3D Assistive Technologies and Advantageous Themes for Collaboration and Blended Learning of Users with Disabilities

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ABSTRACT

The significance of newly emergent 3D virtual worlds to different genres of users is currently a controversial subject in deliberation. Users range from education pursuers, business contenders, and social seekers to technology enhancers and many more who comprise both users with normal abilities in physical life and those with different disabilities. This study aims to derive and critically analyze, using grounded theory, advantageous and disadvantageous themes and their sub concepts of providing e-learning through 3D Virtual Learning Environments (VLEs), like Second Life, to disabled users; hence providing evidence that 3DVLEs not only support traditional physical learning, but also offer e-learning opportunities unavailable through 2D VLEs (like moodle, blackboard), and offer learning opportunities unavailable through traditional physical education. Furthermore, to achieve full potential from the above-mentioned derived concepts, architectural and accessibility design requirements of 3D educational facilities proposed by different categories of disabled students to accommodate for their needs, are demonstrated.

INTRODUCTION

The ultimate goal of this research is to analyze factors enhancing disabled students' blended learning experiences comprising of both face-to-face and online courses. The research focuses on the investigation of:

(i) Educational prospects that can help achieve maximum assimilation, achievement and enjoyment from e-learning within 3D Virtual Learning environments such as Second Life,

(ii) Finding the effect of 3D virtual architectural design elements of learning spaces on students and their e-learning experience.

The driver for emphasising on the above areas is recognising the design characteristics of the learning space as one of the vital aspects recognised in affecting students' physical learning. This would hence allow reaching best practices in virtual architectural design of 3D educational building facilities. Subsequently it would most definitely help increase the accessibility of the learning space and make it

more suitable and desirable for the benefit of students and augmenting their e-learning experience within virtual worlds.

This research applies to multiple sectors of disabled students in higher education e.g. large universities (under-graduate and post graduate student), community colleges, adult education and ongoing researchers. This study is also not specific to Second Life but rather general to 3D Virtual worlds in general since the psychological impact of the design of a 3D virtual learning space on its users is universal in any virtual world.

Online 3D Virtual Learning Environments (3D VLEs) have been since their onset a receptor for virtual campuses, built by hundreds of universities such as Harvard, Princeton, and Oxford. Innovation in educational techniques within these virtual existences offer e-learning opportunities for all diversities of students in many fields including science, medicine, engineering, business, law, computer science, humanities and many more (Kay, 2009). Such opportunities include experimentation, teleporting between sites, flying, game-based activities, role-play, modeling and co-creation, immersion, critical incident involvement, medical training and many other practices. This has reaped noticeable participation, satisfaction and hence achievement from students (Calongne, 2008). Through 3D VLE online courses, online avatars allow students and their instructors to interact synchronously by audio, text chat and other media presentation techniques (Butler & White, 2008). It thus becomes imperative to utilize the merits and drawbacks of delivery of e-learning within these environments to encourage blended learning. The appearance of digitally inclined generations of students, some of which are confined due to disability and whose refuge to a more able life is through technology, whom Prensky (2001; 2007), Oblinger and Oblinger (2005) refer to as "Digital Natives, "Games Generation" and "Millenials", deems it rational to anticipate that in order to boost future learning, these students will be encouraged to employ the game-like 3D virtual worlds, or VLEs like Second Life, Active Worlds and others to accommodate for new evolving learning style changes. These changes play a vital role in shaping future e-learning since "Today's students are no longer the people our educational system was designed to teach". This pedagogical transformation is considered beneficial even by researchers like Margaryan and Littlejohn (2008) who argue that students are not using technology effectively to support learning, but rather primarily for recreation.

This research helps demonstrating, by practical grounded theory evidence, the presence of three advantageous themes for using 3D VLEs to deliver education to disabled users:
- Proving that 3D VLEs augment and complement traditional learning techniques in physical classrooms to help reach higher educational achievement.
- Proving that 3D VLEs provide additional opportunities and options for e-learning unavailable within 2D Virtual Learning environments such as moodle and Blackboard.
- Proving that 3D VLEs can, furthermore, not only sustain traditional methods of learning but can offer e-learning prospects that are not probable to achieve using conventional real-life methods of education.

Along with this trend appeared creative opportunities for constructing buildings that cross boundaries of reality and delve into the dominion of creativity of the designer. This is because of the fundamental difference between the physical and virtual worlds where there are no constraints on budgets, no engineering natural forces and material strength limitations, no infrastructure requirements, sound, ventilation regulations or even gravity which can be defied to have 3D virtual buildings floating in midair or immersed under the deepest ocean. Such innovative construction techniques have also been used to erect virtual university campuses in 3D VLES to produce a wide variety of designs from realistic depictions or replicas of physically existing campuses, to completely imaginative embodiments.

However there is no academically conducted research that directly correlates between the new e-learning blended learning techniques sprouting within 3D VLEs, and the design specifications of the 3D virtual spaces within which this e-learning is taking place, and thus whether these design specifications have an

impact on the effectiveness of e-learning in 3D VLEs. One of the factors that have been proven to affect learning in the physical world, the degree of assimilation of knowledge, achievement and enjoyment of students from education, is the architectural design and physical building characteristics of the space in which students learn in which affect accessibility and satisfaction from the space. Such design features include color, texture, dimensions of space, lighting, and ventilation amongst others. On the other hand, sparse study explores the effect of 3D architecture in virtual worlds in general on any genre of users, not just disabled students in 3D VLEs, and their satisfaction and contentment from it. The current research thus focuses, as one of its objectives, on closing this gap by raising the query on and capturing the specific architectural design elements of virtual educational buildings, within 3DVLEs, proposed by students to provide satisfaction and contentment from their e-learning session, hence giving the opportunity to issue recommendations for future learning space enhancement.

Learners are divided into three groups: under-graduate students, post-graduate students, and adult learners and researchers. Data collection techniques include surveys to demonstrate students' perception of the visual qualities of the spaces, preferences and suggestions for a better learning environment. Data analysis focused on in this study involves comparing satisfaction results attained from the identified three groups of learners, subsequently examining the impact that this might have on a student's blended learning experience. Moreover this research can help initiate the development of a framework or recommendations for building codes, for educational facilities within 3D Virtual Environments, to complement existing codes for erecting such facilities in the physical real-life world.

The results of this research disseminate recommendations for possible applications of the technology through the use of a variety of educational scenarios in 3D Virtual Learning Environments. The key contribution is to initiate discussions, trigger debates and offer brainstorming opportunities for students with respect to the use of such assistive technologies in Higher Education. Additionally, this study offers insights in preliminary stages for defining the effect of environmental factors on a disabled student's e-learning experience within 3D Virtual Learning Environments. More specifically the use of 3D VLEs could address issues relating to learning & technology, open educational resources and inclusion.

BACKGROUND
Disabilities in 3D Virtual Environments

According to the U.S. Census Bureau, around 17% of the U.S. population, aged 16 and over, lives with some form of disability. Types of disabilities include visual and auditory disabilities like color blindness, low-vision, and complete or partial-blindness, being hard of hearing or completely deaf. The expression also includes cognitive impairments like Autism, Dyslexia, and ADHD, and also psychiatric conditions. Finally, disability can also comprise motor or dexterity impairments like Cerebral Palsy, Repetitive Strain Injury or even paraplegia and quadriplegia (Epstein, 2008). Moreover, according to the World Health Organization, every 5 minutes for example, a child goes blind. This is just one of many disabilities of children who are going to grow up needing special access to education, employment, entertainment, and social engagement. These needs can be provided through 3D virtual worlds like Second Life (SL) as will be shown later. In fact, current demographics show that people with disabilities represent at least 20% of the users of SL (5% higher than their representation in physical world) and spend much more time in SL than avatars who do not identify themselves as disabled in RL (Information Solutions Group, 2008). Testimonials from different disabled users attribute the reasons behind this phenomenon to the fact that a virtual world is a place where they can feel equal because their disability doesn't hold them back from anything like in "real life". For whether they choose for their avatars to use a wheelchair or to be without disability e.g. in SL, they can mingle with others, walk, fly, dance, socialize, work, visit different places whenever they wish with no restrictions or constrains to one place and without being discerned, alienated, pitied or judged by others who do not know of their disabilities (Stein & Waterstone, 2006). In other

words, virtual worlds like SL give the freedom for users to be however they wish, and to know each other in ways they would not have without SL, hence adding enjoyment to their lives (Black, 2007; Hickey-Moody & Wood, 2008). As one user states, "it is very inspiring to know that when an obstacle, such as being a paraplegic, may happen to one, that you can still make something of yourself and make life better for other handicapped individuals through exploiting potential not judgment of condition" (Information Solutions Group, 2008).

Within this research, grounded theory will be used as a scientific method to provide evidence for the advantages and disadvantages of using 3D virtual learning environments for delivering education for differently abled people. This will be done by deriving themes and their sub-concepts from existing case studies of universities and educational institutions using Second Life for e-learning.

DESIGN OF EDUCATIONAL FACILITIES FOR ACCESSIBILITY IN 3D VIRTUAL ENVIRONMENTS

In the physical world, various design measures are taken to provide appropriate accessibility within buildings for the use of the disabled. For example, the US Disabilities Act ensures that new structures are built so that they are accessible to the disabled. The (UK) DDA - Disabilities Discrimination Act 1995 - also states taking 'reasonable steps' to supply business services or products to disabled persons, including 'online services' (McCullough & Beauchamp, 2009).

How ever do buildings in 3D virtual worlds, e.g. SL, need to adhere to "real life" principles of accessible design?

As Black and Clark stated, "The "biophysics" of SL are clearly designed in part to surpass the universal human impairments of our physical embodiment" (Black, 2007). This means that people with certain disabilities in the physical world might be without disabilities in the virtual world, or maybe their real life disability causes them no impediment in SL e.g. people with lower body physical mobility problems face no problems dealing with the virtual world using their upper limbs. However people with arm, hand or finger control problems might be able to walk in real life, might find difficulty using keyboard, mouse or navigating in the virtual world and might therefore need features like wide ramps or corridors "in-world" to manipulate their avatar across. The same applies to people who might have specific digital visual impairment only and thus might need certain colors in the background or building textures or fonts (Krueger, Ludwig & Ludwig 2009). Other disabled users, while not suffering from any difficulty inside a virtual world, might feel more comfortable if certain accessibility elements appear "in-world" analogous to what they are used to in the physical world. Also the nature of the 3D digitalized world might exacerbate or improve other aspects of accessibility for the disabled. These aspects need to be investigated as they might change the architectural and accessibility requirements for designing educational learning spaces in 3D VLEs for the disabled.

As mentioned previously, there are endless possibilities for creativity in building in SL and similar virtual worlds. This innovation also includes designing educational facilities and campuses. However there are currently no existing specifications or design codes especially created for building in virtual worlds, analogous to those present in the physical world, that can be used as guidelines for designing 3D virtual educational facilities or even general constructions in 3D VLEs. There is also no research conducted up-to-date depicting students' needs and preferences from design elements of their learning space to enhance their e-learning experience. Even though no avatar in Second Life is actually physically disabled, creating specification guidelines with universal design principles for disabilities in mind has several benefits: i) It ensures a baseline modality. ii) If buildings are designed to accommodate users with challenges, the

overall experience will be improved for all users. iii) Virtual environments should be built to consider best practices in interface usability as acknowledgement of respect for others (Smith, 2009).

Currently educational campuses, buildings and learning spaces in 3D VLEs are being designed using one of three approaches:

i)   On an ad-hoc basis according to the designer's preferences or best practice experience (with no consideration to specific educational or accessibility needs of students in virtual world buildings).

ii)   As a blind replica of an existing building in real-life (maybe of the same university e.g. Harvard University – Austin Hall Berkman)

iii)   Using universal "real-life" documented design codes for constructing similar buildings physically (e.g. Universal Design (UD), developed at North Carolina State University) (Krueger et al., 2009). E.g. in Virtual Ability island in SL spiral stairs, grass, sand, and deep carpet textures for the ground are avoided because they are difficult to move a wheelchair across, while smoothly leveled and landscaped walkways, ramps with rails and bright high-contrast signs are used by users with visual impairments with beige textured background and tilted downward at roughly 15 degrees from eye level to be at eye level of users with wheel chairs (Zielke, Roome, & Krueger 2009).

However, all three approaches for building, mentioned above, do not guarantee satisfaction of students from the design of their learning spaces since there might be additional factors affecting them during e-learning sessions in 3D VLEs that are different to those in the physical world. Regarding students with disabilities, this issue is further aggravated by the fact that the design of the virtual buildings might also need to cater for accessibility issues for different disabilities. Hence arises the need to uncover the effect of different 3D virtual architectural design elements of the learning space on students' assimilation, participation and enjoyment in general and disabled students in particular.

This research delves into capturing architectural and environmental design elements proposed by disabled students from different categories (under graduates, post-graduates, adult learners and researchers) in order to accommodate for and provide accessibility improvements in 3D educational spaces, so as to achieve the advantageous themes and sub-concepts of delivering education in 3D VLEs derived henceforth, and subsequently enhance their e-learning experience.

THEMES AND SUB-CONCEPTS OF DELIVERING EDUCATION IN 3D VIRTUAL LEARNING ENVIRONMENTS

Method

The primary concept of Grounded Theory established by Glaser and Strauss (1967) designates that research, starting with no preset hypothesis or theory, can eventually generate one by examining primary data sources, whether from qualitative empirical data, existing literature or any kind of data (Glaser, 2001; 2002), where the unit of analysis is an incident. From many incidents, a chain of key points can be mined which are then tagged with "codes". These in turn are grouped into "concepts", and from related concepts emerge main "categories" (or themes) (Glaser, 1992). Within this study, our raw source of data (or incidents) was documented literature representing case studies of Second Life colonization or usage by a multitude of educational institutions for e-learning in its diverse types. Key points, each signifying a possible advantage or disadvantage for delivering e-learning in VLEs, were deduced from each documented incident and clustered into three main groups of codes:

1- Those supporting traditional physical education,
2- Those unavailable in and adding to capabilities of 2D virtual learning environments (2D VLEs), and
3- Those unavailable in physical classroom learning.

Components of each code group were then named as 70 concepts, which were in turn grouped into 16 advantageous and disadvantageous categories (themes). A final general hypothesis was devised as a result of the emerging categories (themes). Whilst the low level individually mined key points are not included in this research, following is a description of each theme and its sub concepts, formulated from the key points, showing the division of these concepts into the 3 coding clusters mentioned above.

ADVANTAGEOUS THEMES AND SUB-CONCEPTS OF LEARNING IN 3D VLES

The following fifteen categories, summarized in Figure 1 and 2 below, are high level advantageous themes of delivering e-learning within 3D VLEs for users with disabilities. Underneath each of them is their sub-concepts derived used grounded theory divided into three categories:

  i)   As supplement to real life education
  ii) As benefit over 2D virtual learning environments
  iii) As benefit over real life learning

The circles in the figures represent the educational institutions in real life that employ these themes and concepts in Second Life, as follows:

1) Massachusetts Institute of Technology
2)Trinity University San Antonio
3) Johnson & Wales University
4) Bradley University
5) University of Kansas
6) Colorado Technical University
7) Texas A & M University
8) University of Florida
9) University of Colorado

10) Hong Kong Polytechnic University
11) Virtual Ability Island
12) Harvard University Law School
13) Oxford University
14) Edinburgh University
15) University of Houston
16) University of London
17) Kingston University
18) University of Texas

Figure 1. Advantageous themes and sub-concepts of using Virtual Worlds to deliver learning for disabled students

Figure 2. Advantageous & Disadvantageous themes and sub-concepts of using Virtual Worlds to deliver learning for disabled students

Disability Support

Second Life as an example of virtual worlds has taken many considerations into account to reduce accessibility problems for differently challenged users to be able to use the environment easily, offering at the same time therapeutic and educational solutions that are both beneficial over real life learning and 2D virtual learning environments as follows.

Concepts as benefit over 2D VLEs & real life education
▪ *Autism Management:* audio visual pseudo-immersive stimulus inside virtual worlds could provide a potential communications pathway for both those suffering from autism as well as those close to ones suffering from autism to be able to interact with them (Talamasca, 2009).

- *Visual Impairment Management:* a user interface suitable for usage of blind students in virtual worlds is "Accessible Rich Internet Application" (ARIA) which gives the ability to participate in many virtual world activities. It provides basic navigation, communication, and perception functions using GUI (graphical user interface) elements that are familiar to blind computer users. In Second Life, other accessibility scripting groups also devised "inworld" tools for these special users like scripted canes and guide dogs that can help navigation inside the virtual world by voice or text commands (IBM, 2008). People who are blind tend to assume sequential, route-based strategies for moving around the physical world. Virtual worlds provide great opportunity for allowing people who are blind to explore new spaces, reducing their reliance on guides, and aiding development of more proficient spatial maps and strategies. This is because when exploring virtual spaces, people who are blind use more and different strategies than when exploring real physical spaces, and thus develop accurate spatial illustrations of them (White, Fitzpatrick & McAllister 2008).
- *Hearing Impairment Management:* consideration is made for people with hearing impairment. When presentations are conducted in voice, they can be simultaneously transcribed into print (voice-to-text or V2T) to aid those with hearing disabilities. Sound signals, such as for starting a race, can also be given in a simultaneous visual manner (Joseph, 2007).
- *Mobility Impairment Management:* Scientists in Japan have created a small helmet that enables the wearer to animate a 3D avatar in Second Life so it will perform basic movements just through thought impulses. Future plans will allow avatars to execute more complex movements and gestures, with the ultimate goal of enabling students (with severe paralysis, who are often too depressed to undergo rehabilitation) to communicate and do future business in virtual worlds as readily as fully able people. This device can help all students with upper limb disabilities who have problems with typing e.g. only one hand, one finger, or toes they can control to type. Voice recognition software can also be used to control the computer and overcome these challenges inside virtual worlds (Vivian, 2007).
- *Career Management:* Virtual worlds as a form of improved reality, allows surpassing users' physiological or cognitive challenges. Differently abled students sometimes suffer from discrimination in real life and are forced to drop out of courses which are unable to compromise with certain disabilities. Furthermore many job fields overlook hiring graduates with disabilities for misconception that they are unable to function with their conditions. However there are proven cases of Second life users for example who were able to run whole companies from inside SL, work in consultancy, take up photography etc.

  An example of this is a quadriplegic student who set up an exhibition for his art work inside SL at the building that Illinois-based Bradley University have established on Information Island (Cassidy, 2007). Virtual world employment fairs for graduates are also an added asset e.g. those conducted by major organizations like IBM. Another example is an online company, Coraworks, which has currently employed upto 200 graduates with disabilities in jobs ranging from data entry to computer programming to architectural design, and many other computerized jobs (Carey, 2008).

Involvement

In the context of this research, involvement can be defined as student participation, interaction and contribution during a 3D VLE e-learning session. This can be seen noticeably in 3D VLEs, encompassing the ensuing concepts grouped according to the following classification codes.

Concepts as supplement to real life education
- *Active student roles:* New roles surface as disabled students move from the physical campus or online discussion boards to the virtual world classroom. Learning generally centers on discovery, yet students may feel that they are space confined with a restricted view of their role in the physical classroom. Shifting students from passive roles of survivors and castaways in real-life to the active roles of researchers can be done in 3DVLEs (Calongne, 2008).

Concepts as benefit over 2D VLEs

- ***Object ownership:*** The capability to buy or freely acquire personalized accessories, buildings, contraptions etc. in each user's individual "in-world" inventory, gives a feeling of belonging and true existence adding to the allegiance to the virtual world and motivation to return back again and resume activity within the environment (Robbins, 2007).

  The Second Life (SL) Design Competition organized by Massachusetts Institute of Technology required from each student to design and create his own space for learning and residence, so as to interact and connect with others, is an example of imposing active student roles and object ownership (Nesson, 2007). This can be achieved without requiring much previous knowledge of how to build and create.

- ***Embodiment and sense of belonging:*** The personification of the disabled user in the form of an avatar and the ability to revamp its shape, skin and style, can convert the sentiment of the disabled user towards the space of a virtual world into a sense of belonging to a place (Joseph, 2007).

- ***Sense of presence:*** The ability to communicate, add face gestures and body movements to the avatar, adds to the sense of presence within the scene (Robbins, 2007).

  For example, media students at Trinity University San Antonio employ promotional campaigns in SL by exploiting these avatar functionalities to advertise (Michels, 2008).

Activities

Positive actions and behavior undertaken by students in 3D virtual environments can be categorized into the following concepts.

As supplement to real life education

- ***Experimentation:*** The virtual world opens up opportunities for disabled students that the physical world does not offer, e.g. experimentation with simulated real life difficult science experiments like fertilization, space phenomena, studying minute biological entities or chemical reactions enlarged.

- ***Exploration:*** This also includes exploring new ideas that might be impossible or too dangerous to approach in reality like nuclear explosions (Joseph, 2007).

  Johnson & Wales University demonstrates these concepts through BLAST, a scientific ballooning project committed to understanding the origins of the universe. Students work with practicing scientists to translate the complexity of scientific ballooning into SL. They design, build, and operate the balloons (Mason, 2007).

Existence

The nature of presence as a user in 3D VLEs differs entirely from real life, enriching the e-learning process via the following concept.

As benefit over Real life Learning

- ***Distributed/ co-present existence:*** 3D VLEs enable submergence within them. This is due to the fact that they are spaces populated by users, who are themselves both distributed (their physical bodies are spread out all over the world) and co-present (their avatars are in the same space) (Thomas & Brown, 2009).

Communication

Contact methods during e-learning sessions between disabled students and students in general, and transportation between locations, are innovative techniques for delivering education within 3DVLEs, characterized by the consequent concepts coded as follows.

Concepts as supplement to real life education

- ***Alternative communication support:*** There are also benefits from using alternative communication support for 3D VLEs via voice in the virtual world, voice over IP, or by means of a conferencing tool (Dickey, 2005).
- ***Ease of guest lecturing:*** Guest speakers can also be invited in to attend lectures, seminars or conferences without their actual physical presence (Kujawski, 2007).

Concepts as benefit over Real life Learning

- ***Public and private messaging:*** Students with disabilities can communicate via text if they have hearing impairments or voice if they have visual or upper limb motor impairment that prevents them from writing. Using text communication they can ask confidentially whenever they please, without interrupting others, by corresponding with classmates or teacher via private messaging channels, thus overcoming shyness (Calongne, 2008). This is essential in interactive courses such as that conducted by Bradley University to coach its students in the qualitative research methodology field (SimTeach, 2009).
- ***Teleporting*** can be done in seconds between different 3D sites, whether replicas of existing places and countries or representations of historical simulations e.g. "Paris 1900" in SL (Joseph, 2007). This is extremely important for students with disabilities in the "real-life" who are often confined to their place due to their disability and unable to travel, venture or experience different places in the world whether touristic or scientific or even to attend meetings, exams, conferences, perform jobs in remote areas etc. A successful example introduced by Johnson and Wales University was creating "virtual Morocco" to provide an immersive experience that educates about Moroccan culture while enticing students to teleport to it, develop technical prototypes on an unfamiliar platform like SL, and communicate with partners on another continent and across language barriers (Mason, 2007).

Educational Aids

Additional methods and objects are available within 3D VLEs to assist delivery of e-learning for students with challenges, including the ensuing concepts grouped as follows.

Concepts as supplement to real life education

- ***Ease of snapshots:*** the simplicity of recording pictures/ snapshots within e.g. SL allows for future reference to events in lectures and workshops etc. (Rickenbacker, 2009). For example University of Kansas hosted its first online International Media festival in SL featuring works by art students around the globe, with live interactive lectures. These events required extensive imagery recording as a form of documentation (Lombardi & McCahill, 2004).

Concepts as benefit over 2D VLES

- ***Cheap file upload*** is also available for presentations, images etc. only requiring inexpensive payment per file for usage within a 3D VLE (Burton, 2006).
- ***Streaming music*** can also be used by instructors during live lectures unlike in 2D VLEs (Burton, 2006).
- ***Presentations on 3D objects:*** Furthermore presentation images and streaming videos can be placed on cubical objects and presented to students in a more interesting manner than 2D environments (Burton, 2006). Professors from Texas A & M University upload photographs, students' work, streaming video, written projects and presentations to conduct Second Life classes, provide tutorials, assign projects and achieve research related to digital visual culture (Kujawski, 2007), e.g. Oxford University's virtual First World War Poetry Digital Archive inside SL dedicated to honoring classical works and poems connected to this era, including audio and video interactive tools and tutorials for students (Elen, 2009).

- **_Sandboxes to practice building_** are used freely by students and instructors in 3D VLEs like Second Life (Joseph, 2007). Students from Colorado Technical University learn basic virtual world building and texturing skills, develop user-interface prototypes, design usability experiments, and conduct usability evaluations with the help of sandboxes in Second Life. The virtual world classroom becomes an open space version of a usability lab (Calongne, 2008).
- **_Supporting all learning styles:_** Some people learn best by listening to course content, others by seeing and visualizing, and some using a hands-on approach. In case of students with disabilities more than one learning style may be required to best convey educational concepts and material. In 3D VLEs, a mix of content and activity supports all learning styles: auditory, visual, and kinesthetic (Kujawski, 2007).
- **_3D learning stations and objects:_** Learning stations "in-world" can be designed to provide content to students who are absent or who need extra time to study and reflect. Students with disabilities can take note cards easily by touching 3D objects, listen to podcasts, or watch streaming video covering lesson material without leaving the vicinity of their home or risking undesirable contact or conflict with others. Although this ability is also obtainable in online course management systems and websites (2D VLEs), the shared nature of an avatar interacting with an object and seeing 3D simulations of the content come to life, is more powerful (Calongne, 2008).
  This is exemplified in stations offered by Texas A&M University for students to receive assignments written on note cards along paths on the SL campus (Michels, 2008).

Concepts as benefit over real life learning
- **_Session message logs:_** Instant communication messages can be saved as logs for future reference of lectures (Calongne, 2008).
- **_Online assignment submission:_** Students can also submit assignments in the form of note cards easily to teacher by dropping it over his avatar or profile (Burton, 2006).
- **_Program execution in linden language:_** Submission of a program assignment can be done in SL Linden scripting language (LSL) to see the program run directly in the environment and working. The advantage is that LSL is easy to learn for its similarity to Java and other programming languages like C# (Icaza, 2008).
  Students from University of Florida, for example, created programs represented in 3D using scripting languages like LSL, Java, Python and Lisp (Mason, 2007).
- **_3D architectural assignments_** can moreover be submitted in a virtual environment as 3D models that can be rotated around or entered inside. Students can create any structure, using built-in tools to construct their ideas as a form of virtual sketching. These 3D objects and models help students express ideas and offer a context for discussion during class projects (Calongne, 2008). Architecture students from University of Colorado are an example of utilizing SL to design buildings (Michels, 2008).
- **_Engagement in real world issues_** is another experience, undergone by students from University of South Australia. Interacting with their experimental clients through SL provides insight into the real world through virtual work encounters i.e. by experiential learning (Wood, 2009). Furthermore Texas A&M University engages students in SL with significant questions about real-life and virtual associations (Michels, 2008).

Interaction
Additionally, different types of networking options between disabled users are offered in 3DVLEs, characterized by the following concepts.

As supplement to real life education
- **Social spaces** existing within 3D VLEs provide successful shared communities. These are also **cultural spaces** opening up opportunities to truly engage and communicate with others to learn about different customs, behaviors and ethnicities (Joseph, 2007). This is an option not readily available for students whose disabilities hamper their movement, make them too withdrawn from facing real society, give them difficulties in talking or communicating, or sometimes whose disabilities might be intimidating in real life for others to encourage them to correspond with them. In SL and other virtual worlds all of these inhibitions disappear by communication through avatars.

  Hong Kong Polytechnic University uses SL to help 1st year students get acquainted with university life and adjust to the transition from high school, offering a variety of interpersonal, learning and self-management ideas to help excel in their undergraduate life (SimTeach, 2009).

As benefit over real life learning
- **Networks of distant users** can be created for the sharing of skills and knowledge through blogs, wikis and knowledge repositories that can be opened within a 3D VLE window during active e-learning sessions (Butler & White, 2008).
- **Network evolution and Future group work:** Any network within a 3D VLE can develop and increase in size with time to include people from many backgrounds or collaborative universities (Butler & White, 2008). An example of this is the launch of Virtual Ability Island, an environment in Second Life created by the Alliance Library System (ALS) and Virtual Ability, Inc. (VAI) to help residents with disabilities find fellowship, training and education (Smith, 2009).
- **Instructor practical role shift:** In virtual worlds, the instructor's role shifts from being the "sage on the stage" to being the domain specialist or facilitator who motivates and manages discovery while providing organization, guidance, feedback, and assessment without being the main focus of the session (Calongne, 2008).

  A successful implementation at Harvard University (Law School) involved building a court room in SL for students to practice their advocacy skills, but without the intimidation from similar real-life spaces. Under the supervision of their professors, simulations of trials were conducted on Berkman Island in SL. Weekly office hours were also held on SL to discuss material and homework with teachers, or simply socialize with classmates & faculty (Nesson, 2007; Shepherd, 2007).

Security
User identity protection and account safety are vital issues within 3D VLEs, as demonstrated by the following concepts.

As supplement to real life education
- **Anonymity safety**: The sense of safety through anonymity of a user's identity can encourage students to experiment in ways not possible offline (Joseph, 2007). This is especially useful for disabled users who are unable to do certain activities in the physical world due to their disabilities e.g. dancing, rock climbing etc. without uncovering their true identity in "real-life".
- **Username & password**: Requirement of access permissions is similar in 2D and 3D VLEs – both environments necessitate authorization of the participant in the form of a user name and password. Furthermore each educational institution can restrict usage of its premises within a 3D VLE to only specified lists of students thus ensuring security (Robbins, 2007).
- **Free registration** to 3D VLEs is available for normal users e.g. students. Premium (paid) access is only for organizations like universities to purchase lands and build their personalized virtual campuses (Butler & White, 2008).

2. Output

The degree of productivity of courses within 3D VLEs can be assessed through the following concepts.

As benefit over 2D Virtual Learning Environments
- *Immediate instructor feedback* within the synchronous class experience in a 3D VLE allows for engaging interaction and expression while drafting ideas and conducting activities (Calongne, 2008).
- *Early assessment of course* can be performed by students since the learning process and measurement instruments are observable. This allows immediate in-course enhancement and spending less time in critically assessing a course after it ends (Calongne, 2008), e.g. The Management School at Edinburgh University UK, relies heavily on instructor feedback and assessment issues for its MBA courses delivered in SL (Nesson, 2007).

Psychological Support

Moral and psychological support provided for both students with disabilities and the people in close contact with them is an important aspect of consideration in virtual worlds. It is manifested in the following concepts.

Concepts as benefit over 2D VLEs & real life education
- *Parental Advice:* "Contact a Family" is a charitable organization that has an existence in Second Life and is dedicated to helping parents of disabled children access services that can help them deal with their children's disabilities and educate them. Parents are given a lot of useful information at any time of the day, and share experiences with others in similar situations thus providing moral support and exchange of ideas. This is vital for parents who do not have the luxury of leaving the house to attend such events in real life due to supervision of their disabled children (Parker, 2008).
- *Emotional support* is one of the major advantages of immersion inside virtual worlds by disabled students and users in general. An enhanced sense of community, equal environment, disclosure, an outlet for creativity, constructive use of time working with various entities within SL and even just having 24/7 contacts is an extreme moral boost for those who are unable to achieve that in the physical world. It can be considered a form of medical treatment (Yifenghu, 2010; Later & Milena, 2009).
- *Pain Management:* virtual environments are also a good pain management tool. It helps people with disabilities not to "escape into fantasy", but rather "escape from persecution." Therefore by creating a meditative state through focusing on an activity in a virtual world like SL, this can help ease the pain of the disabled user (Epstein, 2008).

Educational Strategies

3D learning environments can provide innovative instructional techniques, methods or archetypes for learning facilitation (Scopes & Lesley, 2009) including:

Concepts as benefit over 2D VLEs
- *Classroom emulation* allows for re-creation of the physical classroom environment within the 3D world. The advantage of this method is achieving familiarity with the virtual space because of its analogy with the real-life space. This provides disabled students with a sense of connection through the classroom representation (Scopes & Lesley, 2009), as can be observed by the immersion experience of Texas A&M University in SL, teaching reading competency in reality depicted learning spaces (Michels, 2008). Accessibility elements of design can also be added to the classrooms to add to the sense of comfort and familiarity of the learning space to the disabled students, even though their avatars may not be disabled or need the accessibility elements in the virtual world.

- ***Game based learning - treasure, scavenger hunts:*** With little time and a lot of content to cover, one way to realize effective learning is to use game-based techniques to pique students' interest especially with the resemblance in appearance of 3D VLEs with game settings (Calongne, 2008). Examples of such game metaphors are treasure or scavenger hunts which provide opportunities to explore areas. This could e.g. be used to orient students with how a campus is laid out (Scopes & Lesley, 2009). A software design class from Colorado Technical University, for example, created a 3D game maze and populated it with traps, sensors, flags, a scoreboard, treasures, and other game features, then played the game on the last night of class as a form of testing. These students were so immersed in the learning experience they didn't realize they had accomplished goals of several classes in a single term (Calongne, 2008). This movement-based activity for example would be impossible for students with mobility disabilities to join in "real life".

- ***Role play:*** enacting or assuming an alternate character to oneself is a widely employed learning technique which can also occur virtually within a 3D VLE. This virtuality might remove some of the traditional hindrances and obstacles of performing face-to-face role plays especially with the presence of disabilities, e.g. it's easier to dress the avatar in a variety of clothes, be placed in the right imaginary situation, be given the right tools and not be shy to participate. This enhances learning because students are encouraged to use all their skills and abilities to impersonate the role play presented to them (Scopes & Lesley, 2009). One example of class role-play represents literature activity in which students enact the courtroom scene from John Steinbeck's Of Mice and Men, to benefit from this social learning environment (Calongne, 2008).

- ***Guided Tours*** are used to show learners in a 3D synchronous environment the location of items and features within an area. A tour can be led by the instructor or it could be a pre-programmed item the avatar carries with him that takes him on a virtual "guided tour" without the need for a live person. E.g. a tour of countries or historical buildings or battle fields or forts or a tour inside a blood capillary or volcano where the learners appear to be diminished to a tiny size to experience areas they could not otherwise travel to (Scopes & Lesley, 2009), like project "Virtual Morocco" created by Johnson and Wales University described earlier (Mason, 2007).

- ***Conceptual Orienting:*** learning to create plans, e.g. for business. This entails providing the student with examples and non-examples of a concept and then allowing him to determine the attributes that do and do not apply to the concept. The procedure of side-by-side contrast allows a student to identify and apply concepts in a multitude of environments and do a mental comparison through the capability of instantaneously moving from one site to another (Scopes & Lesley, 2009). As an example, University of Houston architecture students build business plans in the SL virtual world and subject their models to the forces of SL's free market (Michels, 2008).

- ***Operational Application:*** This is "learning by doing" in the virtual environment. Students must follow the regulations and constraints of the physical world to achieve a goal. The facilitator monitors the students and then makes remarks or recommendations. This could be fixing a piece of equipment, trouble shooting a computer network, performing a virtual experiment or repairing a car (Scopes & Lesley, 2009). This can be extremely helpful for hand-on training for students with disabilities who are unable to achieve similar training physically.

- ***Joint Co-Creation:*** This is when more than one person collaboratively craft items within the 3D world. This procedure teaches teamwork, cooperation and sheds light on benefits and pitfalls of group work (Scopes & Lesley, 2009). This is again vital for disabled users who due to disability might not be able to change location in order to engage in group or team work.
  An innovative group work approach adopted by St George's, University of London and Kingston University was presenting paramedic students with critical patient emergency scenarios on the streets "inworld". The students then have to collaborate in synchronous teams taking rapid decisions to check a dummy avatar's vital signs e.g. pulse, and apply preliminary treatment e.g. dressing wounds, oxygen masks, administering drugs, setting GPS in ambulance etc. Their submitted reports in virtual hospital are then mailed to their real-life instructor. This educational approach solves the problem of

rarity of critical cases in reality to practice on, and relieves stress from risk of trying out incorrect remedial techniques in reality (Online Nursing, 2008).

- **_Critical Incident involvement:_** students are positioned into an environment or dilemma comparable to the real situation, where they have to use their previous knowledge to resolve a problem. For example a student can be placed into the heart of a disaster like the aftermath of a hurricane, earthquake, car accident or into a blazing building (Scopes & Lesley, 2009) which is a situation not possible to create in "real life" for students with disabilities.

Concepts as benefit over real life learning:

- **_Practical training:_** Students get the chance to be given real life situations to train at within a 3D VLE allows them to brainstorm together (Online Nursing, 2008).
  University of Kansas teaches medical and nurse training in Second Life, including how to deal with different equipment, studying anatomy of patients and attaching different devices to them. Moreover, physical therapy and occupational therapy students use Second Life to evaluate handicap hazards in virtual homes, recommend improvements and apply changes. The simulation records all steps of the process, which are then sent to the instructor (Skiba, 2007).

Performance

Speed, efficiency, quality of technical connectivity and delivery issues online while using 3D VLEs for e-learning are evident through the presence of the following concepts as a supplement to delivering real life Education.

As benefit over Real life Learning

- **_Faster MONO virtual machine:_** on August 29, 2008, the entire production grid of SL was updated to being able to use the Mono Virtual Machine (VM). The LSL scripting language remains, but executing on the Mono VM gives up to 220 times speed increase, reduced lag and improved stability (Icaza, 2008).
- **_Dot-net languages' support:_** An additional benefit is that any dot-net language that compiles to the Mono VM can be uploaded to execute in SL. This will enable any program of a student to be seen working immediately by an instructor on submission (Icaza, 2008).

Setting

The importance of the surrounding environmental arrangement and background settings of the spaces, where educational sessions are held within 3D VLEs, constitutes the following concepts as benefit over real-life physical learning conditions.

As benefit over Real life Learning

- **_Untraditional class settings,_** including non confinement to having chairs facing forwards, helps revolutionize to capture students' attention by moving freely within the learning environment, putting chairs or sitting in any position without affecting the view (Dickey, 2005). Examples of untraditional classrooms are on display within the Art Department at the University of Kansas featuring a lecture hall, open air studios, a film production area and an interactive gallery of sculpture, animation, game creation and performance arts (Lawrence, 2009).
- **_Easy class management_** can be attained, for few problems can arise from noisy interruptions of students. This is because communication is either text-based, or even with audio transmissions only one person can talk on the system at a time. Instructors can also block or remove inappropriately behaving students (Burton, 2006).

Perspective

The viewpoint and angles of perception of a user within a virtual 3D space are essential factors signified by the consequent concepts encoded as follows.

As benefit over 2D Virtual Learning Environments

- *Customization and conceptual imagination of avatar:* As mentioned before, alteration of the personal representative avatar in the virtual world allows for the user's identification with it. Conceptual blending also provides further insight into the role of imagination e.g. using talking animal avatars. One can change his or her gender, race, and even species (Joseph, 2007).
  Students from Colorado Technical University commented that "the sense of presence and customization of avatars are high on the list of priorities for learning and participating in virtual world classes", despite the fact that it took time for them to modify their avatars and to master communication, expressing emotion and gesturing (Calongne,2008).
- *Virtual reality versus virtual world view:* The option of changing between virtual reality view (in 1st person by looking through the eyes of the avatar within the environment) or as a virtual world view (in 3rd person by watching the avatar move) can change the feeling of immersion in the environment giving a more dynamic perspective for the student during an e-learning session (Dickey, 2005).
- *Adjusting cameras and lighting:* This can be done by adjusting cameras/ lighting etc within the 3D environment to change the angle of perception of the real user within the 3D VLE despite the position and direction of the avatar (Rickenbacker, 2009).
- *Day and night settings* can also be customized within a 3D VLE according to users' preferences e.g. to be dusk, dawn, midday, to help learn in the most idealistic and comfortable surroundings possible (Robbins, 2007). This is a vital option for students with visual disorders who require certain colors or brightness for the background lighting of the environment in order for the interface to be seen comfortably by the "real-life" student. Furthermore, users with physical medical conditions can benefit from the same option, for example a testimonial from inside SL recorded a case of a user with migraines who could only operate comfortably if the background lighting settings were adjusted to midnight.
  An example of teaching by adjusting viewpoints inside Second Life can be seen through the virtual historic and contemporary worlds' visit of students, at the University of Texas, inside enlarged replicas of Vincent van Gogh's Starry Night, the cave paintings in Lascaux and Gotham City--the home of Batman (Kujawski, 2007).
- *Attractive 3D graphical setting:* The three-dimensional (3D) graphical settings themselves are very attractive and vivid for users. The dominant content form of a 3D VLE is imagery thus making it an image-based environment (Robbins, 2007) which is suitable for most students with disabilities.

As benefit over Real life Learning

- *Viewing and hearing from any position:* Viewing and hearing any part of the learning space from any angle with clarity, regardless of the position of the avatar (even if seated behind the lecturer), eliminates the need, like in real-life, to sit near an instructor to see him properly or find acoustic solutions for hearing a lecture conveniently (Dickey, 2005), which is a suitable solution for students with manual dexterity disabilities. These are disabilities which render them unable to maneuver their position adequately and easily inside the virtual world.
  An application of this feature can be seen with Buffalo State College fashion design students (Polvinen, 2007) who manage host fashion shows in SL without have to give consideration to positioning all spectator avatars near the runway for proper viewing.

Locations

There are multitudes of places to visit and learn from in 3D VLEs as benefit over real life learning places.

As benefit over Real life Learning
- ***Imaginary, dangerous, historical or unreachable places:*** Students with disabilities are able to examine and explore a variety of places that are imaginary or difficult to reach or teach in reality e.g. on the top of a mountain, in outer space, bottom of the ocean, representations of historic or extinct civilizations, travelling between continents during the same session thus saving time and money to do so in reality, etc (Joseph, 2007). Texas University, for example, holds classes on a tropical island in Second Life (Michels, 2008).

In an attempt to summarize the above advantageous themes and sub-concepts, the authors have examined each one of them under the prism of different stages in the lifecycle of a person's experience in a virtual world. From the initial creation of a virtual world environment and the design of the user's avatar, to the actions of this avatar specifying its behavior and integration with the entire virtual world community formulated, some clear stages can be identified. The authors perceive the learning experience in a virtual world as a journey that begins with a promise made by the virtual world designers when an environment is designed to serve certain predefined aims and an overall purpose. The promise made is in the form of the SL Island and its contents, and can be described as an allegiance to provide a unique user/learner experience. The users accept the promise by engaging in creating their own avatars and joining this virtual world. When the promise is kept and the learning experience is delivered according to the objectives of the designers as well as the expectations of its users then both needs and the designer aspirations amalgamate in a successful blend.

The three stages identified in this process can be defined as:
A. Conception – at this stage the early ideas of how the learning environment should be and provide, are used to form the virtual world in accordance to any identified requirements and specifications provided. At this stage each user becomes a virtual world entity through his/her avatar and participates in a new learning relationship with everyone else who enters the virtual world and joins the same learning experiences. At this stage the virtual world is still in its infant stage and key concepts are still reconsidered while the dynamics of the learning relationships are defined.
   The advantageous themes included in this stage are (i) disability support, (ii) educational aids, (iii) psychological support and (iv) educational strategies (see table 1).
B. Action – this second stage is in-wrought with the behavioral patterns of the learners and how these may declare patterns of use for each element designed as part of the virtual world. The action stage is primarily concerned with the behavior expressed by learners in the virtual world as well as selected behavioral patterns that are either expected or encouraged by the designers. In addition, this stage allows room for reassessing the success criteria for the learning experience and prioritizes any changes required for the learning process as well as any relating design issues.
   The advantageous themes included in this stage are (i) involvement, (ii) activities, (iii) communication, (iv) interaction, (v) output and (vi) performance (see table 2).
C. Fusion – this final stage is analogous to the maturity of the learning relationship in the virtual world. The parameters involved are finalized after experiencing a continuous development of the learning relationship till the point that learners become part of the virtual world and the virtual world itself becomes the learning experience. After this stage the established community does not behave as a group of learning individuals but rather as a set of symbiotic learning entities.
   The advantageous themes included in this stage are (i) existence, (ii) security, (iii) setting, (iv) perspective and (v) locations (see table 3).

From Table 1, it can be deduced that most themes associated with the Conception stage relate to the benefits offered by virtual worlds in comparison to 2D VLE systems. Most efforts attempt to support functionality and usability aspects of the learning environment and improve the learning experience in terms of the capabilities offered to the users/learners.

As supplement to real life education	As benefit over 2D VLE	As benefit over real life learning
Disability Support		
	▪ Autism Management (+) providing additional communication means (-) using improper stimuli ▪ Visual Impairment Management (+) allowing movement based on coordinated directions (-) using the interface becomes the core task ▪ Hearing Impairment Management (+) Providing text alternatives (-) Ensuring use of audio is constrained ▪ Mobility Impairment Management (+) Allowing mobility (-) Requiring additional devices ▪ Career Management (+) Generating career opportunities (-) Leading to potential isolation	
Educational Aids		
▪ Ease of Snapshots (+) Offering a visual diary (-) Filtering which snapshots can be taken is not possible	▪ Cheap File Upload (+) Offering an affordable media exchange tool (-) Lacking the incentive to prioritize content ▪ Streaming Music (+) Allowing audio stimulation (-) Contradicting the hearing impairment management ▪ Presentations on 3D Objects (+) Offering imaginative media (-) Contradicting the hearing impairment management ▪ Sandboxes to Practice Building (+) Practicing design skills (-) Controlling the usability evaluation variables is difficult ▪ Supporting All Learning Styles (+) Being an adaptable VLE (-) Using mainly VARK model ▪ 3D Learning Stations and Objects (+) Catching up with the class (-) Offering route to escape synchronous sessions	▪ Session Message Logs (+) Providing a text based diary (-) Lacking ability to backtrack ▪ Online Assignment Submission (+) Reducing time delays (-) Supporting formative feedback ▪ Program Execution in Linden Language (+) Embedding information in the virtual world (-) Learning unnecessary skills ▪ 3D Architectural Assignments (+) Allowing 3D manipulation (-) Shifting from 2D techniques ▪ Engagement in Real World Issues (+) Having a reality check (-) Misunderstanding the critical aspects of such work
Psychological Support		
	▪ Parental Advice (+) Allowing access to additional support means (-) Challenging the traditional pathways for such support ▪ Emotional Support (+) Getting community support (-) Antagonizing other means for such support ▪ Pain Management (+) Maintaining a realistic view of the situation (-) Detaching from the real world	
Educational Strategies		
	▪ Classroom Emulation (+) Recreating learning spaces (-) Loosing the respect for the environment ▪ Game Based Learning (+) Offering a more informal setting (-) Adopting game like behavior ▪ Role Play (+) Allowing to overcome communication barriers (-) Blaring the original roles ▪ Guided Tours (+) Providing induction support (-) Removing the joy of exploration ▪ Conceptual Orienting (+) Supporting conceptual modeling (-) Understanding how concepts affect real life architecture design ▪ Operational Application (+) Assessing practical skills (-) Lacking real life impact appreciation ▪ Joint Co-Creation	▪ Practical training (+) Practicing necessary skills (-) Resorting primarily on peer support

	(+) Establishing peer support (-) Collaborating must always be synchronous ▪ Critical Incident Involvement (+) Practicing relevant skills (-) Viewing scenario as a game	

Table 1. Conception stage – Themes and sub-concepts

As supplement to real life education	As benefit over 2D VLE	As benefit over real life learning
Involvement		
▪Active student roles (+) Increasing engagement (+) Supporting hyperkinetic persons	▪ Object ownership (+) Creating an interface identity (-) Intimidating learning curve ▪ Embodiment and Sense of Belonging (+) Establishing a typical presence (-) Shifting between the avatar and real life presence ▪ Sense of Presence (+) Belonging to the community (-) Accepting the virtual reality of the SL community	
Activities		
▪ Experimentation (+) Increasing the boundaries of feasible actions (-) Obtaining only the virtual reality aspect of senses ▪ Exploration (+) Allowing to broaden experiential horizons (-) Feeling the effects of the aftermath after logging off		
Communication		
▪ Alternative Communication Support (+) Establishing a support network (-) Shifting between real life and SL support means ▪ Ease of Guest Lecturing (+) Increasing the knowledge base on offer (-) Blaring the boundaries of the constructivist paradigm		▪ Public and Private Messaging (+) Communicating in private (-) Challenging to maintain focus ▪ Teleporting (+) Seamless boundary free environment (-) Affecting synchronous sessions
Interaction		
▪ Social Spaces (+) Engaging with peers and the wider community (-) Opening up to dangers of social networking		▪ Networks of Distant Users (+) Accessing resources and different perspectives (-) Clashing priorities and agendas ▪ Network Evolution and Future Group Work (+) Allowing the enlargement of the class (-) Maintaining a network of SL friends ▪ Instructor Practical Role Shift (+) Having the lecturer as a helper (-) Fading notion of respect
Output		
	▪ Immediate Instructor Feedback (+) Reducing delay & vague support (-) Lacking opportunity to reflect ▪ Early Assessment of Course (+) Providing formative feedback (-) Making early assumptions	
Performance		
▪ Faster MONO Virtual Machine (+) Supporting technology (-) Proprietor based platform		

▪ Do-net Languages' Support (+) Supporting technology (-) Proprietor based platform		

Table 2. Action stage – Themes and sub-concepts

As supplement to real life education	As benefit over 2D VLE	As benefit over real life learning
Existence		
		▪ Distributed/ Co-present Existence (+) Submerging within the VLE (-) Confusing reality
Security		
▪ Anonymity Safety (+) Allowing anonymous contributions (-) Maintaining control of sessions ▪ Username & Password (+) Allowing a secure environment (-) Limiting access to institutional users ▪ Free Registration (+) Allowing free access (-) Being crowded by random, casual users		
Setting		
		▪ Untraditional Class Settings (+) Allowing unconventional learning and creativity (-) Requiring a steep learning curve ▪ Easy Class Management (+) Controlling class activities (-) Maintaining asynchronous class management
Perspective		
	▪ Customization and Conceptual Imagination of Avatar (+) Personalizing the look and feel (-) Moving away from reality ▪ Virtual Reality Versus Virtual World View (+) Enabling users to achieve the unthinkable (-) Confusing the real and virtual ▪ Adjusting Cameras and Lighting (+) Customizing the interface (-) Differentiating own experience of the environment ▪ Day and Night Settings (+) Choosing own settings (-) Moving away from reality ▪ Attractive 3D Graphical Setting (+) Using familiar gaming interfaces (-) Focusing too much on interface	▪ Viewing and hearing from any position (+) Allowing truly customizable experience (-) Overlapping of avatars
Locations		
		▪ Imaginary, dangerous, historical or unreachable places (+) Allowing experiences not possible in real life

		(-) Obtaining designer's perception of settings

Table 3. Fusion stage –Themes and sub-concepts

Table 2 shows the behavioral Action stage, it seems that an equilibrium has been achieved in arranging themes and sub-concepts under the three different categories. Most effort seem to be directed towards establishing an improvement on the learning and educational experiences obtained in real life.

As shown in the Table 3, the maturity Fusion stage of the virtual world and the 3DVLE seems to deal with all three aspects (life education, life learning and 2D VLE) but with minimum overlapping between the various themes. It seems that distinct themes and sub-concepts deal with specific issues of the learning experience.

DISADVANTAGEOUS THEMES AND SUB-CONCEPTS OF LEARNING IN 3D VLES

Contrary to the preceding assertions elaborated so far within this research, the following four categories are the perceived high level disadvantageous themes of delivering e-learning within 3DVLEs derived using the grounded theory methods described earlier.

Connectivity problems

An apparent problem experienced by users of virtual worlds like Second Life is the lag in service or "rezzing" (appearance of items inside the virtual world). Smooth online server connections with 3D VLEs are not always available since they necessitate:

- *High connectivity requirements:* Dial-up access is inadequate for connectivity with online 3D virtual worlds like Second Life (Butler & White, 2008).
- *Limited internet quotas:* For practical and financial reasons, universities commonly limit student internet access by imposing quotas. Access to virtual worlds for synchronous classes, or extended periods required for creating educational models, such as virtual landscaping and orientation to Second Life, can quickly drain standard access quotas (Butler & White, 2008).

Expenses

Financial requirements to setup and maintain an existence on a 3D VLE can be quite high. Involvement in Second Life, for example, requires a modest investment of funds by the university to establish an ongoing base of operation and premium account to assist with distribution of 'in world' currency. Staff and students however are not required to make a monetary investment. Return from this investment may be measured in terms of learning experience afforded to students and professional development of staff in the skills and pedagogy associated with the technology (Butler & White, 2008).

Prerequisites

Previous technological knowledge of users can be an asset for using a 3D VLE easily. Students familiar with 3D gaming environments do not need much orientation to utilize 3D VLEs unlike novice users to technology. Also, the text-based nature of 3D VLES sometimes does not favor every student's learning style and physical abilities especially if there are manual dexterity problems, since text typing requires that its participants have fast fingers. This is further aggravated by what educators refer to as loss of face-face contact between instructors and students, which is important for visual learners in particular. However, many online learners are familiar with the principles of an alternative online social environment, one that is not text-based but instead predominately visual – e.g. the immersive, interactive

online game environments which lessens from the gravity of the previously mentioned disadvantages (Lombardi & McCahill, 2004).

3D graphical setting

As mentioned earlier, the dominant content form of a 3D virtual learning environment is imagery thus making it an image-based environment (Robbins, 2007). This renders it unsuitable for students with visual disabilities who require customized interfaces in order to operate inside virtual worlds. An example of an interface is "Radegast Metaverse Client", which is a text-based alternative for accessing Second Life. It is proving to be very useful for people with disabilities because of speech plugins and keyboard enhancements (Radegast, 2010).

ARCHITECTURAL REQUIREMENTS PROPOSED FOR DESIGN OF EDUCATIONAL FACILITIES FOR THE DISABLED

Method

In order to achieve best results from the above explicated advantages for delivering e-learning in 3D VLEs for disabled students, the environment must be subjected to the best possible design criteria that can ensure maximum accessibility, satisfaction and contentment of users from the environment to achieve a successful e-learning experience.

This study is part of an ongoing research to determine the optimum architectural design elements of educational facilities that can be used to realize highest participation, assimilation and enjoyment of students during their e-learning sessions in the 3D virtual learning space. The current study focuses on depicting the most desirable architectural design features suggested by students with disabilities to be utilized within their 3D learning spaces.

This was achieved by adopting a quantitative research approach comprising of a survey questionnaires containing open ended questions (Alarafi, 2008). The partaking sample of users consisted of 50 online participants all using Second Life as a 3D VLE and all having one or more type of disability. These were divided into the following categories which correspond to the different clusters of users utilising 3D virtual university campuses for e-learning sessions in general: 14% undergraduate students, 33% graduate students, and 53% adult learners and researchers. The purpose of the study was explained to them in an online general invitation to Second life educational lists, groups and educators' lists.

The open-ended questions were:
- What interior design aspects would you recommend in your 3D learning space? How do they make you feel (optional)?
- What interior design aspects do you dislike most in 3D learning spaces? How do they make you feel (optional)?
- What exterior design aspects would you recommend in your 3D learning space? How do they make you feel (optional)?
- What exterior design aspects do you dislike most in 3D learning spaces? How do they make you feel (optional)?

The open ended questions were used to allow students to think freely with no inhibitions on their desires, thus opening up points for discussion that we as researchers might overlook and not specifically asked about within closed options questions.

Results

Quantitative results were calculated from the conducted questionnaire described above. The resulting propositions offered by students and researchers, to enhance the interior and exterior design of learning spaces within 3D VLE university campuses, were grouped into 10 major categories as follows:

1. The architectural style (e.g. modern, classic, gothic) and shape of the building (e.g. circular, square, use of columns etc.)
2. Wall design, finishing and colours
3. External environment elements of design
4. Seating arrangements and shapes
5. Window styles, shapes and lighting intensity
6. Internal space design factors (e.g. dimensions)
7. Roof and ceiling design, finishing and colours
8. Floor design, finishing and colours
9. Circulation design specifications (e.g. stairs, corridor width etc.)
10. Entrance design (e.g. width, height, shape, doors, ease of accessibility etc.)

Figure 3. Highest 30 recommended architectural features of a learning space proposed by disabled learners

The above 10 categories represent all the design features of a 3D virtual educational building that are of interest to the disabled categories of students to provide satisfaction and contentment during an e-learning session within a 3D learning space. These are illustrated in the above Figure 3 which portrays the top 30 architectural design characteristics proposed or requested by students from all age groups to be present in their ideal 3D virtual learning environment (representing 65% of total suggested votes and features). As can be seen, the top 30 propositions are divided into 8 major categories, the highest achieving were those related to lighting, walls, internal circulation and environmental elements; whilst shape of space, floors, roofs, seating arrangements were less in demand, and those related to building entrance and style were non-existent within the highest 30 characteristics (although existing in the list of major categories). This can be attributed to the fact that the elements of space most seen directly at student's eye level are the lighting, walls, surrounding environment (e.g. water elements, greenery etc.), and also presence of accessibility elements like ramps, wide corridors, elevators have an impact on them and therefore demanded most despite their avatars being without disability in SL; whilst floors, ceilings and seats are below and above direct eye perspective, hence perceived and required less by students. As for building entrance and style, since these are outside the immediate learning space that the students take their e-learning session in and do not affect their manipulation "in-world", they are probably not remembered as essential categories for design by students.

On an individual element's basis, the following could be noticed. The highest recommended characteristic was presence of light interior colors, followed by spaciousness, ramps and usage of one floor single space building. This indicates that users with disabilities are highly conscious of usability requirements for design of their learning spaces above any other design requirements. As for building style, simple modern and plain classic styles were most preferred with no over decoration or imagination so as not to cause distraction for learners. Semi-circular or circular seating arrangements (along with circular shaped spaces) also seemed most agreeable for students. An unexpected finding was the fact that students recommended abundance of greenery, flowers and water elements (e.g. fountains, sea etc.) but surrounding their learning space more than inside of it, again so as not to cause distraction among them but rather comfort surrounding them.

In general, the fact that over 500 votes comprising almost 100 different design features in total were recommended by students i.e. almost 10 suggestions per student is definitive evidence that architectural design of the virtual learning space is important in disabled students' opinions.

RECOMMENDATIONS

The major problematic issue faced during this research was the scarcity of locating participants eligible for answering the survey used. Future recommendations can include conducting focus groups and individual interviews in a more qualitative approach to the research to delve into specific issues regarding requirements and needs of disabled students from the design of their learning spaces.

FUTURE RESEARCH

Since this study is part of an ongoing research to define best design practices for educational facilities within 3D virtual learning environments suitable for users with disabilities, the following strategic goals are subject to future research:

- Defining the propositions of students with disabilities based on the following categorizations: gender, type of disability, ethnicity, and field of education
- Measuring the effect of individual design elements of the 3D virtual learning space on the understanding, assimilation, participation and enjoyment of the disabled students during e-learning sessions
- Conducting interviews with 3D design professionals to depict their contribution towards the same goal of enhancing educational space design.

CONCLUSION

So far we have seen numerous pieces of research presenting virtual worlds as the means to support users with disabilities and the mechanism to overcome the obstacles of geographic dispersion, location and distance. In our work we have emphasized on the importance of 3DVLE applications in enhancing the learning experience of disabled students. In an attempt to integrate our work with previous research in virtual teams, tele-work and outsourcing we would recommend that 3DVLE applications should attempt to align (i) the solutions provided by virtual worlds in addressing learning needs along with (ii) the ones available for supporting mobility problems. The key factor is that 3DVLE may provide adequate support both for online learning and distance education activities as well as eliminating any obstacles relating to mobility difficulties. The potential benefits are numerous and span across various fields, offering possibilities even for virtual work and virtual businesses. A few years ago Mollman (2007) reported for CNN several cases where virtual worlds have provided clear benefits for the disabled. More specifically David Stone, a Harvard University scholar, argues that SL "offers the opportunity to those who are disabled to be productive members of the world economy by doing very useful work". Several examples, as seen earlier, have been presented where SL applications have offered work satisfaction, intellectual stimulation and professional as well as personal relationships. Blurring the line between real world and virtual worlds means that people with disabilities may experience the ability to contribute, the freedom and worth. After reviewing our current practices in SL and the existing virtual world we have established for some of our students, we are reviewing the priorities we have identified for the design of virtual world environments as well as the learning activities supported by SL. The authors' initial aim was to investigate the way architectural features as well as other environment factors may affect the learning experience provided by a 3DVLE. Following the recent findings of our investigation we have identified the following concerns that are likely to affect our research decisions in the immediate future. We envisage that design principles of 3DVLE applications will evolve so they can accommodate the needs of all user groups without heavily customizing their interfaces. This would allow us to provide a harmonized set of learning activities available to all members of our student cohorts, therefore providing a

homogeneous learning experience. Furthermore the ability to design a learning environment, where any mobility or usability obstacles are dealt with prior to the engagement of the learners, should succeed in supporting disabled learners' engagement and integration.

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KEY TERMS & DEFINITIONS

2D Virtual Learning Environment: An online software system with a website interface containing tools to support learning

3D Virtual Learning Environment: an online environment that can be used for learning, created in 3 Dimension where users can move, build, communicate using created 3D characters

ADHD - Attention deficit disorder: a condition (mostly in boys) characterized by behavioral and learning disorders

Architectural Design Guidelines: These are the different codes, specifications and rules used to design a building

Autism: An abnormal absorption with the self marked by communication disorders and short attention span and inability to treat others as people

Avatar: A 3D character which the user creates to login and use a 3D virtual environment
Cerebral Palsy - a loss of motor control with involuntary spasms caused by permanent brain damage present at birth

Dyslexia: A learning disability that manifests itself as a difficulty with reading decoding, reading comprehension and/or reading fluency

In-world: A term meaning being logged into the 3D virtual world

Rezzing: A term referring to the process of appearance or loading of objects inside a 3D virtual environment

Second Life: An online software which allows creation of a virtual environment