Enhancing Learning on Information Security Using 3D Virtual World Learning Environment

Vicky Maratou*, Michalis Xenos*, Divna Vučković**, Andrina Granić***, Aleksandra Drecun**
* Hellenic Open University, Patras, Greece
** Center for the Promotion of Science, Belgrade, Serbia
*** Faculty of Science, University of Split, Split, Croatia
v.maratou@eap.gr, xenos@eap.gr, andrina.granic@pmfst.hr, dvuckovic@cpn.rs, adrecun@cpn.rs

***Abstract*—This paper explores the technology of 3D virtual worlds in relation to their possible benefits for education. The taxonomy of the 3D virtual world platforms (proprietary and open source) are presented and evaluated for the implementation of virtual learning platform of the V-ALERT project. Based on the recent literature, the platforms' characteristics are reviewed. Additionally, the main criteria that are set by the consortium of V-ALERT for the selection of the most appropriate virtual world platform are outlined and the final choice is discussed. The platform of choice is described in more details concerning its functionality and features, as well as its possible integration with other modules such as Learning Management Systems (LMSs), for example LMS Moodle.**

I. Introduction

Numerous 3D Virtual Worlds, formally called Multi-User Virtual Environments (MUVEs), have recently become available, many of which are tuned to specific uses, either for socialization and leisure activities, or for more "serious" purposes such as commercial facilitation (e.g. sales and marketing, or customer support) and education enhancement (e.g. training simulations). The special characteristics and distinct possibilities of the Virtual Worlds (VWs) make them a powerful technological tool towards enhancing the learning experience. This is one of the main reasons for the selection of 3D VW platform for development of the advanced, interactive and motivating tool for rising the awareness on Information Security threats and learning how to recognize and avoid unsafe actions in the scope of V-ALERT project, as teaching and training applications in VWs seem to offer remarkable benefits to students. As stated by [1], "VWs are ideally placed to support pedagogies that aim at moving away from chalk-and-talk learning and focus on more real-world learning styles such as learning through action, cooperation, gaming, problem solving, etc".

The aim of this paper is to present the results of the first phase of the V-ALERT project co-financed by European Commission under the Framework Lifelong Learning Programme / Key Activity 3 – ICT / Multilateral Project [10]. The goal of the V-ALERT project is to support the establishment of Information Security (IS) culture through providing awareness and facilitating learning process using 3D Virtual Worlds platforms. The high proliferation of information and communication technologies (ICT) and everyday use of Internet and computers by majority of people of all age groups for work, learning, entertainment, communication etc. brings a lot of benefits, but also certain risks related to non-informed ICT use. The ICT user should be aware of the basic principles of information security and data protection. This is the reason for the development and implementation of the innovative and immersive e-learning tool in different ICT user target groups (pupils and teachers, ICT students, academics and enterprise employees) in the scope of V-ALERT project. An online 3D Virtual World Learning Environment (VWLE) is being developed which is simulating real-life Information Security threat scenarios, allowing users to gain first-hand experience of different risks and threats, but in a safe manner.

The paper presents the 3D Virtual World platform selection in accordance to project requirements and the transformation of 3D Virtual World to the educational virtual environment for advanced learning on Information Security.

II. Virtual World platforms for the enhancement of the learning process

A. 3D virtual worlds

Although various definitions of the VW have been proposed by different authors, one commonly accepted definition does not yet exist. However, all the definitions have in common the following basic characteristics of the VW:

1. shared space which allows multiple concurrent users to be present,
2. graphical user interface which depicts the virtual environment,
3. immediacy that supports real-time interactions,
4. interactivity that allows users to interact with the virtual environment, providing the means for building, creating and embedding digital content,
5. persistence which ensures that the VW (objects and constructs) as well as any alterations made by the user will continue to exist and function even after the user has left the VW,
6. synchronicity for synchronous users' communication through text and/or voice,
7. network of people who can communicate and interact with each other, forming short term and long term social groups, i.e. a sort of ecosystem,
8. avatar representation in other words a digital representation beyond a simple label or name, that has agency (an ability to perform actions) and is controlled by a human in real time,
9. networked computers managing all data and facilitating the virtual experience.

B. Virtual world platforms

The 3D Virtual Worlds platforms are an innovative ICT technology that provide tools for the creation of highly immersive 3D graphical and interactive online environments which can be either replicas of existing physical places, or imaginary places, or even places that are impossible to visit in real life due to restrictions such as cost or safety. These VW platforms can be either proprietary or open-source.

In the following text the proprietary and open-source VW platforms are presented. Those are currently most popular in the educational community for the development of fully customizable and thematic rich virtual worlds in which multiuser interactive educational simulations, serious games and learning activities can take place. VW platforms that are mainly used in business sector for meetings and collaboration are not included because they would not support the development needs of a project similar to V-ALERT.

C. Proprietery Platforms

The evaluated proprietary 3D Virtual Worlds platforms are Second Life, Active Worlds, Jibe and Unity.

Second Life [12], launched by Linden Lab in 2003, is the most popular of the Social Worlds, with the largest active user and educational community. It features a detailed 3D graphical environment and customizable avatars, built-in voice and standard text communication tools (i.e. chat, IM). SL provides a social network with groups, through which information and object sharing can take place. SL also has an in-world economy (the virtual currency is Linden Dollars (L$): 2500L$=10.09USD) and an enormous market with user-generated virtual goods and tools. One of the most exceptional capabilities of SL is the ability to build objects and write scripts in-world. Registration and basic usage is free but the users have the option of paying a small monthly fee in exchange for a small parcel of land where they can build a home and become "residents". However, serious building projects require the purchase of a private island or a large piece of land (parcel) in the Mainland. A parcel in the Mainland may be made private and accessible only to those who belong to a group, but visitor avatars may still access the neighboring land. Hundreds of learning organizations - from nearly every country- are either augmenting their current curriculum with a virtual learning component or they are holding classes and entire programs exclusively in immersive learning environments in SL. More details on the features of SL are presented in [9].

Active Worlds [13] was launched in 1997 and works much in the same way as SL. Although restricted usage is free through the "tourist" account, paying a small monthly fee allows one to become a "citizen". Only "citizens" can have a unique name, unrestricted access to any part of any world on the platform, avatar customization, object building and access to social networking features such as voice chat, IM and file sharing. For users who need more control over their environment and more privacy, private firewall-protected Universes are available for enterprise and educational projects. These are separate worlds from the main universe and their cost varies. A separate set of worlds and a community for educational projects is also available under the name Active Worlds Educational Universe where over 80 organizations have presence. More details on the features of AW are presented in [9].

Jibe [14] is a multiuser 3D virtual world platform developed by ReactionGrid Inc. The developed virtual worlds can be embedded in any web page or accessed from mobile devices, they can either be hosted by ReactionGrid Inc. or fully installed on private servers. Jibe requires the installation of the Unity web plugin with Android and iOS support under development. Using the Unity 3D editor to build a Jibe virtual world, it results to a professional development environment with professional quality graphics, physics and sound. It allows the creation of 3D objects and the import of 3D models from Maya, Blender, etc. Jibe also features customizable 3D avatars, private/public text chat, user tracking, Vivox voice integration, built-in registration database, integration with Facebook, LMS, CMS, hooks for Augmented Reality apps, support for SCADA and Robotics. More details on some of the features of Jibe are presented in [9].

Unity [15] is not a virtual world platform. It is a 3D (& 2D) professional game development tool which can be used to create suitable training simulations and educational virtual worlds in 3D from scratch which can then be accessed through a client or a web based player. The Unity offers the possibility to develop a game and its user interface without having to program in complex computer languages, such as C++. The language behind the Unity scenes is C#. The development of single-player games/apps requires only downloading and installing Unity but the features and properties of the developed training environment depend mostly on the ability to use the content creation tools. The Unity Asset Store, a global marketplace of objects (as well as code) for Unity, provides content (character models, materials and textures, landscape painting tools, game creating tools, audio effects, music, visual programming solutions, scripts, etc) for a very low cost or even free. Unity evolves with the latest mobile (iOS, Android), desktop (PC, Mac, Linux), Web (web player, Flash) and console (Wii U, PS3, Xbox 360) technology, offering smooth development and deployment of a game with high quality of graphics and solid performance on any device. More details on some of the features of Unity are presented in [9].

D. Open source Platforms

The special emphasis was given to the evaluation of the open source platforms due to the fact that the V-ALERT project is co-founded under the LLP Programme of the EACEA agency of the European Commission which encourages the use of open source software. The platforms OpenSimulator, OpenWonderland and OpenCobalt are compared and analysed.

OpenSimulator [16], often referred to as Opensim, is a free, open-source, 3D application server that allows the creation of 3D virtual worlds, where multiple users can simultaneously be present. These virtual worlds can be accessed through various open source clients and can remain private, behind the firewalls, or become public. OpenSimulator is written in C# and its framework is designed to be easily extensible through external modules. The OpenSimulator project started in early 2007 as an open source server side to Linden Lab's Second Life open-source client. Consequently, OpenSimulator's current architecture is heavily influenced by that of Second Life, allowing the user to produce similar highly detailed 3D graphical environments from scratch at a low cost, or at no cost, provided that the hardware, software

the building, scripting and technical skills are offered for free. The avatars are fully customizable and resemble those of Second Life. The in-world communication is based on text communication tools (i.e. chat, IM). At the moment, a reliable choice for free voice service with lip sync is the one provided by Vivox Inc., by request. An exceptional feature is Hypergrid, a protocol that allows hyperlinking between Opensim worlds and supports seamless avatar transfers among these worlds. Despite the fact that the platform has not reached a beta version yet, it proves to be quite stable and robust. The aforementioned reasons plus the freedom of owning, building and configuring the virtual world, have made OpenSimulator very popular among the educational and science community. Virtual worlds and education. [9] includes some basic features of OpenSimulator.

OpenWonderland [17] is an open source 100% JavaTM toolkit for creating 3D collaborative virtual worlds from scratch. OW is in its early stages of development and although the graphics of the environment are rather simplistic, other features of the platform are comprehensive. The toolkit allows the creation of modules which can extend any part of the system (client or server) and add functionality. Out of the box and with a bit of software development effort, customized, special-purpose virtual worlds can be created. Some examples of the external modules that have been created by different developers and can be downloaded from the Module Warehouse are: Authentication system, webcam viewer, writable (text or HTML) poster, collaborative text editor, etc. Open Wonderland offers the ability to run Java and X11 (Linux) applications inside the virtual world. Almost all Java applications, which can be 2D or 3D, are created with multiple users in mind. For example, there is a shared whiteboard which multiple people can draw on at the same time, there are sticky notes for brainstorming and a multi-user PDF Viewer for browsing slides independently or in sync with a presenter. A distinct feature of Open Wonderland is the ability to easily bring in existing content. The list of document types that can be dragged and dropped into the world is ever growing. Moreover, a creator can import any content found in the Google 3D Warehouse. Open Wonderland does not offer in-world 3D building, but 3D stuff can be imported from Maya, Google SketchUp, Blender, etc. Hence, avatar, instead of being built in-world, must be created on Evolver website and then dragged and dropped into the OW virtual worlds. Also, OW does not support avatar's inventory. Within OW worlds, users can communicate with high-fidelity, immersive audio, share live desktop applications and collaborate in an education or business context (simulations, meeting rooms, mixed-reality worlds, etc). Basic features of OpenWonderland platform are shown in [9].

Open Cobalt [18] is an open source virtual world browser and a toolkit for creating private virtual worlds. OC shares similarities with other 3D virtual environments such as Second Life, but OC uses the peer-to-peer technology instead of servers. Through the OC website, peer-to-peer technology allows its users to access OC virtual worlds on LANs, intranets, or across the Internet without any need to access anyone else's servers. Anyone can host an OC virtual world from all over the Internet for free. Open Cobalt's ability to leverage peer-to-peer technology as a way of supporting interactions within virtual worlds is a major point of difference from commercial multi-user virtual world systems, such as Second Life, where all in-world interactions are managed by central servers. Hence, users can set up virtual spaces and interact with others of their choice with no hosting fees, licensing or virtual land lease costs. Similarly to OpenSimulator, OC makes it possible for people to hyperlink their virtual worlds via 3D portals in order to form a large distributed network of interconnected collaboration spaces. It also offers a set up of public or private 3D virtual workspaces that feature integrated web browsing, voice chat, text chat, and access to remote desktop applications and services. OC lacks 3D content creation tools in-world. It provides the infrastructure for world creation, navigation and collaboration and it supports content created in free or open source authoring applications such as Sketchup or Blender. Through Open Cobalt's VNC capability, web resources (LMS, CMS, wikis, etc.) can be brought into the virtual spaces - interactively. One distinct advantage of OC is the motion simulation. Motion Simulation written in Smalltalk through using FreeCAD application can be easily imported in OC virtual worlds. Basic features of OC are presented in [9].

III. 3D Virtual Worlds and Education

The aforementioned characteristics of the 3D Virtual Worlds could potentially transform these environments to "educational virtual environments". In [6] an "educational virtual environment" is defined as an environment that is based on a certain pedagogical model, incorporates or implies one or more didactic and learning objectives, provides users with experiences they would otherwise not be able to experience in the physical world (or in a classroom) and redounds specific learning outcomes.

Within this context, a rapidly growing interest in learning and teaching within 3D VWs is observed and a large number of schools and universities own virtual spaces for their educational purposes mainly by extending their campuses to the virtual space. 3D educational VWs are usually being used either as safe simulation environments or as virtual classrooms.

The concept of "Encoding Specificity" is a critical issue in the use of simulations for learning. Extended research on human memory, carried out by cognitive scientists and psychologists, show that the "transfer [of learning] is maximum when the conditions at retrieval match those present at encoding." [2]. This means that a learner will be better able to remember what he/she has learned if the conditions during learning match those during recall. In certain educational topics, immersive simulations of the "real life" environment or situation could lead to better recall comparing to only reading books or watching PowerPoint presentations.

In comparison to other e-learning technologies, 3D VWs can provide learners with a full understanding of a situation using immersive 3D experiences which allow the learner to freely wander through the learning environment, explore it, obtain sense of purpose, act, make mistakes, collaborate and communicate with other learners [3]. Indeed, two unique features that the technology of the 3D VWs can offer is the sense of immersion, i.e. the impression of "actually being in there" watching the world through the eyes of the avatar and the sense of presence, i.e. the feeling that the person is an entity of the virtual

world, capable of interacting with other entities in the same way as in a physical space.

The anthropomorphic avatars can enhance the sense of presence [4]. As stated by [5] "an avatar was perceived to be more social present and co-present in the social interaction as compared to an agent represented by a low-anthropomorphic virtual body". Eventually, 3D interactive VWs occupied by human-like avatars could effectively enhance collaborative training activities (games, simulations, and alike). Additionally, immersion accompanied with the interaction with virtual objects can enhance learners' interest and engagement to the learning tasks and help them develop a stronger conceptual understanding, depending on the content [6] [7].

However, according to [4] "it should be considered that the simple use of highly immersive technology alone could not be effective unless it is coupled to specific design strategies, such as for example "goal-based scenario approach". In other words it is important to set training goals for the learner and offer meta-cognition and reflection mechanisms either embedded in the VW or readily available by a trainer who is present.

IV. V-ALERT VIRTUAL LEARNING ENVIRONMENT

The V-ALERT project, co-founded under the LLP Programme of the European Commission, aims to support the establishment of an Information Security culture in different ICT user target groups (pupils and teachers, ICT students, academics and enterprise employees) by providing awareness and training through an innovative and immersive e-learning tool.

A. V-ALERT aims and outcomes

The vision of V-ALERT is to use a uniform environment that is simulating a real-life security threat scenarios, examples and counterexamples in a way that different groups of users are experiencing the risks and combining critical skills, knowledge and collaboration to overcome them, without exposing their organization to real risk. The end-users are immersed in a virtual environment which simulates real-life working or educational environments. These environments are also being enriched with relevant multimedia educational material for further comprehension of the subject.

The underlying pedagogy in this approach is "learning by doing" which can enhance experiential learning, increase intrinsic motivation of learners and lead to deeper understanding and learning. Furthermore, the virtual world learning environment that is being developed in this project is going to be an on-line 24/7 educational tool which can support distant learners of different ages and provide Information Security Awareness in a way that is technologically simple, pleasant, safe and cost effective. The project aims to:

- enrich pupils' awareness on Information Security through collaboration, critical thinking and "learning by doing",
- empower teachers to adopt novel ICT approaches in teaching and also offer them the chance to become aware of Information Security risks,
- help enterprise employees realize their crucial role in securing information assets of the enterprise, allowing them to "safely" experience the security risks, the types of countermeasures available, the situations in which they are suitable and any constraints that they may impose,
- expand and consolidate the existing Information Security knowledge of ICT students and University/ College Professors of various expertise.

An on-line 3D virtual world learning environment (VWLE) is being developed which simulates real-life Information Security threat scenarios, allowing users to gain first-hand experience of the different risks and threats, though in a safe manner (see Figures 1 and 2).

Figure 1: Interactive Slide Presentation "In-world"

Figure 2: "In-world" Library on Information Security Risks

Due to the broad nature of end-users, the implementation of VWLE is reinforcing transversal competences, such as digital competence, while bridging the worlds of education and work. An initial end user requirements collection was conducted through questionnaire, interviews and focus groups, while participated users from Cyprus, Greece, Serbia, Croatia and Bulgaria have been categorized in 4 different target groups: (i) students of primary or secondary education, (ii) teachers or academic professors, (iii) ICT college or university students and (iv) enterprise staff or employees in an organisation or administrative personnel [11].

Besides the specific types of security threats that users would like to learn more about, requirements gathering revealed the following:

- users believe that 3D virtual worlds could be effectively used for educational purposes by offering educational oriented experiences to the user,
- users believe that 3D virtual worlds facilitate a "learning by doing" educational model, and
- users would like to participate in learning sessions facilitated through 3D virtual world simulations.

The virtual environment is providing scenarios in a core language, but is easily expandable in any new language. Within the scope of the project, the in-world learning material and scenarios will be available in English (as a

core language) as well as in Greek, Serbian, Croatian and Bulgarian. Furthermore, V-ALERT main outputs are listed in the following:

- conceptual design of Information Security threat scenarios concerning the needs of each target group,
- customizable on-line 3D virtual world designed to best implement these scenarios through in-world engaging learning activities and simulations,
- supportive documentation and Information Security educational material for the end-users,
- reports on the formative evaluation of the virtual world learning environment and the pilot implementation of this environment in each partner country.

B. V-ALERT platform selection

The VW platform selection criteria were set in line with the aims of the V-ALERT project, the development requirements, the context philosophy and the budget. General criteria is presented in the following list:

1. cost-free and open-source,
2. development of fully customizable and multiuser virtual worlds in order to simulate various scenarios,
3. good system stability,
4. straightforward server configuration and parameterization in order to fully control the VW and the usage rights at will,
5. self-hosting possibility,
6. reasonable hardware and bandwidth requirements that can be provided by Hellenic Open University's Software Quality Lab,
7. user-friendly and free downloadable, multi-platform client software allowing for non-Windows users' participation,
8. high-quality 3D graphics and human-like fully customizable avatars to support the issues of immersion and presence,
9. platform popularity for educational projects along with large, active and supportive community of developers.

Furthermore, a number of specific criteria was also taken into account:

1. built-in 3D editor for in-world creation and editing of 3D virtual objects and landscapes,
2. expandable functionality and in-world interactivity through scripting language,
3. possibility of free object/landscape/virtual world import and backup,
4. real-time communication through text chat, IM and Voice,
5. in-world scripting language to support the implementation of NPC creation and programming,
6. possibility to embed LMS/VLE functionality inside the virtual world.

Additional to the aforementioned required general and specific criteria, the existence and availability of free, rich, open, and customizable pre-made content (i.e. 3D objects, scripts, functionality modules) was considered a benefit.

Based on the first general criterion, the platform of choice must be open-source and free. Therefore, comparing the features and the functionality of the three open-source platforms that are presented in Chapter II of this paper, only OpenSimulator is more mature and full-fills all the requirements described. Additionally, OS's compatibility to SL, the most popular 3D virtual world platform for educators all over the world, as well as its open and modular design makes OS platform ideal for educational institutions and enterprises that need to have full control and maximum flexibility on their 3D simulations, in virtual worlds that offer pretty much the same graphics, functionality and building possibilities as Second Life but in significantly lower cost (or at no cost at all). Furthermore, anyone who wishes to develop virtual worlds on OS can benefit from the intellectual outcomes of two very large and active educators' and developers' communities, which is a major advantage for someone who is not experienced in this field.

Although OW and OC platforms present some quite interesting features, they are still in earlier stages of development and evolve in slower rate comparing to OS. They are supported by smaller community of developers, especially the OC platform. For the V-ALERT project and its requirements, the fact that OW and OC require the use of external 3D modelling applications for avatar customization and 3D object creation and editing as well as the fact that they do not offer a built-in mechanism for NPC creation and programming, was considered as drawback that could increase the total workload of the development. Finally, the LMS/VLE functionality, that can facilitate the accomplishment of the project's objectives, can be integrated only to the OS platform through the open-source SLOODLE [19] module of Moodle LMS [20].

C. OpenSimulator as the basis of V-ALERT platform

The 3D VWLE is being developed on the open source VW platform OpenSimulator and is integrating functionality of the Moodle LMS through SLOODLE middleware.

OpenSimulator 3D VW platform (current version 0.8.) facilitates the development of 3D environments using a variety of technologies. It is easily extendable through loadable modules that enable to build completely custom configurations and embed extra functionality to the platform. OS is being developed in C# programming language, and additional functionalities can are added using loadable modules. OS is released under a BSD License, making it both open source and commercially friendly to embed in products. Out of the box, OS is used to simulate a virtual environment similar to SL (including client compatibility due to the same client-server communication protocol). Although OS is still considered alpha software version, its improvement is progressing rapidly and at the moment the platform is considered relatively stable and robust to be used for the development of rich and immersive multiuser virtual worlds.

At the broadest architectural level the main components of OS system are three: a) the server (or "simulator"), b) the client (or "viewer") and c) the services [8].

The OS server is responsible for the maintenance and update of the virtual world status, managing every user and/or object applied alteration to the virtual environment state. For this reason it is also called "simulator". The client or "viewer" is the software responsible for the 3D graphical rendering of the avatars and the virtual world and acts mainly as an interface between the user and the simulator(s). The backend of the system consists of the

Services which provide the virtual world simulator(s) with the common resources requested. An example of the interaction between client, regions simulator and services in classic standalone architecture is shown in Figure 3. As presented in the figure, only the simulators have access to the VW services – clients, except for login phase, always send and receive data through a simulator instance.

OpenSimulator can operate in two different modes: a) Standalone or b) Grid mode. In standalone mode, a single computer process (i.e. OpenSim.exe) handles the entire simulation and the services of the virtual world. Standalone mode is simpler to configure, but is recommended for "light" worlds and smaller number of concurrent avatars. In grid mode, the services are not part of the VW simulation process (OpenSim.exe). Instead, they run in a separate process (Robust.exe).

The main advantage of using virtual worlds is, according to most authors, the impressive 3D graphics that create an environment that can attract user's attention and facilitate immersion. Built into the software of OS is a 3D modeling tool which is based around simple "prims", allowing the avatars to link them and build complex virtual objects.

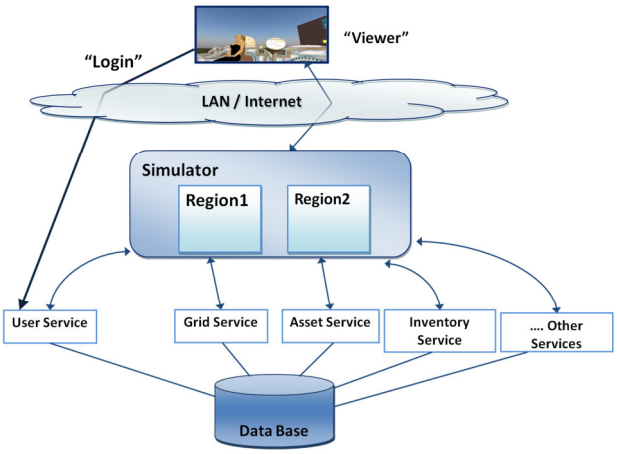

Figure 3: OpenSimulator architecture

V. Concluding Remarks

Based on the literature survey about the 3D virtual world platforms used for educational purposes and the aims and objectives of the V-ALERT project, it is concluded that the most appropriate platform is the OpenSimulator. The OpenSimulator offers all the functionality needed for the development of the threat case simulations, it is expandable and open-source. On the other hand, it can be integrated with Moodle LMS through the SLOODLE middleware. This additional functionality is going to be extremely helpful for the enrichment of the virtual world simulations with educational materials related to Information Security and it can also offer the option of keeping record of the users' in-world performance and profile. The latter option will aid the application of the recommendation algorithms on the users' stored data in order to provide real time in-world personalized recommendations.

Acknowledgment

This work has been carried out within the project V-ALERT - "Virtual World for Awareness and Learning on Information Security", partially supported by the European Commission under the Framework Lifelong Learning Programme / Key Activity 3 – ICT / Multilateral Project. This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

References

[1] Daden Limited. (2010). Virtual Worlds for Education and Training. White Paper. Retrieved February 22, 2011 from http://www.daden.co.uk/media/white-papers.

[2] Clark, R.C., & Mayer, R.E. (2003). E-learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multi-media Learning; John Wiley & Sons.

[3] Daden Limited. (2014). Immersive Environments for Learning, Education and Training. White Paper. Retrieved January 30, 2014 from http://www.daden.co.uk/media/white-papers.

[4] Mantovani, F., & Castelnuovo, G. (2003). Sense of Presence in Virtual Training: Enhancing Skills Acquisition and Transfer of Knowledge through Learning Experience in Virtual Environments. In G. Riva, F. Davide, & W.A IJsselsteijn (Eds), *Being There: Concepts, effects and measurement of user presence in synthetic environments* (pp. 167-181). Amsterdam, The Netherlands: Ios Press.

[5] Nowak, K., & Biocca, F. (2001). The influence of Virtual Bodies and Agency on Co-presence, Social Presence and Physical presence. In Proceedings of 2001 of the 4th Annual International Workshop PRESENCE 2001. Temple University, Philadelphia, PA, USA.

[6] Richter, J., Anderson-Inman, L., & Frisbee, M. (2007). Critical engagement of teachers in Second Life: Progress in the SaLamander Project. In Proceedings of 2007 Second Life Education Workshop (pp. 19-26). Chicago, USA. Retrieved October 20, 2012 from http://www.garito.it/prog/psico08/testi-def/slccedu07proceedings.pdf.

[7] Dickey, M.D. (2005). Three-Dimensional Virtual Worlds and Distance Learning: Two Case Studies of Active Worlds as a Medium for Distance Education. *British Journal of Educational Technology*, 36(3), 439-451.

[8] Clark-Casey, J. (2010). Scaling OpenSimulator: An examination of possible architectures for an Internet-scale Virtual Environment Network. Dissertation for the MSc degree in Software Engineering, Kellogg College, University of Oxford.

[9] D2.2 Report on 3D virtual worlds platforms and technologies, V-ALERT project 543224-LLP-1-2013-1-GR-KA3-KA3MP

[10] Virtual World for Awareness and Learning on Information Security (V-ALERT) Official Website, Online: http://v-alert.eu/, 2014.

[11] Mettouris, C. *et al.* (2015). Information Security Awareness through a Virtual World: An end-user requirements analysis, ICIST 2015, (paper submitted for the review)

[12] www.secondlife.com

[13] www.activeworlds.com

[14] reactiongrid.myshopify.com

[15] unity3d.com/unity

[16] www.opensimulator.org

[17] www.openwonderland.org

[18] www.opencobalt.org

[19] http://www.sloodle.org/docs/

[20] https://moodle.org/