TOWARD SUCCESSFULLY INTEGRATING MINI LEARNING GAMES INTO SOCIAL VIRTUAL REALITY ENVIRONMENTS – RECOMMENDATIONS FOR IMPROVING OPEN AND DISTANCE LEARNING

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Abstract

Social virtual reality environments, also known as 3D virtual immersive environments, are three-dimensional computer-generated virtual spaces that are increasingly used in attendance-based and distance education. Thanks to their unique characteristics that separate them from two-dimensional virtual learning environments, social virtual reality environments can enhance distance education efficacy when used in combination with applying instructional methodologies such as situated learning, experiential learning and game-based learning.

The authors of this paper describe the design and findings of a research study on game-based learning in social virtual immersive environments. The research methodology of the study incorporated a mixed approach for evaluation; the participants answered to a survey and participated in semi-structured interviews.

More specifically, the paper exposes the design and the implementation of two mini serious games as proof of concept for the supplement of a postgraduate course on Cybersecurity in the University of Washington, USA. These social learning experiences were constructed taking into account various game mechanics and components designed to increase their appeal to most game player types. The games featured narrative, rules, team collaboration, competition, challenges, achievements, surprises, levels, rewards, choice, feedback, scoring, time-pressure, exploration.

The findings of the study showed that the participants in distance education programmes i) think that playful experiences in 3d social virtual reality are beneficial for their learning and ii) they value learning activities based on active participation and social interaction. The findings from the study also confirmed that the steep learning curve of new users in 3d virtual immersive environments is an obstacle for learning that needs to be addressed meticulously.

The paper authors illustrate how social virtual reality environments enable educators to create interactive exhibits and 3d content as well as entertaining social experiences of learning value in order to illustrate and visualize real Cybersecurity practices. In addition, it is explained how programming in virtual reality environments helps participants to experience intangible notions such as malware and behavioral patterns with the help of storytelling and visual metaphors. Overall, the authors offer recommendations on the effective use of game-based instructional approaches such as serious games, gamification and play in virtual immersive environments for educational purposes. Game-based learning experiences should be crafted in close conjunction with the course's learning outcomes. A course-wide narrative can help overall participants' engagement and content retention. The thinking styles of the participants and their learning preferences should also influence rapid tweaking of game parameters in programming and general curricula design decisions in order to accommodate epistemological needs and particular knowledge desires.

Keywords: Open and Distance Learning (ODL), serious games, virtual immersive environments, e-learning, gamification, game-based learning.

1 INTRODUCTION: VIRTUAL REALITY AND EDUCATION

Virtual reality (VR) is a technological field with origins in the 1960s [1], but has re-emerged in recent years with the promise to offer sensory immersion [2] into virtual environments. VR environments are currently used mainly for entertainment [3] but also for educational purposes [4]. So far most new VR platforms offer environments for single-player experiences. A new generation of sensor-based Social

VR Environments (SVREs) are expected to arrive in the coming years [5]. Regards education, developers often do not take into account the long experience in immersive education [6] and tend to "reinvent the wheel" or present already well-documented characteristics as novelties [7]. It is wise and practical to remember that text-based social VR environments had been used successfully for educational purposes decades ago [8]. The next desktop-based SVREs, also known as 3D virtual immersive environments (3D VIEs) or multi-user virtual environments (MUVEs) or 3D virtual worlds, are three-dimensional computer-generated virtual spaces that offer social immersion, and are increasingly used in attendance-based and distance education [9]. SVREs offer unique characteristics that separate them from two-dimensional virtual learning environments; they feature a superior sense of self since the participant controls his or her embodied representation or agent, the avatar [10]. This creates the sense of being in a space experiencing a prevalent power of co-presence when meeting with other avatars [11]. The identification with one's avatar in a virtual environment can have profound psychological impact on behavior and learning [12]. However, just like other novel systems, desktop-based SVREs faced early the trap of routinization [13], the tendency to use new tools to replicate old, existing methods instead of striving for new solutions.

In this paper, the authors describe how they designed and implemented mini serious games in a SVRE so as to accompany virtual lectures and improve the quality of learning for a postgraduate university course. In the next sections the paper includes the presentation of the design and results of a research study on the quality of learning.

2 IMMERSIVE EDUCATION

Immersive Education is the use of SVREs for teaching and learning, targeting to facilitate the social and psychological immersion of participants into a compelling, realistic learning experience that engages multiple senses. Immersive educational experiences in SVREs can act as a synthesis of learning activities that can help participants achieve learning outcomes in multiple domains. In each domain, one can pursue the attainment of skills and abilities in various levels of sophistication and mastery organized in a taxonomy. As described in the Cybergogy Blended Taxonomy for Learning Domains model [14], immersive educational experiences can be used to facilitate the enhancement of competences in four intersecting domains [15]: Cognitive (intellectual); ranging from remembering and understanding up to creating [16]; Emotional (perceiving, integrating and managing emotions and feelings); ranging from perceiving to influencing; Dextrous (virtual kinesthetic skills such as doing, being, moving, organizing, communicating); ranging from imitating to mastering; Social (fostering the sense to community, collaboration); ranging from personalising to channeling.

More specifically, SVREs enable educators to enhance the quality of both attendance-based teaching [17] and distance learning [18], [19]. Some approach to achieve this is the application of socio-constructivist instructional methods such as situated and experiential learning [20], [21], simulated [22] and game-based learning experiences [23] to achieve deep learning [24]. Deep learning occurs when students are actively involved and are given opportunities to construct meaning [24], [25] and metacognitive skills in deep levels of processing [26]. In so doing, students should be able to transform the course's concepts to personal (learning) experiences and competences.

2.1 Learning Motivation through Games and Play

In the quest for deep learning in education, motivation enhancement strategies [27] can be used to engage participants in active learning experiences. Strategies such as Game-based learning (GBL), Playful Design, Serious Games and Gamification [28] have become popular elements and concepts for teaching and learning innovation for classroom-based and distance education [29]. These methods have successfully been applied in education [30] and e-learning [31]. Games, in particular, have been frequently used to enhance and facilitate learning [32], [33] by increasing students' intrinsic motivation [34]. Nonetheless, the value of game and play for learning is not new. Plato argued in favor of the value of play and positive motivation and voluntary participation in education: "Do not, then, my friend, keep children to their studies by compulsion but by play" [35]. Serious (or epistemic) games comprise a set of meaningful choices with a primary educational purpose [36]. Serious games can be used as appropriate learning experiences according to Vygotsky's zone of proximal development [37]. Studies have shown that serious games can be very effective learning tools in multiple fields [38]. Mini games in education are 'bite-sized' activities with limited learning purposes and of short duration that can be played in the context of a broader course [39]. Otherwise, mini serious games are sophisticated, interactive learning experiences.

The design of games should consider players' (learners') preferences and favourite styles of thinking and play. Early studies have identified four basic player types and styles: explorers, achievers, socializers and killers [40]. Explorers value freedom and discovery, achievers strive for completion and high scores, socializers focus on collaboration and communication, while killers prefer competition.

3 DESIGNING THE MINI SERIOUS GAMES

The *Foundations of Organizational Information Assurance (IMT 551)* was a course module offered as part of the Information Security Specialization, one of the six paths of study in the University of Washington (UW), at the MSc in Information Management (MSIM) degree programme. The course took place fully online with weekly lectures. For the premises of lecture 9 on Security in Social Media, the class session was scheduled to take place in the UW's island in the social virtual reality platform Second Life.

Aspiring to showcase the potential of Social Virtual Reality in this domain, we proposed as a proof of concept the development of a mini serious game to supplement the scheduled class. "Cybersecurity Challenge Game Level I" was developed rapidly and had an average playing time of 30 minutes. After the successful implementation of the game, we added the sequel, "Cybersecurity Challenge Game Level II". These mini serious games were constructed as social learning experiences taking into account various games' mechanics and components to increase their appeal to most game player types. The games featured a narrative, rules, team collaboration, competition, challenges, achievements, surprises, levels, rewards, choice, feedback, scoring, time-pressure, and exploration. Level I was a role-playing team competition that required group collaboration. The participants as cadets had the task to earn their gear, a shield and a sword by facing hostile animals they could locate by exploring the surrounding environment. The animals would ask them content-related questions and if answered correctly, players received the awards and earn points. The team with the most points were the game winners.

Figure 1. Snapshots from Level I and Level II mini serious games respectively

In Level II both teams received a mandate, the disarmament of a huge bomb set to explode in 50-60 minutes. The members of each team had to disperse and collect evident, maintain group communication, navigate a maze to find a hidden passage, and solve puzzles related to the course's content. Meanwhile, they faced unforeseen surprises that emulated online behaviours related to cyber safety; e.g. clicking on appealing 'malware' objects caused their avatars to become disfigured and they had to find the cure in healing waters. This level took place in the Cybersecurity island, an environment designed and developed by graduates of the University of Washington's Virtual Worlds certificate program [41].

> *Breaking News! The University of Washington has just been the target of a large scale cyber-attack! Homeland Security located the suspects who are currently on the run. Before escaping they placed a huge time-bomb in the central of the island! [] You are a member of one of two elite Cybersecurity teams that are deployed to find clues about the attack, their techniques and the hidden Steganography keep before the bomb explodes! []*
>
> (Exerpt from the Cybersecurity Challenge Game Level II initial briefing)

Figure 2. Scenes from Level II serious game (disfigured avatar and maze exploration respectively)

4 RESEARCH METHODOLOGY

As ODL and Open Education are becoming mainstream in all levels of Education worldwide, there is a constant quest to improve and safeguard learning quality [42]. Our initial intention was to see if online teaching can be enhanced using mini games and playful elements. What would be the reaction of postgraduate students, accustomed to traditional e-learning platforms when exposed to a new environment with game-based learning activities? Our research aim was to capture their level of satisfaction of all components of the course as means to evaluate the pedagogical potential and effectiveness of the employed instructional method.

More specifically we aimed at tackling and answering the following research question:

> RQ1. Can a mini serious game in a 3d VIE have a positive impact on the quality of learning in an e-learning course?

The hypothesis is that playing the games would have been instrumental for students' learning and motivation (enhancement).

Fifty-six (56) students in total participated in the particular learning experience. The participants in this study were balanced in terms of gender (male 53,8%), and belonged mainly to the age categories 25-34 (61,5%), 18-24 (14,3%) and 55-64 (14,3%). Almost all participants had never used SVREs (85,7%) before, only 14,3% had experienced them occasionally in the past. The large majority (84,6%) had no or few experience with computer games in 3D environments such as Multiplayer Online Games (MMOs). They were very familiar with web-based communication software such as Skype and e-learning platforms such as Adobe Connnect (85,7% respectively). The weekly classes in their distance programme took place in Adobe Connnect.

To address the research question, we used a mixed research method approach [43] in a sequential manner to collect data and find facts. First, participants (N=28) were invited to evaluate the intervention by completing an anonymous online questionnaire whose results were analyzed statistically. The questionnaire, designed by one of the authors, consisted of 21 question items focusing on the overall assessment of the experience and participants' demographics. The survey used predominantly closed five-level Likert scale questions according to the following format: 1-Disagree totally, 2-Disagree, 3-Neutral, 4-Agree, 5-Agree totally such as how would you evaluate 3d virtual world Second Life? I prefer it over 2d synchronous learning tools, how would you evaluate the mini Learning Game "Cybersecurity Challenge"? Playing it improved my learning. The questionnaire was sent to the participants two weeks after the session took place accommodating their study schedule. Students had one week to complete the survey voluntarily. Second, after an initial analysis of the survey results, one of the authors interviewed 14 volunteering students for further exploratory research issues. The interviews had an average duration of 10 minutes; they were planned and took place four weeks after the intervention via Skype. All interviews took place in a two week-period. Notes were kept from each interview. During these interviews, the students were invited to voice their views on the experience freely, as well as comment on their participation and learning.

5 RESULTS

5.1 Survey results

The survey generated an ordinal dataset that was analysed using non-parametric statistics [44]. For each question item we calculated the median, the mode, the inter-quartile range (IQR) and the variation ratio (VR). The median and the mode are expressions of the central tendency of data while IQR and variation ration measure the dispersion of responses.

In the evaluation of their experiences, the participants expressed which components of the environment were more and less advantageous to them (Fig. 3 and 4). The immersion into a virtual environment and the ability to be embodied in a moving avatar and occupy a virtual space were the top responses (Fig. 3). In contrast, most participants had to overcome technical shortcomings either from the software or their configuration and internet connection (Fig 4). The findings confirm the main affordances and barriers of SVREs for teaching and learning in past studies [45].

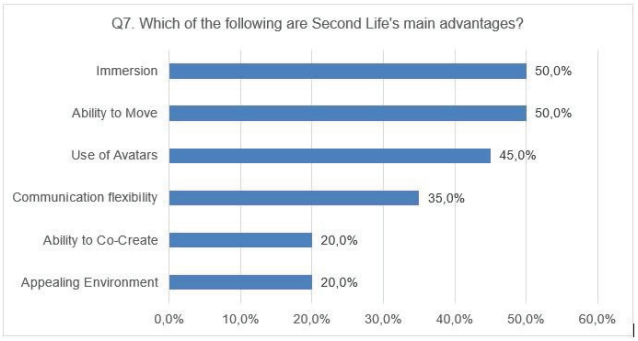

Figure 3. Perceptions on SL advantages

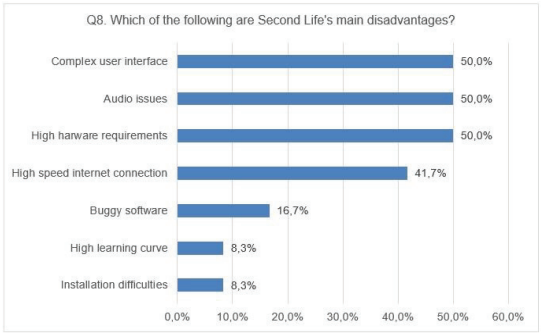

Figure 4. Perceptions on SL disadvantages

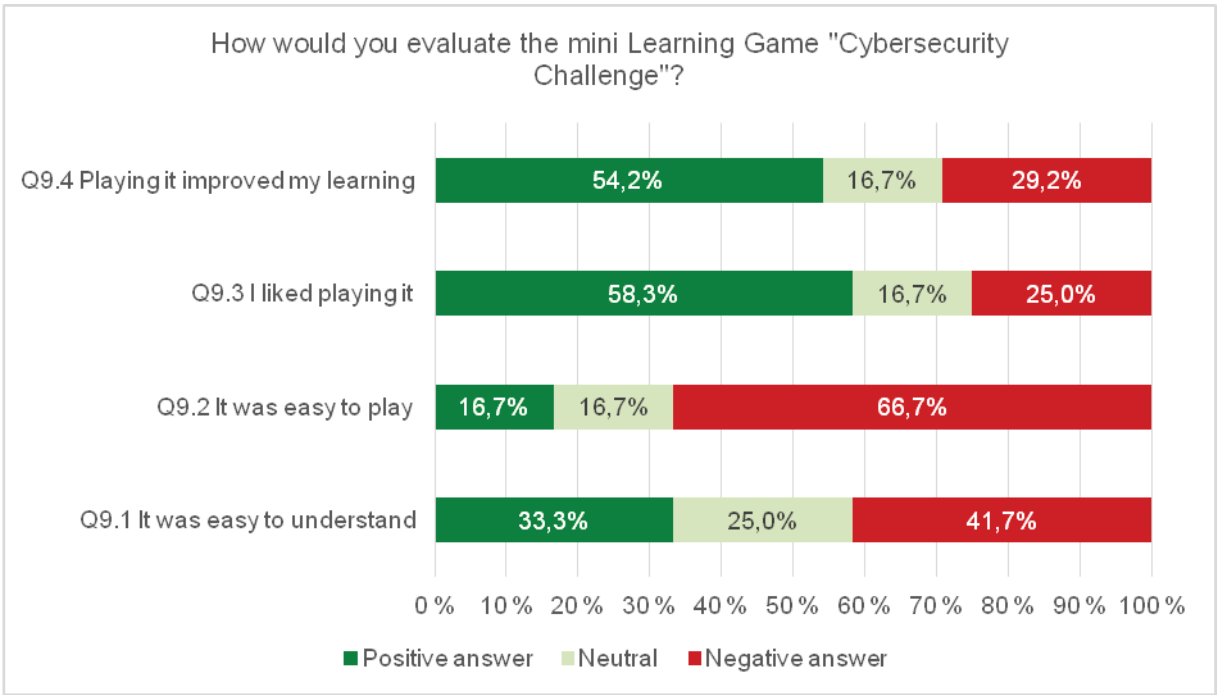

Figure 5. Participants' evaluation of the mini serious game

Despite the fact that the onboarding process to the games was not smooth, Fig. 5 and Table 1 suggest that there was a high barrier for most to understand and play the game, the outcome was rewarding for the majority of participants. This finding is in line with the results by Falconer et al and De Freitas that students appreciate playing games and conducting projects for learning [21], [46].

Table 1. How would you evaluate 3d virtual world Second Life?

	Median	Mode	IQR	VR
Q6.1 It was easy to use	2	4	3	64,3%
Q6.2 It was easy to learn	2,5	4	2	64,3%
Q6.3 I prefer it over 2d synchronous learning tools	2	2	2	64,3%

The high variation of responses in Table 1 and Fig. 5 suggests that there was a dichotomy among participants; we labeled the groups as techno-enthusiasts and techno-challenged. The first group participated smoothly and valued the experience. The second group faced serious technical issues in technology access or software use and this fact had a negative impact on their overall experience.

5.2 Interview results

We conducted interviews seeking to explore further and investigate some of the early findings of the survey. After the interviews, we analyzed and grouped the responses in four common predefined topics: technology (technical issues), organization, game play, and learning.

We confirmed that one cluster of participants faced technical difficulties of varying severity. As we found out, this happened partly due to the fact that many students accessed the class lecture session over corporate, firewall-protected lines with heavy port-blocking services that prevented Second Life's software components such as voice/audio communication to function properly.

> *I had technical difficulties periodically and was unable to hear the lecture, which made it difficult to play the game. (P2)*

> *Our network security policy didn't allow all necessary ports for Second Life to be open so I couldn't play, I just watched it in Adobe. (P4)*

This is confirms experiences and observations by other researchers, especially in projects with an international dimension [47].

On the organization aspect, we discovered some flaws in the implementation. The fact that the course had a tight weekly schedule was another stress factor; some participants had to step out of their weekly comfort zone to participate. Those who were unable to do so, e.g. attend the preparatory practice session to learn the basics of using the SVRE, they faced the challenge of self-learning or rapid onboarding; understand how to perform necessary in-world actions and communicate so as to play the game within minutes.

> *I was unable to attend the extra practice session - I was not able to find it - I did not get a message about where to go - that might have helped me. (P7)*

> *I didn't attend the practice meetings. I did go out to second life and practice on my own - but because I was a novice on the site, I found that the game went faster than I could manage - maybe extra time for people who were novices or an avatar to help people that got lost during the game would have been helpful. Now that I have had this experience, I would like an opportunity to play additional games like this in second life. (P13)*

This confirms the suggestion by previous studies that as Second Life wasn't designed for education, providing support and guidance prior and during classes is essential for learning success [48].

However, when technology was removed as inhibiting factor, participants appreciated the new active participation possibilities, the game play and capabilities of serious games in social VR.

> *It was hard to orientate myself at first and understand what to do in the environment. When I finally got going, I needed more time to find the objects and get the rewards. (P5)*

> *Because this is such a new environment for me; even though I did 'practice' a little, the environment tended to be distracting. I hadn't mastered all of the moves, and when I started to, flying in the virtual world was intoxicating. Definitely has some interesting benefits...and is worth investigating. Now I understand my daughter's fascination with Poptropica. (P11)*

This finding is in line with the results by De Freitas highlighting the pedagogical benefits of game-based learning over more traditional approaches [46].

Some participants reported that the game had a positive effect on their learning. They noted that the game was a memorable experience, it stimulated their senses and emotions and it enhanced their learning. Several also noted that they were motivated to experiment with these characteristics.

> *Great environments, I returned to explore them after the class. (P3)*
>
> *Getting around with a disfigured body was a scary yet memorable experience. (P8)*
>
> *I liked the game a lot especially the Trojan horse. The ticking bomb made me a little anxious. The game definitely helped my learning and connected with the lecture. (P10)*

This result is also in line with the results by Jarmon et al. They showed that engagement and learning improved thanks to the pedagogical use of Second Life [49].

6 CONCLUSIONS AND RECOMMENDATIONS

Regarding the paper's research question, one can say that this study confirmed the hypothesis that mini serious games in a 3d social virtual reality environment can have a positive impact on the quality of learning in an e-learning course. One of the major concerns of educators is how to increase the quality of learning for all students. New technologies such as SVREs have attempted to offer some answers. A 3d SVRE makes the experience of interacting with a situation available to people. They can see different parts of the world, can feel to be there, and can touch items over there. This kind of learning environment is extremely close to reality by evoking a feeling of immersion. SVREs can be of great value since the physical counterpart might be too expensive, too dangerous or just unavailable. SVREs can offer a truly new way to engage people and provide them with unique experiences. The participants of this study appreciated the variety of active learning modes and acquired new skills for virtual team work. The course demonstrated that the effective use of SVREs for rich, synchronous formal and informal learning can enhance distance education.

However, the findings of this study also confirmed that the steep learning curve of new users in SVREs is an obstacle for learning. This issue needs to be addressed meticulously. On one hand, the question is about time and effort that is needed in order to achieve an appropriate technical skill level for using SVRE for increasing the quality of learning. That is, the students must be trained. On the other hand, the question is about technical fluency. From this perspective, it is disappointed that we still have not managed to overcome the technical difficulties. These put unnecessary obstacles while trying to improve learning by using the tools and environments as well as running smoothly the course. Moreover, the continuous facing of technical challenges can be a very frustrating experience particularly for non-technically oriented persons. This negative experience can evoke emotions and feelings such as anger, anxiety, boredom, hopelessness and even shame, which can decrease learning and performance and reduce interest and increase task irrelevant thinking. However, the same negative emotions and feeling can improve for example persistency, which is a valuable feature for learning, if one chooses to carry on regardless difficulties.

The findings of this study showed that participants considered playful experiences in SVREs beneficial for their learning. There has been an increasing trend to personalise the learning process by using new technology. Particularly designed learning games or serious games are thought to assist people's learning process and achieve their current learning needs. Playful games can produce enjoyment and fun which can have positive influence for learning. Nevertheless, by overemphasising the fun part of learning might lead to the development of an attitude that learning must always be fun and enjoyable, and if learning does not feel like it, then a person might think that he/she is not learning.

The findings of this study showed that participants valued learning activities which were based on social interaction and active participation. Games have the potential to exert a powerful influence upon players' social development which can have a positive impact on the quality of learning. By embedding social content within the games, such as caring of something or of someone, through characters, plots and themes, players can experience decision making with the real consequences. By presenting a system of rules and act on it, such as facing an ethical dilemma, can have a positive influence upon players' social development and social learning. In addition, by discussion and debating about the game and its content online and offline can have a positive impact on developing players' argumentation, elaboration and reasoning.

Games can be useful for preparing students for the "real world" of work. SVREs enable educators to create interactive exhibits and 3D content in order to illustrate and visualise, for example real

Cybersecurity practices. Learning by doing, learning with others and learning through problem finding as well as resolving can be considered as benefits of games.

Educational context can be considered relatively traditional as a nature. That is, every new educational idea must be very convincing in order to become as a norm. This is for very good reason since education is not a random activity. The use of SVREs and games are still relatively uncommon ways of improving the quality of learning. Many worries might exist such as how to align SVREs and games to the existing curriculum or course, what if students use the limited time not for learning from the game but spend the time learning the game itself, and how expensive, time consuming and labour intensive it is for designing, developing and testing games for educational purposes. One appropriate way to start can be by using mini serious learning games for educational purposes i.e. in SVREs. They can be developed relatively quickly and cost-effectively.

7 LIMITATIONS AND DIRECTIONS FOR FUTURE STUDY

The main limitations of this study can be considered to be i) the research design. This study used a cross-sectional design but by using longitudinal study design could have revealed different results for example how impact on mini serious learning games for improving the quality of learning might change over time. ii) The data was collected by using a questionnaire and semi-structured interviews, but by using different data collection methods such as unstructured interview or narrative diary, writing the results might have been different. iii) The data was collected from university level students which were novices concerning with 3D SVREs. Data from experts on SVREs, or data from different education levels such as primary education might have produced different results. iv) The data was collected from a formal learning context, but informal learning context might have brought different results. v) The data was collected from Western culture, but for example Eastern culture might give different results. vi) The data sample was relatively small. By collecting larger data and from many different mini serious games the results might be different.

For researchers who are interested in studying SVREs and use of mini serious games we would like to recommend focus on the relationship between learning and emotions. Also it would be worth investigating if students would be motivated and interested in becoming co-creators of games and co-designers of the courses' content and activities. This could be a revolutionary step toward participants' empowerment. In addition, further studies could reveal similarities and differences among participants in other disciplines, from various cultures and geographical locations. That is, what kind of attitudes different disciplines, cultures and countries hold concerning the use of mini serious learning games in SVREs for learning.

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