Personalized Context-Aware Recommendations In 3D Virtual Learning Environments

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ABSTRACT
The employment of 3D Virtual World (VW) platforms in an educational field is an emerging phenomenon that enlarges the concept of learning environments, providing users technology that creates an immersive learning experience. This is one of the main reasons for the selection of a 3D VW platform for the development of an innovative and motivating tool under an umbrella of a V-ALERT project. The project aims to support the establishment of Information Security culture through providing awareness and facilitating learning process using the developed 3D Virtual World Learning Environment (VWLE). The provision of recommendations to users within 3D VWLE is a novel research field and to the best of our knowledge there are no publications in the field. This paper aims to provide an insight into the design and development of a context-aware recommendation in the V-ALERT 3D VWLE that considers available relevant information such as the context, user (learner) individual characteristics and user history to provide personalized content to assist the user during the learning activities. The paper also offers results of pilot usability evaluations which will be taken under consideration in the final, redesigned version of the 3D VWLE.

Keywords: 3D virtual world learning environments (VWLE), user individual characteristics, context-aware recommendations, learning experience

INTRODUCTION
Numerous 3D Virtual Worlds 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 a 3D VW platform for the development of an 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 the V-ALERT project, as teaching and training applications in VWs seem to offer remarkable benefits to students. The V-ALERT project, co-financed by European Commission under the Framework Lifelong Learning Programme, aims to support the establishment of Information Security (IS) culture through providing awareness and facilitating learning process using the developed 3D Virtual World Learning Environment (VWLE).

The aim of this paper is to provide an insight into the design and development of a context-aware recommendation system in the V-ALERT 3D Virtual World Learning Environment that considers available relevant information such as the context, user (student) individual characteristics and user history in order to provide personalized content to assist the user during the learning activities within the 3D VWLE. First, a number of challenges are discussed including the design of a user profile, the presentation of the recommendation, the issue of context in the 3D VW as well as the presentation of the learning material within 3D VW scenarios. Second, due to the nature of the system and the challenges mentioned, a selection and usage of a Utility-Based Function is explained. The Utility-Based Function is 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, it retrieves information from the user profile and past user actions within the 3D VW in order to determine the

level of expertise and experience of the user, as well as how much (s)he has progressed within the scenario and computes personalized recommendations that are then displayed to the user in a non-intrusive manner. Third, an Information Security awareness scenarios developed in the context of the V-ALERT project are briefly addressed, specifically Identity Theft, Phishing/Spam, Social Engineering and Strong Password. However, for the needs of this paper, the personalised recommendation mechanisms are presented in relation to the Phishing/Spam scenario, which has been designed as an one-player simulation and aims to educate the user on phishing attacks. Within the Phishing scenario three different ways of providing the recommendations to the user are supported: (i) the Head-Up-Display (HUD) as an informational display that may appear at user's will upon her/his screen, (ii) the Phishing Presenter as a personalized slideshow of phishing information that the user is able to observe and interact with within the 3D VW, and (iii) the Quiz Customization Module which updates the content presented to the user through the School Library quiz of the Phishing scenario, as well as provides tips to the user on what to do while interacting with the Inbox Quiz. Finally, the paper brings some results of the preliminary testing with a small number of users to acquire important user feedback on usability issues. Within the final evaluation framework of the 3D VW the recommendation module will be evaluated as a separate module in order to obtain more detailed user feedback on the recommender system.

3D Virtual Worlds and Education

Although various definitions of the Virtual Worlds (VW) have been proposed by different authors, one commonly accepted definition does not yet exist. Basically virtual worlds could be considered as persistent virtual environments in which people experience others as being there with them and where they can interact with them (Schroeder, 2008). VW is a computer-based online community environment that is designed and shared by individuals so that they can interact in a custom-built, simulated world. Users interact with each other in this simulated world using text-based, two-dimensional (2D) or three-dimensional (3D) graphical models called avatars.

The 3D Virtual Worlds platforms are innovative and sophisticated ICT technology that provide tools for the creation of highly immersive 3D graphical and interactive on-line 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. Currently the most popular VW platforms 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 are Second Life, Active Worlds, Jibe and Unity as examples of proprietary 3D VW platforms and on the other hand OpenSimulator, OpenWonderland and OpenCobalt as examples of open source platforms.

The development and usage of 3D Virtual World platforms in an educational field is an emerging phenomenon that challenges and enlarges the idea of learning environment (Za and Braccini, 2012). The aforementioned characteristics of the 3D VWs could potentially transform these environments to "educational virtual environments". According to Mikropoulos and Natsis (2011) an Educational Virtual Environment (EVE) or Virtual Learning Environment (VLE) can be defined as a virtual environment that is based on a certain pedagogical model, incorporates or implies one or more didactic objectives, provides users with experiences they would otherwise not be able to experience in the physical world 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.

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 (Daden, 2014). 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. However, 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, for example "goal-based scenario approach" which intent is to provide motivation, a sense of accomplishment, a support system, and a focus on skills rather than facts (Schank, 1996).

V-ALERT: Virtual World for Awareness and Learning on Information Security

The V-ALERT project is co-financed by European Commission under the Framework Lifelong Learning Programme / Key Activity 3 – ICT / Multilateral Project (V-ALERT, 2015). 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 the V-ALERT project. An on-line 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.

Additionally, the V-ALERT project aims to design and develop/adapt appropriate context-aware recommendation algorithms and methods that will use available user (student) model/profile, the context and any social information (if feasible) to provide personalized recommendations to assist the student during the learning activities within the 3D VWLE. The implemented recommendation algorithms consider the context, both real world context i.e. student's individual characteristics (for example background, competences, different abilities, experience, learning style) as well as VWLE related context i.e. student actions within the 3D environment, virtual character information, interactions with other objects and characters within the 3D environment, and alike.

CONTEXT-AWARE RECOMMENDER SYSTEMS

Recommender systems have attracted the research community's interest for the past fifteen years. Many techniques have been proposed, as well as many extensions and improvements, but it was not until recently that the research community realized that recommenders have only been using a part of the available information for producing recommendations. The problem was that traditional recommenders do not utilize the context. Instead, they focus on two dimensions, the user and the items (also called two-dimensional recommenders), excluding other contextual data that could be used in the recommendation process, such as the day/time, with whom the user is with, weather conditions, and a like.

Context-awareness is the process of sensing/acquiring information relevant to the user while interacting with a computer system. The information can be about any person, place or object that is considered relevant to this interaction, including the user and system themselves (Dey, Abowd and Salber, 2001). Hartmann and Austaller (2008) note that context characterizes the actual situation in which the application is used; it refers to information as context that can actually be processed by an application (relevant information), but that is not mandatory for its normal functionality (auxiliary information).

Adomavicius and colleagues were among the first to prove that contextual information incorporated in the recommendation process indeed improves recommendations; they proposed that the recommendation procedure should not be two-dimensional but rather multi-dimensional, introducing CARS, the Context-Aware Recommender Systems (Adomavicius, Sankaranarayanan and Tuzhilin 2005; Adomavicius and Tuzhilin, 2008). Context-Aware Recommender Systems cover a wide spectrum of different research areas of computer science and information technology, with the field of e-learning as one of the most important, see for example (Verbert, Ochoa, Wolpers, Drachsler, Bosnic and Duval, 2012).

CONTEXT-AWARENESS AND RECOMMENDER SYSTEMS IN E-LEARNING

In learning, the adoption of context-awareness is not a new idea; it has been demonstrated in relevant systems for quite some time. Classical methods, such as those encountered in early intelligent tutoring systems (Wenger, 1987) and student modelling (Brusilovsky and Schwarz, 1993) can all be regarded as context-aware approaches used as adaptation methods. In order to be effective and usable, at the same time supporting individualization of learning, e-learning applications need to adapt continuously to their users as they gain more domain knowledge and task experience while learning.

In general, adaptive systems commonly implement dynamic adaptation on the basis of system assumptions about the user, inferred by monitoring user's interaction and stored in user model (Kobsa, 1995). While acknowledging that differences among individuals have an effect on learning, as of now, user modelling in the e-learning field has not yet successfully addressed the variety of the learning environment in terms of personalization and individual user profiles, especially at the initial stages of e-learning system use (Granić and Adams, 2011). Even though some user individual characteristics can be assimilated by users' education or by interface redesign, a

number of these differences will certainly need to be accommodated through adaptive interface, thus engaging a user model in an e-learning system. In web-based learning student's individual characteristics have a more and more significant role and can even became a crucial factor of student's success or failure (Nakić, Granić and Glavinić, 2015). Recent adaptive educational systems, most of them web-based, promise to offer adaptation with respect to the presentation of the learning material, the navigation support, the curriculum sequencing as well as problem solving support, see for example (Yang, Hwang and Yang, 2013). Consequently adaptive interfaces can be the starting point for depicting the significance of context-awareness in e-learning applications.

Context-awareness is also used by recommender systems for the e-learning domain. Such systems utilize the context in order to provide personalized recommendations that will assist the user and enhance the learning process. Drachsler (2009) states that two approaches can be followed when developing recommender systems for education:

- top-down approach (facilitating formal learning) where the structure and learning materials are maintained by domain professionals and
- bottom-up approach (facilitating informal learning) in the rest of the cases where learners by themselves interact with information sources shared in the network.

Manouselis, Drachsler, Vuorikari, Hummel and Koper (2011) provide a review on recommender systems in the Technology Enhanced Learning (TEL) domain. Most common approaches however, focus on recommending suitable materials or learning activities without considering the context (Santos and Boticario, 2010). The context in the e-learning domain includes from simple web resources to more interactive activities such as on-line exercise activities, reading messages on forums even running on-line simulations (Zaiane, 2002).

ENHANCING THE 3D VWLE WITH CONTEXT-AWARE RECOMMENDATIONS

To the best of our knowledge, the provision of recommendations to users within a 3D Virtual World Learning Environment (VWLE) is a novel research field and no relevant works exist in the bibliography. The aim of this paper is to provide an insight into the design and development of a context-aware recommendation system that considers available relevant information such as the context, user (student) individual characteristics and user history in order to provide personalized content to assist the user during the learning activities within the 3D VWLE. First, a number of challenges are discussed including the design of a user profile, the presentation of the recommendation, the issue of context in the 3D VW as well as the presentation of the learning material within 3D VW scenarios. Second, due to the nature of the system and the challenges mentioned, a selection and usage of a Utility-Based Function is explained. Third, the personalised recommendation mechanisms are presented in relation to the Phishing/Spam Information Security awareness scenario. Finally, the paper brings some results of the preliminary usability testing conducted in order to acquire important student feedback.

Challenges

Providing recommendations within a 3DVW is very 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 her/his profile and then interacts with the 3DVW through the scenarios. In this aspect, the recommender system within the 3D VW must be able to facilitate the user in learning about information security through her/his 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 3D VW and therefore more user-oriented information is available, the recommender system is more able to provide recommendations.

Based on the above, the most important challenge is that the user profile, as well as her/his 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 3D VW 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 with information upon registration. The profile is simple, can be filled very 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 recommender. Such information includes personal information (age, country, target group, etc.), whether the user has previous experience with 3D VW interaction and on information security matters, along with the level of assistance the user would like to acquire by the recommender. The general idea is that experienced users often do no need to be guided, while inexperienced users do.

Another challenge regards the recommendation presentation. A user within a 3DVW is constantly on the move interacting with objects, bots (system controlled avatars) and other users, giving less attention to traditional learning methods such as a piece of text. Therefore, a learning module that a user could learn by reading a piece

of text in a book in the traditional learning method, will not be successful in the case where the learning takes place within a 3D VW 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 3D VW concept, since it is basically a 2D approach. We state that the recommendations should be provided in such a manner that the user will not be interrupted from her/his current task, will not be forced to interact with something that is boring and out of the 3D VW concept, while at the same time the recommendations will assist to accomplish the scenario, as well as facilitate the learning process as much as possible.

The third challenge concerns the user context within the 3D VW. Theoretically, context within the 3D VW is easier to acquire than real world context as everything happening with the user, her environment and the system is already sensed, tracked and recorder by the 3D VW in the database and log files. In practise however, the problem is that the recommender is being asked to perform, i.e. provide personalized context-aware recommendations without having yet a considerable amount of context information on the user and her/his avatar. Therefore, while the recommender can know the places the user has been within the 3D VW, it cannot come to a real, safe conclusion on the places the user prefers until the system is being used by her for an extensive amount of time. This problem is known in the Recommender Systems literature as the "Cold Start" problem.

Finally, another important challenge is that, due to the fact that the scenarios are relatively short and that a large amount of time is spent by the user on interacting with her environment, little time is eventually left for the user to 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 class within a classroom where a whole book chapter could have been taught. In the case of presenting learning material within a 3D VW 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.

Scenario-based Simulations

In the context of the V-ALERT project and according to the results of the user needs analysis, various Information Security awareness scenarios have been developed, specifically Identity Theft, Phishing/Spam, Social Engineering, Strong Password. Some of these are oriented to all envisaged target groups, that is pupils, teachers, ICT students, academics and employees, whereas one scenario is designed as role-play game especially for pupils and teachers.

The conceptual design of the scenarios and their virtualisation approach has been based on the principles of experiential learning, also considering instructional design strategies related to situated learning in immersive 3D virtual world simulations. The "branching scenario" approach has been used as a form of storytelling. 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 path or "branch". All scenario-based simulations of the V- ALERT put the user in a "role", motivate them to explore the 3D virtual environment, while offering sequences of tasks which the user must complete in order to accomplish the scenario-defined goal and successfully complete their mission. As the simulation progresses, the embedded educational content is presented as part of the plot and the knowledge gained can eventually be used for the completion of the following tasks. The non-completed tasks may either lead to other situations which place the user to experience the negative consequences, or simply prevent them from proceeding. In the end, all scenarios provide the user with general feedback on Information Security threats and preventing actions.

Special attention has been drawn on issues such as user's meaningful interactivity with objects and computer-driven avatars (bots), level of difficulty and total duration of the scenario, clear feedback on the goal and the reasons of success or failure. To this aim the provision of the personalised recommendations have been of great importance.

Recommendation Algorithm and Provision of Recommendations

The recommendations within the V-ALERT 3D VWLE have two goals: firstly facilitate the user in her/his learning task by offering learning appropriate content and secondly to assist the user in her/his interaction within the 3D VW and offer guide through the scenario by providing tips, summary of tasks and the like.

Due to the nature of the system and the above-mentioned challenges, well known recommendation algorithms such as Collaborative Filtering and Content based Filtering could not be utilized. Instead, we have used a Utility-Based Function that retrieves information from the user profile and past user actions within the 3D VW in order to determine the level of expertise and experience of the user, as well as how much the user has progressed

within the scenario and compute personalized recommendations that are then displayed to the user in a non-intrusive manner. The Utility-Based Function is 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 recommender system merges in real time the pieces of learning content with the highest utility into one final learning module that is projected to the user.

For the needs of this paper, the personalised recommendation mechanisms will be presented in relation to the Phishing/Spam scenario. The Phishing/Spam scenario has been designed as one-player simulation (Figure 1) and aims to educate the user on phishing attacks. The user holds the role of 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 could have happened and get informed on phishing attacks.

Figure 1: The virtual area for the Phishing simulation.

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 (Figure 2). This simulation foresees two "turning points" where the user's gained knowledge is tested through a quiz. Only when the user succeeds in the quiz 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:

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

Figure 2: The Investigation Department of the Phishing simulation.

The Head-Up-Display (HUD) is an informational display that may appear at user's will upon her/his screen (Figure 3). The HUD aims to assist the user in interaction within the 3D VW and guide her/him through the scenario by providing a summary of tasks and tips on what the user may/should do within the scenario. The information provided is personalized in the aspect that it reflects the experience and expertise of each user. The idea is that experts and experience users require (and often demand) less instructions regarding the tasks in order to find the scenario interesting and challenging. The HUD is projected in a see-through mode on user screen so that the user can be advised while continuing activities within the scenario.

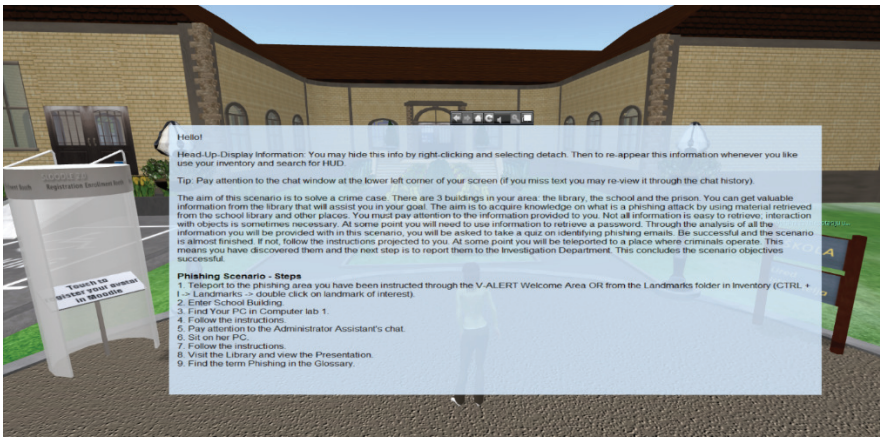

Figure 3: The HUD is projected in a see-through mode on user screen.

The presenter is a personalized slideshow of phishing information that the user is able to observe and interact with within the 3D VW (Figure 4). The recommender system updates the content of the presenter according to the user profile information and user actions. In this manner, the user is being projected with learning content that is appropriate to her/his needs and educational level.

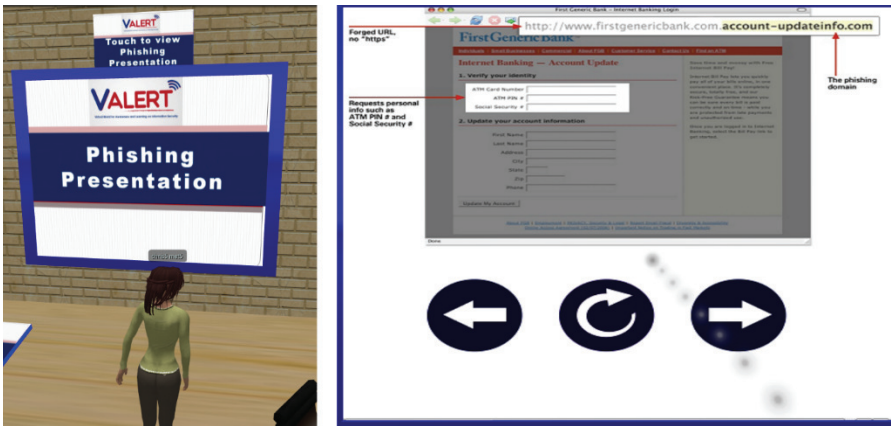

Figure 4: The Phishing Presenter with which the user can interact to learn about phishing.

This recommendation module updates the content presented to the user through the School Library quiz of the Phishing scenario (see Figure 5), as well as provides tips to the user on what to do while interacting with the Inbox Quiz (Figure 6). More to the point, based on the user's experience, expertise, target group and other personalized information, as well as based on user past actions (if available), the recommender updates the Library Quiz with questions appropriate for the particular user. Since the questions are part of the phishing learning content, by providing questions appropriate for the particular user's needs and educational level, we enhance the learning process of the user.

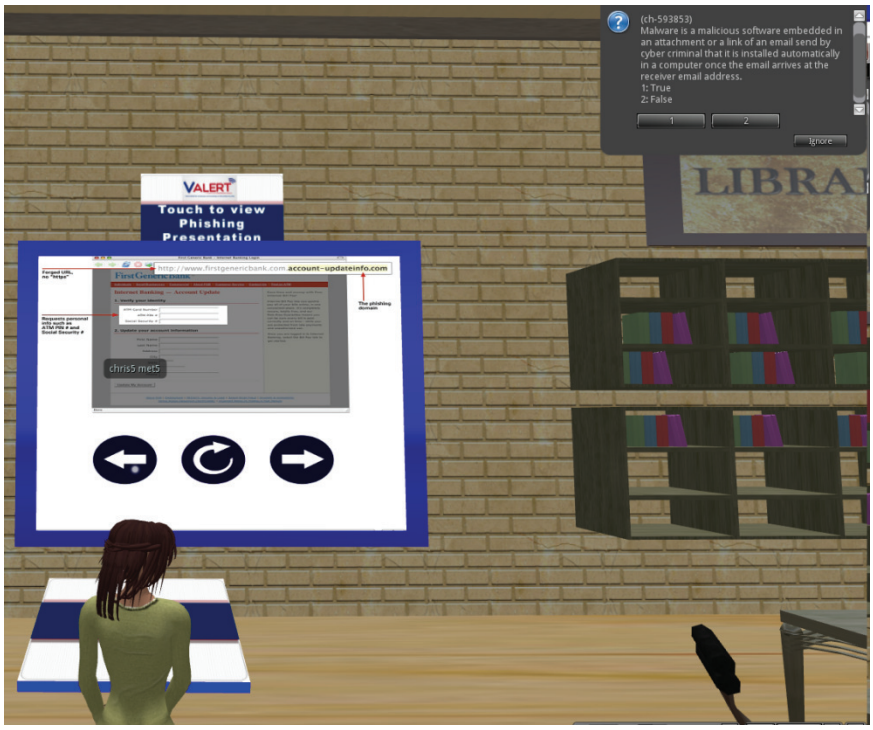

Figure 5: The School Library quiz of the Phishing scenario: each question is presented in the upper right corner of the user's screen.

Moreover, the recommender system monitors the attempts of the user on the quizzes and provides useful tips to her/him while interacting with the Inbox Quiz (Figure 6). The goal is to assist the weak learner with her learning task, ensuring that the user will not get frustrated in case the learning tasks prove challenging for the user.

Figure 6: Inside the "INBOX": The emails as numbered boxes, the quiz chair that initiates the quiz and the recommender system monitor which provides the user with personalised recommendation tips.

USABILITY TESTING OF THE DEVELOPED 3D VWLE

The testing of the alpha version of the V-ALERT 3D VW has been conducted at the premises of University of Cyprus (UCY) and Hellenic Open University (HOU) and aimed primarily to engage a small number of 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. Since the development was still in progress, this testing would also enable V-ALERT 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.

In the UCY premises a total of 6 users were engaged, all university students (ages 22-25). In the Software Quality Lab of HOU a total of 16 users, educators and administrative staff, were engaged (ages 25-40). The evaluation however did not concern the recommender system per se. Rather, the users were asked to evaluate the system as a whole as well as their experience in interacting with the 3D VW in order for the development team to detect malfunctions and usability problems. Before the evaluation, the users were offered a 20-minutes training session in-world so as to get familiarised with the basic viewer controls to be able to move their avatar, control the world camera and learn the basic interaction modes. After the training they were asked to enter the Phishing/Spam simulation and follow the steps of the story that they would receive through the Head-Up-Display (HUD) and an infocard (or "notecard") which are both scripted virtual objects and are automatically offered by the platform to the avatar when she first enters the simulation. The HUD and the notecard are stored into avatar's inventory and are always available for further review.

Also, they were advised to explore the 3D virtual environment, interact with objects and pay attention to the received feedback. From then on they were free to act and make decisions in order to complete their mission. Most of the users (19 out of 22) managed to complete the scenario within 30 minutes which was the pre-defined time for the testing. At the end of the evaluation procedure, the users were asked to complete a questionnaire which aimed to investigate their opinion on the aforementioned usability issues, the Phishing scenario simulation as learning mechanism and to indicate any weaknesses.

Regarding the evaluation results for the Phishing/Spam scenario, when users were asked whether the recommender system was helpful and whether it provided added value to the system, the users mentioned that they liked the way they have been provided with the recommended information, although the information presented in the HUD was at some occasions too extensive. They also stated that they liked the idea of being projected with personalized information based on their needs and did not have any negative comments on the recommendations within the Phishing scenario.

CONCLUSION

The V-ALERT project, co-financed by European Commission under the Framework Lifelong Learning Programme, aims to support the establishment of Information Security culture providing awareness and facilitating learning activities using the 3D Virtual World Learning Environment (VWLE). The paper provides an insight into just one segment of the project, the development of a context-aware recommendation system in the V-ALERT 3D Virtual World Learning Environment. The goal of recommendations within the3D VWLE is

two-folded: (i) to facilitate and enhance the user in learning process by offering learning appropriate content and (ii) to assist the user in interactions within the 3D VW offering guide through the scenario by providing tips or summary of tasks. In the context of the V-ALERT project a number of Information Security awareness scenarios are developed. However for the needs of this paper, the personalised recommendation mechanism is presented in relation to the Phishing/Spam scenario where three different ways of providing the recommendations to the user are supported: the Head-Up-Display (HUD), the Phishing Presenter and the Quiz Customization Module.

According to the preliminary evaluation results, the majority of the users found the phishing simulation challenging and interesting, although, initially, most of them faced difficulties in avatar navigation inside the buildings as well as the camera controls. However, they also admitted that frequent usage definitely would lead to improvement and all of them agreed that the pre-evaluation training is necessary and helpful. Additionally, the results showed that 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, arrows, etc. All comments and user feedback will be taken under consideration in the final version of the 3D VWLE of V-ALERT. Our future plan is to include the recommendation module as a separate module for evaluation within the final pilot evaluation framework of the 3D VW in order to obtain more detailed user feedback on the recommender system targeting its improvement.

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