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EDUCATING PEOPLE ON REAL-LIFE INFORMATION SECURITY THREATS THROUGH 3D VIRTUAL WORLD SIMULATIONS

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Abstract: *Nowadays, computers and the Internet have become useful tools, supporting important parts of people's lives such as work, education and entertainment. However, there are certain risks involved in using ICT technologies, most of which ICT users, whether professionals or not, are not aware of. Regardless the achieved high level of security, computers, networks and mobile devices always involve the human factor which remains an important vulnerability. In this work we present a 3D Virtual World Learning Environment (3DVWLE) that aims to aid towards the development of information security awareness culture to four different target groups: pupils, university students, teachers-professors and enterprise staff. The 3DVWLE simulates a number of real-life information security threat scenarios, enabling users, through their interaction within the virtual world, to experience the risks, be educated about them and combine skills and knowledge to overcome them, without exposing themselves, their data or their organization to real risk. In this paper we provide information on the information security threat scenarios, the design and development of the 3DVWLE as well as the reasoning mechanism that enhances the user experience. Finally, we present early results on user testing and evaluation.*

Keywords: *3D Virtual World Learning Environment, Interactive Learning Simulations, Information Security Awareness*

1. INTRODUCTION

Numerous 3D Virtual Worlds (3DVWs) exist, 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) and education enhancement (e.g. training simulations). According to the literature, teaching and training applications in VWs seem to offer remarkable benefits to the 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"*. This is due to the special characteristics and distinct possibilities of the VWs that makes them a powerful technological tool towards enhancing the learning experience.

Important characteristics of 3DVWs such as shared space, graphical user interface depicting the virtual environment, immediacy, interactivity, synchronicity, networks of people communicating and interacting with each other and avatar representation could potentially transform these environments to "educational virtual environments". Compared to other e-learning technologies, 3DVWs 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 [2].

The V-ALERT LLP EU project [3] aims to support the establishment of an Information Security (IS) culture in different ICT user target groups (pupils, ICT university students, teachers and academics and enterprise staff) by providing awareness through an innovative and immersive e-learning 3DVW tool. Towards this aim, an online 3DVWLE has been developed which simulates real-life IS threat scenarios, allowing users to gain first-hand experience of the different risks and threats, though in a safe manner. In addition, the 3DVWLE provides real time in-world assistance to users through personalised recommendations made available by a reasoning mechanism. The underlying pedagogy of the V-ALERT approach is the "learning by doing" which can increase intrinsic motivation of learners and lead to deeper understanding and learning [1, 4].

The aim of this work is to present important design and development aspects of the 3DVWLE, as well as the reasoning mechanism that enhances the user experience by assisting the user through personalized

recommendations. Section 2 of this paper discusses related work. In section 3 we briefly describe the user requirements collection process, while in section 4 we present the IS threat scenarios. Section 5 discusses system architecture, design and development. Section 6 describes the reasoning mechanism and how it is embedded in the scenarios, section 7 presents system evaluation and finally section 8 closes the paper with results and conclusions.

2. RELATED WORK

A number of research works aim at providing learners with experiential learning of different scientific topics through simulations or role-play games in 3D interactive virtual worlds [1, 2, 5, 6]. However, there are not many works focused on delivering IS issues [7, 8, 9, 10] through 3D virtual worlds. To this direction, mostly 2D simulations and games have been developed [11].

In the context of V-ALERT project, we fully exploit the possibilities of the 3DVW technology to create and evaluate experiential learning simulations which address the users' real needs for IS awareness.

3. REQUIREMENTS COLLECTION

The requirements collection from the end users was accomplished mainly through an online questionnaire which end users from Cyprus, Greece, Bulgaria, Serbia and Croatia had to complete, as well as a number of of locally held interviews and focus groups. The requirements analysis lead to the development of the specifications for the 3DVWLE [12], as well as contributed in defining the specifications of the IS threat scenarios that have been implemented as pilot learning environment applications.

The most important results obtained from the questionnaire is the confirmation and validation from all 4 end user target groups that: *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 that *users would like to participate in learning sessions facilitated through 3D virtual world simulations*. Moreover, based on the questionnaire data analysis and obtained results presented in [12], the security threat scenarios to be implemented included Identity Theft (a form of stealing someone's identity to gain access to resources or personal information such as credit card numbers), Social Networking (threats related to social networking such as Facebook), and Phishing/Spam (an attempt to acquire sensitive information such as passwords and credit card numbers by pretending to be a trustworthy entity in an electronic communication, e.g. through a misleading email).

4. INFORMATION SECURITY SCENARIOS

The scenarios are oriented to all envisaged target groups of the project. They are developed as multilingual simulations for one player and/or for teams. The conceptual design of the scenarios and their virtualisation approach has been based on the principles of experiential learning [13], also considering instructional design strategies, such as the "branching scenario" approach which is related to situated learning in 3DVW simulations. Based on this approach, the scenario unfolds its narrative as long as the learner uses their critical thinking to decide on their next action in order to move forward along the "branch". All scenario-based simulations of the V- ALERT provide the user (or the team) with a "mission" which puts them in a "role", motivating them to explore the 3DVWLE so as to discover information and "keys" which are important for the completion of the scenario tasks. During the simulation's progress, the in-world embedded educational content is presented as part of the plot and the knowledge gained is eventually used for the completion of the tasks. The non-completed tasks may either lead to other situations which place the user to experience negative consequences, or simply prevent them from proceeding. In the end, all scenarios provide the user with educational feedback on the simulated IS threat. Moreover, special attention has been given on issues such as the user's meaningful interactivity with virtual objects and computer-driven avatars (aka Bots), the difficulty level and the total duration of the simulation.

5. COMPONENTS & ARCHITECTURE

The philosophy under the EU LLP project V-ALERT is to use free and open-source software tools in order to develop the 3DVWLE. To this aim, an extensive research and comparative study on three popular open-source 3DVW platforms [14] took place at early stages of the project work. During this phase, numerous selection criteria were set based on the user needs and the conceptual design of the simulations, namely, usage friendliness, catchy graphics, flexibility, expandability, compatibility with Learning Management Systems (LMS), possibilities for in-world 3D building/editing, scripting language to embed interactivity, large community support, etc.

The platform of choice is the OpenSimulator (OS) [15], an open-source client-server architecture which can host massive multiuser on-line 3D environments. OS can simulate 3D virtual worlds similar to the popular proprietary Second Life™ (SL) platform [16]. Actually, both platforms share many common features, such as the client software (aka "viewer"), scripting language, 3D object and terrain format, etc. Moreover, like SL, OS can too integrate LMS functionality through the SLOODLE open-source middleware [17] which offers 3D tools that connect OS to the MOODLE open-source platform [18] and seamlessly embed learning material from a MOODLE site in the 3DVW. However, OS offers additional protocols and possibilities on the expandability of the system, allowing the development of external functionality modules. Additionally, any development attempt on OS could benefit from the freely available intellectual outcomes of two very large and active educators' and developers' communities, which is a major advantage. The aforementioned reasons have increased

the popularity of the OS platform within the educational community.

The architecture and the components of the 3DVWLE system are shown in Image 1. A MOODLE web site has been created to facilitate the following two main functionalities:

i. Upload of the IS related educational multimedia material to be embedded in the VW. The material is categorised as "children" and "adults".
ii. Initial user registration and extensive profiles creation based on which the reasoning module system will provide personalised recommendations in-world.

Two OS servers have been deployed which are hosted in Hellenic Open University premises. The servers' configuration is standalone-Hypergrid allowing the users' avatars to seamlessly teleport back and forth in the VWs which are supported by the two servers. This possibility is accomplished through the Hypergrid protocol [19] and was decided as a solution to reduce the overall server workload. The two servers simulate 3D virtual areas which consist of immersive and fully interactive 3D sceneries developed to support the story flow of the individual IS scenarios (Image 2).

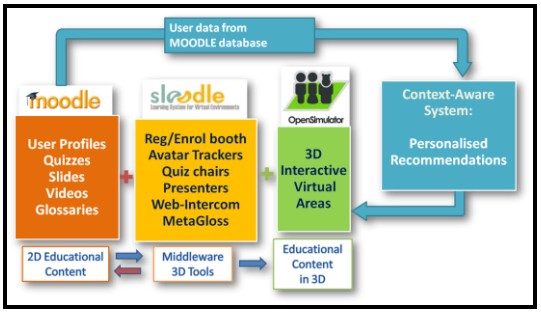

Image 1: System components and architecture

The SLOODLE tools are embedded in the 3D virtual areas as 3D objects, allowing users' avatars to register their profile in MOODLE while being in-world, as well as presenting them the educational material in an engaging way. The SLOODLE 3D objects facilitate the communication between OS and MOODLE by sending and retrieving data between the platforms in real time. In this way, tracking and recording of avatars' performance is achieved. All information is stored in the MOODLE database for further use. In our case, the reasoning module that has been developed, retrieves from the MOODLE database data related to the user profile, the in-world avatar tracking, and the in-world quiz results, processes it and then either offers real-time personalised text recommendations to the avatars through Heads Up-Display objects, or seamlessly adapts the in-world educational material to the user's profile.

6. REASONING MODULE

The aim of this module is to act as a recommender system to assist the user in their tasks within the 3DVW. The recommendations within the 3DVWLE have two goals: a) assist the user in their learning tasks by offering adapted learning content and b) assist the user in their interaction within the 3DVW triggering interactivity of virtual objects or offering guidance through tips and summary of tasks. The reasoning module considers available relevant information such as the context, user's characteristics and user history in order to provide personalized content within the 3DVWLE.

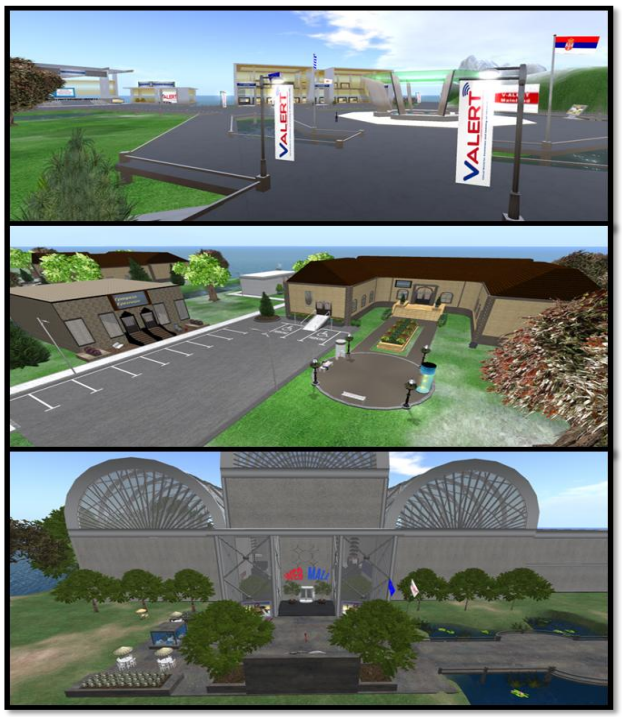

Image 2: V-ALERT 3D Virtual Areas

Challenges

Providing recommendations within a 3DVW is quite challenging in many aspects. The most important challenge is the limited user information available at the time of recommendation. In V-ALERT, the approach used is that the user registers to the system by providing a limited amount of information in their profile and then interacts with the 3DVW through the scenarios. In this aspect, the reasoning module within the 3DVW must be able to facilitate the user in learning about IS through their first experience with the system, even though limited user information is available. As expected, in subsequent user-system interactions where the user interacts more with the 3DVW and therefore more user-oriented information is available, the reasoning module is more able to provide recommendations. Therefore, the user profile, as well as their avatar information is being created and filled with information at the time of user interaction with the system and not at a prior stage (this is the case with the V-ALERT system, however, other 3DVW may follow a different approach). In order to acquire the very basic information about the user, we have designed a user profile that the user fills upon registration. The profile is simple, can be filled easily and quickly even by children, does not demand from the user to write any text and provides interesting information that can later be used by the reasoning module. Such information includes personal and demographic information (age, gender, country, target group), any previous usage experience with 3DVW interaction, as well as experience on the subject of IS, along with the level of assistance the user would like to acquire by the system. The general idea is that

experienced users often need less guidance, while inexperienced users need more. An experienced user may very well be frustrated in case the system offers unnecessary assistance.

Another challenge refers to the recommendation presentation. A user within a 3DVW is constantly on the move interacting with objects, bots and other users, giving less attention to traditional learning methods such as a reading a piece of text. Therefore, a learning module that a user could learn by reading a piece of text in a book will not be successful in the case where the learning takes place within a 3DVW because it would be very difficult for the user to concentrate on reading a book within a VW, not to mention that such an approach would oppose to the whole 3DVW concept, since it is basically a 2D approach. The recommendations should be provided in such a manner that the user will not be interrupted from their current task, will not be forced to interact with something that is boring and out of the 3DVW concept, while at the same time the recommendations will assist them to accomplish the scenario, as well as facilitate the learning process as much as possible.

A third challenge concerns the user context within the 3DVW. Theoretically, context within the 3DVW is easier to acquire than real world context as everything happening with the user, their environment and the system is already sensed, tracked and recorded in the system database and log files. In practice, the problem is that the reasoning module is being asked to provide personalized context-aware recommendations without having yet a considerable amount of context information on the user and their avatar. In addition, due to the fact that the scenarios are relatively short in time and that a large amount of the available time is spent by the user on interacting with their environment, little time is eventually left for the user to read, understand and comprehend the learning material of the scenarios. Therefore, the learning material cannot be comprised of large volumes of information, as it would normally be the case in an ordinary classroom where a whole book chapter can be taught. In the case of presenting any learning material within a 3DVW scenario, the learning material must be restricted in volume, more focused on the learning subject and provided in a format that would attract the users' interest.

Reasoning

Due to the nature of the system and the abovementioned challenges, widely used recommendation algorithms such as Collaborative Filtering and Content-based Filtering could not be utilized. Instead, we have used a Knowledge-based Filtering method that retrieves information from the user profile and past user actions within the 3DVW, determines the level of expertise and experience of the user, as well as how much the user has progressed within the scenario and presents in a non-intrusive manner personalized recommendations. The method uses a Utility-Based Similarity Function as an easy, efficient and effective way to compute the utility of the learning content for each user. Considering a particular user task and learning goal, the Utility-Based Function computes the utility of each piece of learning content against the user and selects the learning content that is more suitable for the user. Then, the reasoning module merges in real time the pieces of learning content with the highest utility into one learning module that is displayed to the user.

Since the 3DVWLE is multilingual supporting English, Greek, Bulgarian, Croatian and Serbian, the implementation of specific translation modules was necessary. The default automated MOODLE language selection mechanism which adapts MOODLE modules based on the user language could not be used in many cases within the 3DVW. This happens since much functionality is provided independently to MOODLE, mainly by the reasoning module which therefore has to additionally handle multilingual functionality. This functionality was developed and embedded within the reasoning module as a user personalization feature, i.e. the user is presented appropriate content in the language that they have selected in their profile.

Following, the personalised recommendation mechanism will be presented in relation to the scenarios.

Recommendations in Phishing/Spam Scenario

The Phishing/Spam scenario has been designed as one-player simulation and aims to educate the user on phishing attacks. The user holds the role of an investigator whose mission is to investigate, resolve and report the phishing attack incident which emptied the school bank account. According to the scenario, the user must find evidence on what had happened and get informed on phishing attacks. Through the analysis of the evidence and clues collected through their interaction with the virtual environment, the user must discover the attackers' lair and report everything to the Investigation Department. This simulation foresees two "turning points" at which the user's gained knowledge is tested through quizzes. Only when the user succeeds in these quizzes can proceed to the subsequent "episode" of the story.

Within the Phishing scenario three different ways of providing the recommendations to the user are supported:

- Head-Up-Display (HUD): an informational display that may appear at user's will upon their screen,
- Phishing Presenter: a personalized multilingual slideshow of phishing information that the user is able to observe and interact with within the 3DVW,
- Quiz Customization Module: updates the content presented to the user through the School Library quiz, as well as provides tips to the user on what to do while interacting with the Inbox Quiz.

Recommendations in Identity Theft Scenario

The aim of this scenario is to educate users on identity theft threats. Users, especially small children and teenagers, can become victims of identity theft as they overlook many potential threats including sharing too much personal information on social networking sites, trusting and talking to strangers they meet on these sites, posting dates of birth and other personal information at online job sites, storing personal information on mobile

phones that can easily be lost or stolen, etc. Within the scenario the user is located at a shopping mall and the goal is to receive the free ticket for the entrance to a premiere of a movie. Seats are limited and the user must act quickly as other users also look to find this ticket. The user must visit the stores within the shopping mall and answer quiz questions provided by the reasoning module, aiming to make them reveal sensitive information about themselves that later will be used to evaluate their performance in the scenario. In return, the system offers gifts such as avatar clothes, and in addition, for every question they answer a letter of the password that grands their access to the cinema, is revealed. In this manner, by being offered gifts and access to the cinema the user incorrectly provides sensitive information, which is the educational aspect of this scenario.

The reasoning module evaluates the user's responses and assigns two scores to each user: the first score is positive (the higher the better) and is related to the amount of correct answers the user has provided. The second one is negative (the lower the better) and concerns the amount of sensitive information the user has provided to the system. A central public board displays the top users by the first score, and at the same time attaches a "smiley face" next to the winners' names that reflects the second score. The face is happy if the user has not revealed any personal information, sad if they have revealed some information and very sad if they have revealed too much information.

Recommendations in Social Network Scenario

This scenario is related to threats that concern social networking activities, such as publicly revealing sensitive information through Facebook. In this scenario there is a cafeteria called SocialSpace. To enter the cafeteria, users need to make a number of security selections by answering questions such as those related to privacy settings within Facebook (e.g. who can see your photos?). Moreover, there exist a number of questions that reveal user's personal info.

The reasoning module is responsible to display the above questions to the users, acquire their answers and then guide other users having a special admin role (e.g. a teacher as in a role-playing game) or bots, on how to approach those users that have responded to the above questions in order to attempt to receive friend request acceptance by them by deception. If a user accepts the request, they have become victim of social network risk. Moreover, the reasoning module ranks the users by their success in completing the security selections: successful users go on top.

7. EVALUATION

The formative evaluation of the alpha version of the 3DVWLE has been conducted at the premises of University of Cyprus (UCY) and Hellenic Open University (HOU), by using the Phishing/Spam scenario. The scope of the evaluation was to primarily engage a small number of end users in interacting with the system for the first time in order to acquire important user feedback on usability issues, such as in-world avatar navigation, movement and interaction with 3D objects, system response, usability of the viewer controls, etc. Since the development was still in progress at that time, this testing would also enable the developers to get feedback from real users and understand whether the implemented scenario is easy to use, and whether users would be able to successfully accomplish all learning tasks within the specified time.

During the formative evaluation phase, 22 users in total, ICT students and administrative staff, males and females, with ages ranging from 22 to 40, participated in the testing. The users were asked to evaluate the system, the educational effect and their experience in the 3DVW as a whole. Before the actual evaluation, the users were offered a 20-minutes training session in-world, so as to get familiarised with the basic controls of the viewer software in order to be able to move their avatar, control the world camera and learn the basic interaction modes of the simulations. After the training they were asked to use the SLOODLE Registration booth found in the V-ALERT Mainland to register their profile and avatar in MOODLE. Following, they teleported to the Phishing/Spam one-player simulation and followed the steps of the story described in the Head-Up-Display (HUD) and the infocard (aka "notecard"), two scripted virtual objects that are automatically offered by the platform to the avatars when they first enter the simulation. The HUD and the notecard are stored into avatar's inventory and are always available for further review.

The users were advised to explore the 3D virtual environment, interact with objects and pay attention to the received feedback. From then on they were left to act freely and make decisions in order to complete their mission. At the end of the evaluation procedure, the users were asked to complete a questionnaire which aimed to investigate their opinion on usability issues, the Phishing scenario simulation as a learning mechanism and to indicate any weaknesses. The official pilot evaluation of the final version of the 3DVWLE with all its scenarios is planned to start at the beginning of October 2015 and it is going to take place in all partner countries, engaging members from all user target groups.

8. RESULTS & CONCLUSION

Most of the users (19 out of 22) managed to complete the scenario within 30 minutes which was the predefined time for this session. The preliminary results were positive and encouraging. The users did not face problems related to system stability and response, though most of the users were not able to directly identify which virtual objects were interactive and offered crucial information. Also, they expressed the need for clearer mechanisms that offer in-world help on navigation, such as labels, signs, arrows, etc. The users, inexperienced of virtual worlds in their vast majority, initially faced difficulties with the avatar navigation inside the buildings and controlling the camera. Though they enjoyed their participation and found the simulation challenging and attractive. They admitted that frequent usage definitely would lead to improvement and agreed that the pre-evaluation training

was necessary and helpful. Moreover, they mentioned that they had actually learned things about Phishing attack and also realised how to distinguish legitimate and phishing emails.

Based on these results, specific improvents were revealed. In order to improve the system's quality, functionality and educational value it was necessary to a) enhance the pre-evaluation training session, b) make improvements to the simulation's navigation tools and guiding mechanisms to be more obvious to the inexperienced users, c) make interactive objects that are crucial for the plot more eye-catching and d) avoid long textual in-world feedback or guidance which could distract the user from their task and downgrade their feeling of immersion. Concerning the reasoning module, the users found that it is helpful enough and they enjoyed the way they had been provided with the recommended information, although some information presented in the HUD was too extensive and thus frustrating. They also stated that they liked the idea of being projected with personalized information and adapted content based on their needs and native language and did not have any negative comments on the recommendations offered during the Phishing simulation. All comments and user feedback have been taken under consideration for the final version of the 3DVWLE.

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