Managing 3D Multi User Learning Environments

A Case Study on Training Disaster Management

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***Abstract*—3D Multi User Virtual Environments (3D MUVE), or commonly known as 3D virtual worlds, have shown proven success in enhancing the present teaching and learner support methodologies. Integrated educational environments that are formed using 3D MUVE can be referred as 3D Multi User Learning Environments (3D MULE). The intrinsic rich and dynamic features of 3D virtual worlds can sufficiently increase the student engagement with the learning tasks in 3D MULE. However, with the facilitation for diverse learning activities, 3D MULE can introduce a new set of challenges for the teachers and students; therefore, suitable management strategies for 3D MULE can be essential for success. In this research, we have proposed a framework for managing 3D MULE using policy considerations and a guidance tool to facilitate policy implementations. This paper presents the evaluation of the proposed strategies for making policy considerations to manage 3D MULE and the developed user guidance tool. To increase the accuracy while evaluating for real educational uses, we selected a teaching and training environment in use as the case study. This case study, a 3D MULE supported learning aid for humanitarian disaster management, provided valuable and supportive feedback to validate the completed work while shaping the orientation of the future research on facilitating 3D MULE management.**

***Index Terms*—3D MULE, Learning Environment Management, Policy Considerations, User Guidance**

I. INTRODUCTION

3D Multi User Virtual Environments (3D MUVE) can be seen in a range of application domains at present, although they were introduced as games. With the increased flexibility to customize the 3D virtual space and content creation, 3D MUVE let the users to explore further. Consequently, 3D MUVE have been a widely held research interest for technology enhanced education. When employed to achieve educational goals, 3D MUVE formulate rich learning environments with 3D support, referred to as 3D Multi User Learning Environments (3D MULE) [1]. 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 [2]. 3D MULE are particularly appropriate for teaching needs due to their alignment with the Kolb's concept of experiential learning [3], and learning through experimentation as a particular form of exploration. Learning in virtual worlds is a dynamic process determined by the user who sets the aims, changes them at will, and the experiences differ from student to student [4].

Although there are many advantages of using 3D MULE for educational requirements over the other non-3D and traditional learner support techniques, the management of 3D MULE can be quite challenging. Most of the widely used 3D virtual worlds for learning activities have been developed with having commercial objectives in mind, and the educational uses came as an afterthought [5]. This introduces the mismatch between the intended educational usages and the 3D MULE support. At the same time, the steep learning curve of 3D virtual worlds [6] can degrade the teacher and student motivation to use 3D MULE sustainably. The students are benefited by having reliable 3D learning environments that support their learning through proper management considerations. Since the teachers and module coordinators can be of multi-disciplinary, an expert knowledge on managing their teaching environments at the system administration level can be an unrealistic option, often. Also, the 3D MULE learning content developers are enormously benefited, if there are agreed and established learning management policies are used. The policy based management of learning activities at the user level is a highly effective mode of practice, which is well-established in education sectors. In this research, we are committed to promote the policy based management to support the teaching and learning in 3D MULE, facilitating all these stakeholders.

For our research on policy based management of 3D MULE, we consider the two popular and widely used 3D MUVE, Second Life [7] and Open Simulator (OpenSim) [6]. A trend towards open 3D MUVE such as OpenSim can be seen, recently [8]. The selected case study environment was developed using OpenSim as the 3D MUVE, Moodle [9] as the e-Learning course management environment and Sloodle [10] as the integrating solution between the former environments, resulting in a complete open source learning solution; This provided the opportunity for a complete case study on an integrated learning environment, as well.

This paper is arranged into following sections: section 2 describes the literature related to 3D MULE and previous experiences on using 3D MUVE for research and learner support. Section 3 presents the selected case study, and section 4 elaborates the policy based management of 3D MULE with the previous work. Section 5 presents the developed user guidance tool, while section 6 discusses the evaluation of the tool using the case study. Finally, the section 7 discusses the future work before concluding.

II. BACKGROUND AND RELATED WORK

A number of successful projects for enhancing education with 3D MULE can be found at present, as extensions to the existing teaching methods. The learning experience could be implemented on other platforms without 3D MUVE support, but then the learner experience would be lost, and users feel contrived [11]. This indicates the benefit of using 3D MULE and its complementary nature of supporting teaching. 3D virtual world supported blended learning environment with e-Learning and traditional methods can significantly support engaging learning while meeting the institutional needs [12]. As highlighted in [12] such integration must include appropriately mapped user role and use case of 3D MUVE to meet the educational needs.

Recent research trends highlight the interest of developing 3D MULE as a mainstream teaching and learner support methodology satisfying institutional and pedagogical needs. However, most of the studies on 3D MULE assume the fact that 3D MUVE implicitly facilitate learning needs. Effective teaching in virtual environments occurs when the teacher is able to align the technology to a deep and continuously tested understanding of the actual students' contextual experiences [13]. Since 3D MUVE are often designed for non-educational needs, fitting these into educational activities can be challenging for the teachers. Therefore, [5] has stressed the need of research for developing instructional and learning management strategies for virtual worlds to achieve the intended educational goals.

A. 3D MULE management and policy considerations

Related studies on managing e-learning environments and 3D MULE emphasise the policy based approaches. In [14], Weippl elaborated the importance of using policies for e-Learning security and management. In his work, a strategy on using roles and use cases of e-learning systems were used. A similar study on 3D MULE management performed in [12] highlighted the necessity of 3D environment supportive policies and user guidance to complement the policy practices of non-3D learning platforms. Use of traditional policies without proper reforms to fit with the new learning environments can create inefficiencies [15]. Thoughtful policies to manage the major areas of the learning environment can keep the learning process running smoothly; policy considerations not only help the teachers but also the students since they make the course management much easier [16]. However, if the users are not provided with suitable guidance, their policy considerations to manage the learning environment can introduce further inefficiencies. System management through policies is complex, and the users must be supported with suitable mechanisms to evaluate and refine their policy decisions [17]. Higher accuracy on effective policy based management was observed in [18] when the users are given user controllable tools for policy learning. More details and related work are presented in section IV.

B. Tool support for learning environment management

In a research on an interactive visualisation tool design for e-learning management, Jyothi [19] emphasised that the visualisation of network interactions in a graphical way assists the moderator or the instructor to understand at a glance, several important concepts without any further investigation or research. In [20], a study on visualisation of user interactions, McGrath argues that visualisation tools embedded in e-Learning systems allow teachers to reveal useful characteristics appropriate to the management of learning activities. Provision of relevant visualisation support to teachers for managing their 3D MULE is therefore, quite essential for a fruitful teaching experience. However, the mere visualisation support in a graphical way cannot effectively support educators; a successful guidance tool should provide interactive operations to manipulate the graphics such as zooming and filtering [21]. The user guidance tool evaluated in this paper indeed supports interactive user visuals with zooming and filtering among other facilities. Moreover, through the Gephi API support [22], it provides advanced statistical analysis on 3D MUVE functions.

C. Related work with 3D MULE

A number of educational tools and learner supporting environments for teaching and research at University of St Andrews have been developed using Second Life and OpenSim. Fig. 1 shows some of the selected educational environments. Teaching Human Computer Interaction (HCI) through various student projects was successful [23]. The Laconia Acropolis Virtual Archaeology (LAVA) [24] project allows students to engage in a simulated archaeological excavation, and then explore a recreation of the site. Wireless Island [25] aids collaborative learning and exploration of wireless traffic through interactive multimedia and simulations. Network Island in OpenSim is developed to facilitate teaching network routing [26]. Research on integrating 3D MUVE with e-Learning infrastructure is conducted [12, 27], which facilitated this research. System and user studies were conducted to evaluate the above projects, and the findings used as preliminary data for this research.

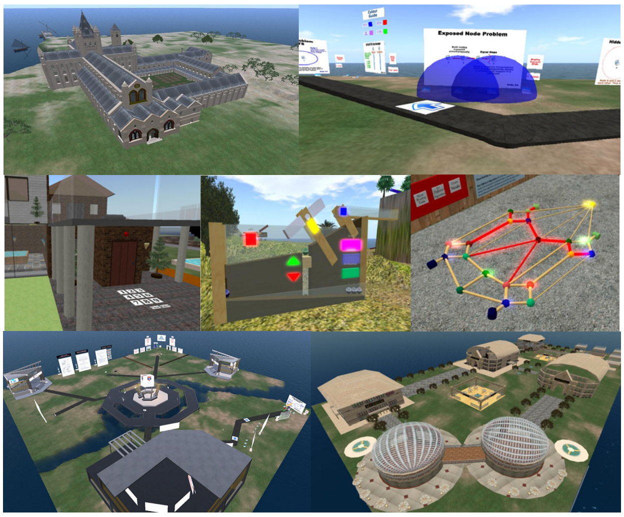

Figure 1. Developed 3D MULE at University of St Andrews

III. THE VHD PROJECT – THE SELECTED CASE STUDY FOR POLICY EVALUATION

To evaluate the developed tool, we incorporated one of our learning support projects, the Virtual Humanitarian Disaster training (VHD) project [28], as the case study. This case study was considered as the first phase of evaluation and the identified improvements and extensions will be used for future development of the user guidance for policy making. Since the case analysis presented later relates with this project extensively, a brief overview on the VHD project would be helpful.

A. Training for Humanitarian Dissaster Management

There are many definitions for a disaster from various global institutions such as International Federation of Red Cross and Red Crescent Societies (IFRC) [29] and United Nations Development Program (UNDP) [30]. A number of studies on disaster management have left the meaning of disaster implicit [31] and intuitive to the context. The VHD project has considered a disaster as a crisis event [28], which is either natural or manmade that affects the inhabitants of the subjected location. Humanitarian aid is the assistance provided in response to a humanitarian crisis. Aids may be logistical, financial, material, counseling, etc. aiming at managing the crisis situation for alleviating human suffering and save lives. Appropriate provision of required training for aid and relief workers can reduce their stress related challenges and preparing them for the demanding situations [32]. The Dept. for International Development UK, humanitarian emergency report [33] highlights that the quality of aid personnel is a major factor in humanitarian disaster response; a major challenge identified in the report is the lack of straightforward professional training channels into humanitarian work.

Field activities on disaster management are challenging and provide instantaneous feedback on the actions, while a sufficient level of theoretical and methodical training facilitate a clearer vision on field activities, explanation, prediction and control abilities to the workers [31]. This indicates the importance of combining the theoretical knowledge and field activities for a successful training design. Available e-Learning and technology supported education tools can be helpful for developing effective training programs for classroom teaching and research on disaster management [34]. However, limited features available in webpages may not provide intuitive user experiences for field work training; compared to 2D web interfaces, 3D MUVE provide more engaging simulated environment with user emersion for learning [12]. Using virtual worlds for training is advantageous as it decreases the training budget, giving the flexibility for training schedule, and improves trainees' motivation [35]. It provides richer interactions whereby face to face communication is replicated more closely than in other mediums and users are allowed to replicate body language and gestures [36]. These broad benefits made the design of the VHD project with the extensive use of dynamism and reusability available in OpenSim 3D MUVE.

B. Project VHD

The Virtual Humanitarian Disaster (VHD) training tool [28] was developed to support students and teachers expecting to create a more flexible teaching and learner support environment in comparison to the traditional classroom methods. The VHD project has been developed as a learning tool for the honours module (SCQF level-10 [37]) MN4266 – Non Governmental Organisations offered by the School of Management, University of St Andrews. The project, in particular, relates with the final thematic area of the module MN4266, i.e., the strategic and operational challenges faced by NGOs operating in the humanitarian relief industry. The key advantage of the tool is that it allows students to take decisions concerning critical situations within the controlled environment of a virtual world where the wrong decisions taken will not have consequences on the lives and property in the real world. The design and implementation of the refugee camp and

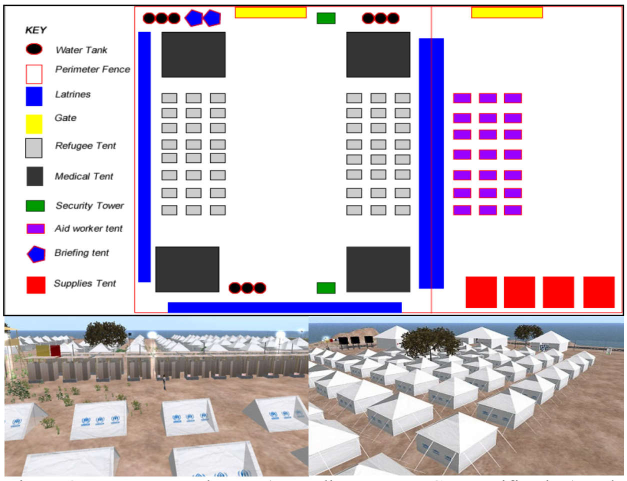

Figure 2. VHD camp layout (according to UNHCR specification) and sectional views of developed 3D MULE

the training area was based on the specific guidelines and standards given by the Office of the United Nations High Commissioner for Refugees (UNHCR) [38]; Fig. 2 shows the VHD camp layout and part of the developed virtual space.

The Moodle e-Learning environment in University of St Andrews is used to associate student identities into the module activities, and Sloodle tools are used to support various learning and assessment tasks in OpenSim and to integrate the Moodle and OpenSim user identities and privileges, seamlessly. Sloodle tools such as Sloodle Choice, Sloodle Presenter, Sloodle Quiz Chair and Sloodle Registration Booth have been deployed in the VHD Island for the learning and assessment requirements. The Sloodle Registration Booth maps the avatar and student identities across the Moodle and OpenSim platforms enabling high level of collaboration. The Sloodle Presenter is used to present learning content and multimedia as scaffoldings for student learning. Sloodle Quiz Chair and Choice tools were used as the assessment tools for the VHD based learner evaluation.

IV. 3D MULE MANAGEMENT

Initial user studies and experiments on 3D MULE as a part of this study, have indicated two main parameters, with statistical significance, for policy considerations: namely, student *self-regulation* and *environment (system) management* [1]. Self-regulatory learning has been widely practiced in traditional and e-learning environments and found in many previous studies, such as [39, 40] and [41]; system environment management has been identified essential for e-learning [14] and 3D MUVE [12] [42] during the previous studies. Therefore, the selection of these two factors has been further validated by the related work. Having identified these two parameters (self-regulation – SR and environment management - EM) as the major aspects of policy considerations, we developed a policy considerations taxonomy to facilitate the 3D MULE management [43], shown in Fig 3.

Taxonomy supported learning environment management has been a popular research interest as it provides the necessary theoretical underpinning. A student engagement taxonomy, including self-regulated interests for 3D game environments was proposed [44]; it provided a valuable basis for this research, although its hierarchical taxonomy does not incorporate the environment management aspect as identified in pervious work. A recent analysis on literature for developing taxonomy for the virtual world based educational uses indicated major areas of usages ranging from autonomous student research to guided teaching [45].

With the support of literature and the previous work four possible scenarios of 3D MULE user engagements were identified. As the Taxonomy in Fig. 3 depicts, EM-Low & SR-Low arrangement does not provide reliable and successful learning activities, according to the scenario characteristics. The other quadrant of EM-Low (SR-High) suggests having small-scale learning activities with high reliance of mutual agreements, although it can highly support the learner. As EM is low, there is a difficulty of enforcing controlling mechanisms to increase the trust and reliability of the learning environment among users and to meet the institutional regulatory requirements. Further if integrated, it can compromise the existing blended learning infrastructure. Learning tasks that require high student autonomy such as postgraduate research and formative assessment tasks might fit into this category.

The two quadrants with EM-High indicate that the 3D MULE can be considered as a part of the institutional blended learning infrastructure, as the required environment management methods are practiced. The policy considerations are expected to achieve EM-High and SR-High state in learning engagements. Even if the SR-High is not attainable, EM-High scenario would help to have formal educational activities at large-scale in an integrated blended learning environment, although, the students might not explore the rich and flexible features of 3D MUVE and may not be committed for achieving ILOs, as they feel constrained against their preferred behaviour. However, EM-High & SR-High is the desired state, which provides higher usability, trust and educational value with cohesive student engagements. Learners with self-regulation are sensitive to the learning environment and possess the ability to follow the best suitable arrangements given by the learning environment without conflicts [46]. This validates our rational of aiming at EM & SR High states through policy considerations and user guidance.

The proposed taxonomy helps to focus on effective user interactions for 3D MULE management; in order to implement effective policy considerations, users have to know the 3D MUVE system behaviour as well. For this purpose, we have proposed a policy framework considering the major categories of 3D MUVE functions [43], and provided a comprehensive guidance tool to facilitate the users; the next section reveals the details of this tool.

V. USER GUIDANCE FOR POLICY CONSIDERATIONS

The steep learning curve causes the management of 3D MULE through policy considerations, a challenging task for teachers, course administrators, and content developers; due to this, students can also experience difficulties during the learning process. The poor awareness on MUVE functions result in significant challenges to the 3D MULE users (teachers, developers, course administrators, and students, in general). In order to overcome this challenge, we developed a guidance tool to support course management staff (teachers, developers and administrative users) in line with our previous findings; similarly, the tool can also be used to train students on 3D MULE, if needed, to facilitate their tasks.

First, we identified the relevant 3D MUVE functions and their classifications for managing 3D MULE. The classifications were based on 5 major functionality areas: Avatar Activity, Group Management, User Management, Content Management and 3D Environment Management [43]. 3D Environment Management was divided into two main sub sections: Near-field Spatial Management and Regional/Estate Management.

An initial attempt was made using word processed documents with tabled functions as a preliminary tool for the user guidance. The 3D MUVE researchers were asked to practice it for their policy considerations, and their feedback was crucial for the tool design. To facilitate the users, we have used dual display apparatus that gives enough screen size for convenient testing. Fig. 4 shows a display screen (two-display setup) snapshot image of a VHD project researcher referring to the guidance document tables while attempting to implement certain policies, in-world (as avatar). Obviously, this practice was a cumbersome experience, although the users (teachers and VHD project researchers) said that they learnt about 3D MUVE functions from that document. However, a major drawback was the inability to portray the functional interactions and the nature of such complex relationships. These users had to refer several sections back and forth to see structure of functions and then interpret the possible interaction on their own; which resulted in many trial and error practices with the VHD environment.

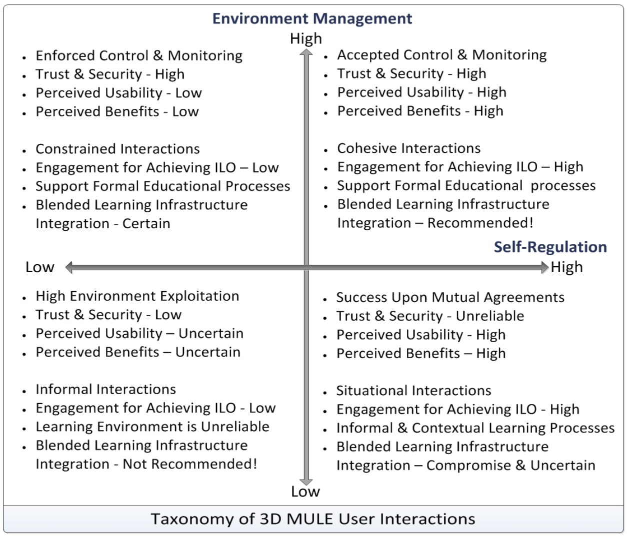

Figure 3. Proposed taxonomy on user interactions for managing 3D MULE

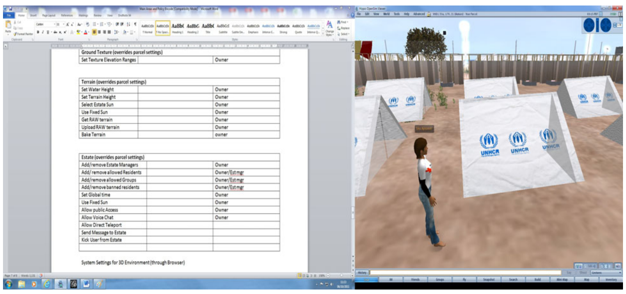

Figure 4. Initial attempts of using function tables as user guidance

A. *3D MUVE Function Interaction Network*

We identified over 200 unique 3D MUVE functions with more than 350 relationships among those functions that can affect learning in 3D MULE. Using this complex information is a challenging task for the teachers, as we have discussed above. To overcome this challenge, we employed a unique approach with Graph analysis. Graphs usually leverage humans to achieve rapid uptake of abstract information through visuals [47]. A directed policy graph (di-graph) G can be defined as G = (V, E), where V is the set of functions (vertices), and E is the set of relationships (edges) between those functions. We use the network analysis and visualisation solution Gephi [version 0.8α] [22], as it aids users to rapidly visualise function interdependencies and statistical analysis of the network. Using the graph description language DOT, we programmatically implemented a complex network of function interrelations; in order to depict the complexity of this network, a scaled down image is shown in Fig 5.

Different colours were used for 3D MUVE function categories (nodes and sub nodes), as defined in the policy framework [43], which enables rapid association of different policy areas with the corresponding functions/function categories. A colour code on edges was used to represent the state of the interaction, namely usual operational interaction (orange), conflicting or overriding interaction (red), and supportive interaction (green). The structural relationships within the function hierarchy are represented as normal (black). The directed graph edges indicate causing function/action (source node) and the result (target node). Different node sizes (large – *major categories*, medium - *sub categories*, and small-*single functions*) are used to highlight the structural significance of the selected functions.

The main advantage of the functional network representation is that users can filter an *ego network* of a considered function with a desired level of depth. Fig. 7, 9 and 11 show such *ego-networks* with different levels of function depths that VHD users used for this case analysis. This facility to select a sub-network based on an ego network of a given function lets the teachers to visualize the functional interrelationships easily and relate that with their policy implementation mechanisms. Furthermore, we have statistically validated the accuracy of graph representation using network analysis models (through Eigenvalues and centrality measures); we found that the proposed functional network is accurate representation of the 3D MUVE functions and their behaviour.

VI. EVALUATION OF THE USER GUIDANCE TOOL FOR POLICY DEVELOPMENT

The following three main scenarios of usage were practiced with the VHD tool to facilitate the student learning on disaster management. Scenario definition was facilitated by the Intended Learning Outcomes (ILOs) of the various levels of course modules, including transferrable skills and constructive alignment with the appropriate Teaching and Learning Tasks (TLAs) and Assessment Tasks (ATs) [48]. Appropriate extensions, considering the future potentials of learning and research use cases, were incorporated for policy considerations per each scenario. By doing that, we expect a thorough and holistic evaluation of the policy guidance tool, even relating the future teaching and learning requirements with the VHD project.

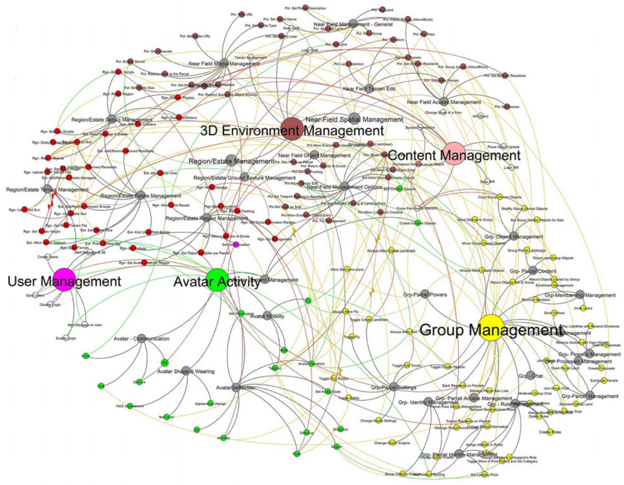

Figure 5. The scaled down (x 0.1) overview image of 3D MUVE function interaction network (to present the functional complexity)

Figure 6. Sloodle tools supported assessment centre for student learning – Sloodle Quiz Chair and Choice tools are used

A. *Scenario 1 – VHD Traning*

This is the primary usage of the VHD environment, in which students are allowed to observe the various constructions in the humanitarian support area and engage in a series of short quizzes as an assessment of the learnt knowledge. The main objective of this arrangement is to provide students a learning aid that helps them to reflect the learnt theories and related knowledge in an interactive and appealing learning environment. Importantly, this scenario does not allow students to experience 3D MUVE tasks such as modifying the environment, content creation or unlimited access. Therefore, the scenario characteristics fit well into the category of High-EM, irrespective of user self-regulation (SR low or high). Students, will be given limited options of interactivity, with guided learning paths in stepwise, as the tasks related with assessments for the course modules are credit bearing.

Moreover, student activities in this scenario are mainly concentrated on the selected Sloodle tools – Sloodle Choice and Sloodle Quiz Chair. The figure 6 shows Sloodle supported student assessment activities. First, the students are guided from one learning location to the next using numbered arrows. In each location, a range of dilemma situations will be presented through Notecards, as shown. Then students are asked to participate in the assessment tasks, in which they have to provide their decisions to address the dilemma and support the refugees while meeting the aid agency objectives. Through the Sloodle interface, the grades and answers are presented at the discretion of the teacher, while updating the Moodle records for data consistency.

The learning activities in this scenario show the basic and typical learning use cases in an e-Learning or similar online learning environment. Therefore, the policy considerations for the 3D MULE management followed a strategy on minimizing 3D environment exploration features as such facility can distract the students from their learning objectives. Few of the selected policy considerations that we have tried with VHD are shown in the Table I. Policy considerations are grouped into the main policy areas defined in the policy framework.

For the implementations of the defined policy considerations, the developed 3D MUVE function network tool was used. Each policy consideration was checked using the tool and possible implementation methods, and functional interactions were identified. The tool support node based *ego-network* selection with a desired depth, to have a clear view on the selected function. As the space permits, we have selected an example policy consideration from the rest to examine the benefits VHD users (teachers, research staff and system developers) had by using our function guide. The colours of the nodes represent different policy areas, and the edge colours indicate the nature of the functional interrelations, as described previously in section 5.

The selected function, Avatar Terraforming (changing 3D virtual land settings) and its inter-functional relationships are shown in Fig. 7. As for the obvious requirements of the learning scenario, the policy considerations indicate that students are not allowed to change the land attributes through terraforming. Here we have considered a set of land editing functions such as Flattening, Raising, Smoothing, Reverting, etc. As the *ego-network* indicates certain functions in parcel and group management intrinsically favour for terraforming (green colour edges). Some of the functions at group and parcel management have toggle switch behaviour, which can be either true or false to terraforming (orange colour edges). It is unavoidable that the learning management settings require having different land parcels and group settings depending on the policy considerations; therefore, to prevent students from terraforming, teachers must use Region level functions to block-therefrom.

B. *Scenario 2 – VHD Simulation and Role-play*

Students and teachers can use the VHD environment as a simulation of a real conflict and disaster environment. Main objective of this arrangement is to facilitate the virtual training of disaster management as a set of field studies. Role-play and appropriate task association for each role can be utilized conveniently if the 3D MUVE functions are properly used.

3D virtual worlds are suitable environments for conducting Role-plays as avatars can demonstrate various types of human characteristics, including communication expressions and gestures [49]. Furthermore, the simulated field studies with 3D MUVE are substantially cost effective while giving a reasonably realistic experience [35]. In relation to conventional forms of education in 'real world', virtual worlds allow participants to experience roles and to do things, which can be difficult or impossible to do in the physical world [4, 50, 51].

Figure 8 shows some of the avatar roles that have been used for the scenario evaluation and test cases. Separate textures were developed for designing suitable clothing for the user roles as a part of the VHD project. Customised clothes and avatar body-parts were developed and

TABLE I.
SET OF POLICY CONSIDERATIONS FOR VHD USE SCENARIO 1

Category	Policy Considerations
Land Mgt.	Students should not terraforming the learning environment
	Students should not be given the land ownership
	Student must retain from accessing restricted areas (if defined for a learning activity)
Avatar Activity Mgt.	Students should engage in the learning tasks for ILOs
	Students should not distract others' learning
	Students should not misbehave in the environment
User Mgt.	User names may be mapped with real identities
	Users should be given appropriate privileges for tasks
	Users may not change their given home locations
Content Mgt.	Students should not alter/move learning content
	Students should not create content objects
	Students should not alter/move the environment content
Group Mgt.	Students should not change settings of their assigned groups
	Students should not change their assigned groups
	Students should not alter group owned objects or land

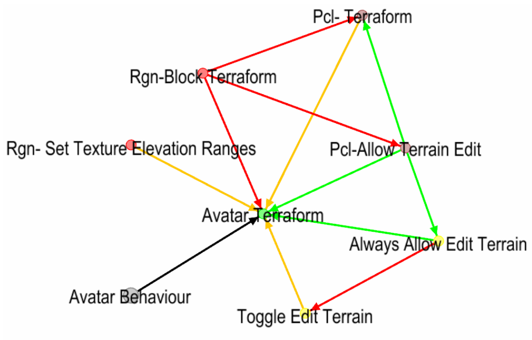

Figure 7. Ego-network of the function avatar terraforming to represent direct interactions between related terrain edit functions

Figure 8. Different roles for the refugee camp role-play scenarios – from left inset; a general female and male refugees, refugee camp official and an aid worker (British Red Cross)

archived so that the role-players can use those through their avatar inventories. We have tested two different approaches to allow students to practice the role-plays: 1) having defined set of accounts for related roles and letting students to use those accounts, temporarily and 2) asking student avatars to load related role inventories and objects (clothes, body shapes, etc.) which transform them to the associated roles. It is important to note that depending on the selected approach, required policy considerations can be substantially different.

The scenario characteristics relate with the EM-High and SR-High configuration of the user interactions. Students in this scenario of use have to follow a highly self-regulated environment interaction as constrained by their assigned role-plays while the VHD training environment follows strict policy considerations to simulate the disaster and humanitarian aiding activities as in the real world (a selected set of policy considerations are shown in Table II).

TABLE II.
SET OF POLICY CONSIDERATIONS FOR VHD USE SCENARIO 2

Category	Policy Considerations
Land Mgt.	Students should not terraform the learning environment
	Students should be placed in the required locations
	Student must retain from accessing restricted areas (if defined for a learning activity)
Avatar Activity Mgt.	Users should retain from flying/teleporting to simulate real mobility
	Students should follow the role-play guidelines
	Students should not misbehave in the environment
User Mgt.	User names can be based on Role-plays
	Users should be given appropriate privileges for Role-plays
	Users may not change their given home locations
Content Mgt.	Students should not alter/move learning content
	Students should not create content objects
	Students should not alter/move the environment content
Group Mgt.	Students should not change settings of their assigned groups
	Students should not change their assigned groups
	Students should not alter group owned objects or land

Similar to the previous scenario analysis, we studied each of the policy considerations, which we identified as important for the scenario needs, using the tool for 3D MUVE functional interactions. For this analysis, we choose a different area of policy considerations – avatar mobility; it is one of the important aspects to consider when the students are asked to follow Role-play to simulate a refugee camp in the real world.

The two avatar mobility activities that have to be controlled for this scenario are the flying and teleportation. It is obvious that in order to experience and intuitively learn about the practical constraints that one could experience during aid working, students must follow the realistic mobility options such as walking, running or crawling. Similarly, they have to follow the dedicated routes such as camp gates, aisles between camp tents, and avoid barbed fences and other barriers. If they are given the opportunity to teleport or fly, they may not intuitively experience the time taken to resolve a dilemma situation that arises in a far corner of the camp and the consequences of their delayed actions due to the physical constraints. They also can learn on the refugee mobility and queuing strategies that they should practice in case of an emergency need.

Fig.9 shows the two ego-networks, representing the avatar actions, teleport and fly, obtained through the 3D MUVE function network tool. Following the same colour encoding as described previously, the ego-networks of each function indicates the related functions or settings that can be used to manipulate the students' teleport between places and flying in the island. Depending on the various 3D MUVE user roles and land ownerships such as estate owner, region owner and parcel owner, avatar mobility can be controlled in the owned land. Precedence will be given to the estate and region over the parcels. Furthermore, the groups in 3D MUVE can affect the policy implementations on their lands. More challengingly, in this role play, depending on the roles practiced students may get the parcel ownership (for roles such as Refugee Camp Officials or Lead Aid Workers on their camp installation parcels) to perform their learning tasks; moreover, they can be associated with a group defined for similar role categories.

For avatar fly control, the teacher or the VHD learning environment administrator has to consider 4 functions that control the user flying and 6 interactions between those. To control avatar teleport and associated settings, we have to consider 7 functions with 13 interactions. And the behaviours of these interactions, as shown in colours, can be supportive or unsupportive for the required control. Moreover, the contextual mapping of the policy consideration and 3D MUVE functionality should be noted. For example, if we are to encourage flying we have to toggle the appropriate set of functional interaction (green links to be true, red links to be false, and orange links as needed) whereas to restrict flying, we have to toggle the selections for each function that we set early.

C. *Scenario 3 – Traning Through Development*

In this scenario of usage, the VHD project intends to facilitate research projects at honours and postgraduate levels (SCQF levels 10 - 12 [37]). The main objective is to let students to use the VHD environment as a platform for evaluating and exploring their creative concepts relevant to the research on disaster management models and methodologies.

The scenario features appropriately fit with the SR-High characteristics (EM-High and EM-Low), since the students engaged in research in the VHD environment must show a higher level of self-regulated learning practice. Unlike the previous two scenarios, depending on the learning task the land parcels can be common and basic sandboxes (without ownership but allowed to create content and build learning constructs) which follows the EM-High type policy considerations. On the other hand, if the learning activities include environment change, land editing and land ownerships at the parcel level, which follows the EM-Low type policy considerations. However, in both instances, students have a narrow margin for misuse the given opportunities, as they should complete their learning tasks with overall responsibility and positive engagement, to obtain the grades. In comparatively, the first scenario differs from this, as the students just complete the quizzes in Sloodle, which then update their Moodle records, and all other activities in-world are not accounted for their grades. Furthermore, this scenario allows the students to explore almost all the benefits of using 3D MULE as a dynamic, engaging and user created learning platform. A selected set of policy considerations for this scenario are shown in Table 3.

It also lets the students the opportunity to create their own scenarios in accordance with environmental, human and financial resource requirements. Thus, in engaging with the VHD tool, students will be encouraged to draw on the knowledge and understanding that they have gained throughout the module and derive benefits, which make this knowledge more real rather than abstract. Figure. 10

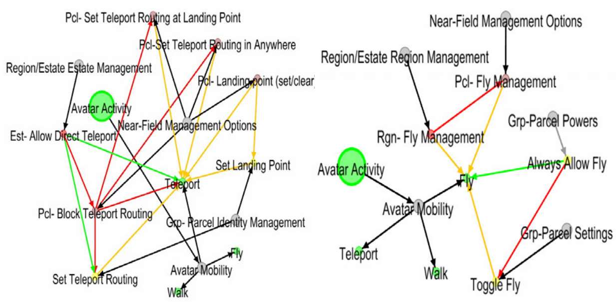

Figure 9. Ego networks of Flying and Teleporting functions for avatar mobility management

TABLE III.
SET OF POLICY CONSIDERATIONS FOR VHD USE SCENARIO 3

Category	Policy Considerations
Land Mgt.	Students may terraform the learning environment
	Students may change their working locations
	Student may change land settings on assigned lands
Avatar Activity Mgt.	Student mobility with no restrictions
	Students should not distract others' learning
	Students should not misbehave in the environment
User Mgt.	User names should map real identities
	Users should be given required role privileges
	Users can change their given home locations
Content Mgt.	Students may alter/move learning content
	Students may create content objects
	Students may alter/move the environment content
Group Mgt.	Students may change settings of their assigned groups
	Students should not change their assigned groups
	Students may alter group owned objects or land

shows an example test case conducted by one of the users (a VHD project researcher), to evaluate the parcel ownerships, various land settings and content creation with the help of the guidance tool. The test case was based on a dilemma situation with a water supply through a natural source (river or lake) and how its geographical location can impact the choices of designing the refugee camp, supply routes and the external influences through the un-fenced pathways. Being close to a natural water source may create more benefits as financially, wealth of refugees, and ease of work for aid workers but the same can introduce more threats for security of tenants and create health risks through waterborne disease epidemics. This is a challenging dilemma that a research student can examine with various solution models through exploratory implementations as test cases with the support of the given virtual space in the 3D MULE. The VHD tool users (teachers and system developers) have followed the various parcel and region level land management settings to test their impact with the assistance of the network tool we have provided.

For a detailed study on this scenario, we selected a more complex and broader policy consideration area as the example to show the significant benefits that 3D MULE practitioners can obtain by using our designed 3D MUVE function network aid. Land settings are a complex and highly interrelated group of functions in 3D MUVE, which users can manipulate for various needs. As per the learning scenario requirements, teachers have to provide land ownership, ideally at the parcel levels to the students with access rights to the land functions.

Fig. 11 shows a section of the ego-network of land parcel management as part of the main policy area Near Field Spatial Management, obtained through the tool. We have specifically selected the ego-network filtration depth at 2 levels to indicate the complexity; in practice, sub-networks and higher level of depths were used for the VHD policy implementations. Following the same colour encoding as described previously, the ego-network indicates the related functions and settings that define a range of activities for students inside their given parcels. Importantly, as the figure indicates land parcels associate 6 major functional areas that facilitate user engagement with the environment. By becoming the owner of a land parcel, a student can explore these functions; depending on the policy consideration, teachers and 3D MULE administrators should decide the level of control over these func-

Figure 10. An example usage of an allocated land parcel with content and land alteration

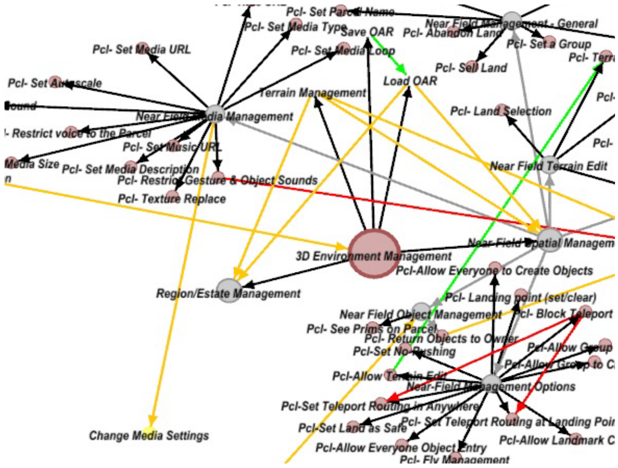

Figure 11. A selection of a complex ego-network for land management

tions. However, if the students are given land parcels with tight controlling at the Estate and Regional levels for their research, such a provision may not facilitate the student learning as expected in the ILOs. Using the 3D MUVE function network tool, teachers can decide appropriate mechanisms for their policy considerations and learning objectives of the TLAs.

Depending on the policy implementation conditions (with parcel ownership or group owned land) VHD environment controllers or teachers can practice controlling mechanisms at the Estate or Regional levels to override or block any unsuitable changes by students to the implemented policy considerations, proactively. Moreover, in this scenario, the VHD users (teachers, system developers and PhD students) suggested that even if the proactive policy mechanisms are not feasible due to the required level of flexibility, reactive strategies, such as restarting the region, disabling scripts, etc. can be quite convenient in an unforeseen event. However, even for such usage, teachers are better off having our tool since they can evaluate the situation and consider their appropriate actions at run time, minimising the impact as the network diagram (including ego-networks) is self-explanatory.

D. *Overview of the Policy Development for VHD*

The VHD project provided multi-faceted benefits for the case study objectives since the intrinsic characteristics of the project incorporated multiple user scenarios for teaching and student support activities, spanning across different policy consideration areas. Because of that, we did not have to explicitly try inappropriate policy considerations for the sake of evaluating our tool. We followed the scenario based policy requirements, making the case scenarios for this study, are as natural as they could be.

The challenge of managing learning activities in 3D MULE by memorising all these settings is overwhelming. In the worst case scenario, with ***m*** number of policy considerations, each associating ***n*** number of 3D MUVE functions, the teacher or the 3D MULE administrator has to consider ***mn(n-1)*** number of functional interactions (where **{*m, n* ε N}**). The implementations of the policies would be very difficult without suitable guidance as the complexity of the arrangement shows polynomial time characteristics.

The observations and the feedback received from the teachers and the developers of the VHD tool indicated a positive and supportive nature of the developed 3D MUVE function network tool as a guidance mechanism for implementing the declared policy considerations. They indicated that with the tool, they could practice their policy implementations with a higher efficiency and certainty, making their tasks more convenient. The students indicated that they could easily practice their tasks with prior knowledge about the activities (especially, in the role-play scenario). Moreover, the developer feedback validated the high usability of our tool, which made it much easier to practice and associate the complex 3D MUVE function interaction topologies with policy implementations intuitively.

In overall, our tool helped the teachers, VHD development staff and system administrators for their work, while promoting engaged student learning. It has also introduced a new benefit by letting the teachers and system administrators to work together on reviewing the defined ILOs and TLAs at the implementation level. This enormously helps to achieve the constructive alignment of learning activities, seamlessly. Moreover, by using the guidance tool, teachers can reflectively associate their learning scenarios and examine the potential impact as a feasibility study, opening up many paths of learning use cases with 3D MULE.

VII. CONCLUSION AND FUTURE WORK

Use of effective policy considerations for 3D MULE management can facilitate teaching and student support as the learning experiences become more reliable. As we have experienced and observed in our previous work with 3D MULE, defining such policy considerations can be a significant factor for the success of learning activities. Moreover, due to the complex behaviour of 3D MUVE functions and their interdependencies, teachers and course management staff may find it more challenging to implement their defined policies in their 3D MULE; such difficulties can hinder the valuable benefits of 3D MUVE to form dynamic and engaging learning environments, which can affect student learning. The developed 3D MUVE function network guidance tool has shown a remarkable success on helping 3D MULE practitioners to define and implement required policy considerations swiftly and without ambiguity. Our observations on the various learning scenarios that associate with the selected case study indicate the value of our tool and the potential it can be extended to facilitate this research, while providing valuable feedback to shape our future work.

As the next phase of this research we expect to develop a virtual island that provides guidance for managing and using 3D MULE. This supportive environment covers all user categories: teachers, course administrators, content developers and students. The network topologies for major policy areas will be included using the developed tool, among other supportive content. The objective is to increase the user awareness of the system behaviour in general to overcome the steep learning curve barrier, while supporting teachers and course administrators to make required policy considerations to manage their 3D MULE with confidence. By doing so, we expect to bridge the policy based formal educational practices that we experience in e-Learning environments with the 3D MULE, resulting in a highly cohesive and manageable blended learning environment with 3D support, for mainstream teaching needs.

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