects in the environment	3.69	4	0.471	0.083
Q3	I tried to change the land or content objects in the learning environment	3.66	4	0.483	0.085
Q4	I communicated with others regularly	3.53	4	0.507	0.090
Q5	I have followed other avatars collaboratively during my learning	3.44	3	0.504	0.089
Q6	I moved to all the places in my island and teleported to other islands	3.81	4	0.397	0.070
Q7	My activities in the environment resulted in a high engagement with my learning tasks	3.97	4	0.40	0.071
Self-Regulation					
Q8	I think my behaviour affected others' learning	3.31	3	0.592	0.104
Q9	The open space and other avatars made me to interact as in a real-world learning session	4.05	4	0.354	0.064
Q10	Use of real identities increases the proper behaviour of students	4.02	4	0.309	0.056
Q15	Students should responsibly use the learning environment	4.10	4	0.296	0.051
Environment Management					
Q11	Land and Content management controls are important to manage environment	3.78	4	0.420	0.074
Q12	System control and management practices are important for a reliable learning	3.91	4	0.296	0.052
Q13	System management settings should not reduce the 3D MUVE usability	4.19	4	0.592	0.105
Q14	Appropriate system security & controls ensure a successful learning experience	3.89	4	0.390	0.070

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.020	50.250	50.250	4.020	50.250	50.250	2.970	37.130	37.130
2	1.730	21.621	71.871	1.730	21.621	71.871	2.779	34.741	71.871
3	.648	8.097	79.967						
4	.538	6.729	86.696						
5	.500	6.249	92.945						
6	.346	4.330	97.275						
7	.168	2.099	99.374						
8	.050	.626	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component	
	1	2
Q9	.937	
Q15	.904	
Q10	.884	
Q8	.607	
Q11		.868
Q14		.818
Q12		.765
Q13		.711

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

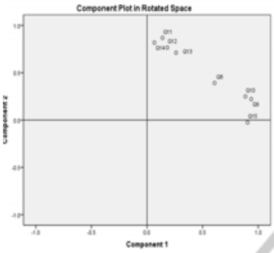

Figure 2: Rotated Component Matrix and Component Plot in Rotated Space.

the 3D MUVE. Therefore, we defined this variable as Environment Management to cover all the aspects that associate. The internal consistencies among the question items within the three variables found to be very high (Cronbach α >.8). The items on self-regulation and environment management also meet the requirements to be considered collectively to represent the variables. One-Sample Kolmogorov-Smirnov test for normality on the variables student engagement, self-regulation, environment management resulted in [X~N(3.598,0.283), α=0.997], [X~N(3.876,0.378), α=0.516], [X~N(3.95,0.175), α=0.796], respectively, retaining the hypothesis of normal distribution confirming the collective use of items with normality.

Table 3: Regression model summary.

Variable	β	Std. Err.	t-value	Sig.
Self-Regulation	.240	.097	2.482	0.019*
Environment Management	.657	.092	7.312	0.000**

* $p < 0.05$, ** $p < 0.001$

The Spearman *rho* between Self-Regulation and Environment Management is 0.398 indicating a weak positive relationship ($p<0.05$). This is important since the two variables measure sufficiently different parameters and the inter-relationship is insignificant. Therefore, we conclude that, *Self-Regulation* and *Environment Management* are sufficiently independent as measuring two different aspects, which further proves the EFA and selection of variables to represent the 3D MULE Management aspect. Moreover, there aren't any other strong and significant variable revealed through the EFA. Therefore, the research hypothesis **H1** and **H2** are substantiated. To test the research hypotheses **H3** and **H4**, we used regression analysis.

A sample size test was done for the fitness for regression analysis. As in Field (2006), for the test statistics of anticipated large effect ($F^2=0.35$), Number of predictors ($n=2$), Probability level of Significance ($\alpha=0.05$) with the desired statistical Power level of ($1\text{-}\beta=0.8$), the minimum required sample size was 31. Therefore, our sample size N=32 (>31) suites well for the analysis and the regression model is reliable.

Linear regression analysis, $R^2=0.759$, indicates that about 75.9% of the variation in the student engagement is determined by the environment management and student self-regulation in 3D MULE, as a combined effect. ANOVA of the model fit showed, that the regression model significantly explains the Student Engagement from the variables Environment Management and Self-Regulation ($p<0.001$). As the variable relationship with predictor parameters of the model shown in table 3, the path coefficients are .240 for Self-Regulation, which is significant ($p<0.05$) and .657 for Environment Management with significance ($p<.001$). Therefore, the research model substantiates our hypotheses **H3** & **H4**.

5 DISCUSSION

Available space prevents a more comprehensive discussion on the individual questions and the recorded scores; the question responses are self-explanatory with the results shown in Table2. However, briefly, Q7 suggests an important relationship between the environment engagement and learning engagement, which is highly recommended for further study. The Q5 and Q8 show the importance of associating collaborative learning tasks with the available 3D MUVE facilities. Student collaboration occurs through learner interaction while interacting with the 3D MUVE that provides supports rather than barriers to learning (Girvan & Savage, 2010).

EFA and consistency tests resulted in the identification of the two variables: self-regulation and system environment management as the major factors of 3D MULE management, confirming the hypotheses **H1** and **H2**. Therefore, we suggest these two parameters as main consideration areas for 3D MULE management policy development. With reference to **H3** and **H4,** the student *self-regulation* on learning activities and *3D MUVE management* practices result in a significant positive effect on the *student engagement* with the environment and learning tasks. We conclude that, for constructive and successful 3D MULE student engagement, we must identify and implement policies for student self-regulation and 3D MUVE system management. Thus, we validate our research hypotheses on considering self-regulation and environment management of 3D MUVE as a prime factor for 3D MULE management policy considerations.

The environment management indicated the highest positive impact on increasing the student engagement. Although, students entertain themselves by various environment engagements they also felt the difficulty of task coordination and unsupportive avatar behaviour during learning engagements. For example, lecture displays reset whenever an avatar hits the play button, disturbing the other viewers. Also, if a student's simulation arrangement is too close to another's setup, simulation interferences were observed. These can be easily solved if we implement suitable environment management policy considerations. Considering the student opinions and our observations, we suggest the importance of cohesive learning activities with 3D MULE user engagement aspects through constructive alignment (Biggs, 1996). This would enable students to spend their time highly engaged with the 3D MULE, while achieving their learning goals comfortably.

Careful analyses and tests were employed to minimise the impact of the following limitations. Due to the nature of the research, the study sample was limited to a particular set of students. These students have provided their feedback and answers based on their experiences, which we validated through observation. Therefore, we consider the data received as accurate and conclusive though the study had a relatively small sample, due to resource constraints. The questions used were appropriately designed, although they have yet to be examined for psychometric measures. It is a challenge to find a widely accepted standard set of psychometric measures in particular for 3D MULE, as the field of study is still growing. We would welcome the researchers to consider this aspect in future research.

6 CONCLUSIONS

3D MULE provide a great potential for engaging students in innovative, immersive learning environments. Use of policy considerations for 3D MULE learning management facilitates the students and teachers in many ways. As we have comprehensively shown, students would have benefited by having a supportive and managed 3D learning environment, while allowing teachers to focus more on the educational value of learning tasks than worrying about the challenges they face with 3D MULE. Policy based management of 3D MULE is essential as the situational approaches for utilizing 3D MUVE for learning would not otherwise be sustainable. We have presented the two important aspects identified for policy considerations through empirical evidence, which were also validated by previous research. With that we look forward to facilitating the policy consideration development through user guidance.

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