

SITUATED LEARNING BASED ON VIRTUAL ENVIRONMENT FOR IMPROVING DISASTER RISK REDUCTION

Jaime Caroca¹
Mario A. Bruno²
Roberto G. Aldunate³

¹ Dep. of Education and Pedagogy, Education - University of Playa Ancha, University of Las Americas, Chile - jcaroca@edu.udla.cl

² Dep. of Computation and Informatics, Engineering, Center of Advanced Research, University of Playa Ancha, Chile
mbruno@upla.cl

³ College of Applied health Sciences, University of Illinois at Urbana-Champaign, USA - aldunate@illinois.edu

Keywords: Disaster risk reduction, Situated learning, Legitimate peripheral participation, Virtual environments

Emergency management systems require skills from decision makers to mitigate the impact of disasters, reducing fatalities and economic losses. Virtual learning environments have the potential to support the development of those capabilities. In particular, situated learning grounded on serious video games may promote the legitimate peripheral participation of learners to develop resilience capacities and become part of the community of practice. In this paper, a game-based virtual environment is proposed and validated to apply situated learning in a real-world learning community. As a result, the video game virtual environment seems to reinforce the learner engagement in the educational content. In addition, video game technology

for citations:

Caroca J., Bruno M.A., Aldunate R.G. (2016), *Situated Learning based on Virtual Environment for improving Disaster Risk Reduction*, Journal of e-Learning and Knowledge Society, v.12, n.4, 81-92. ISSN: 1826-6223, e-ISSN:1971-8829

has a potential to be applied in other learning processes for extending learning experiences, and to transfer knowledge to new situations of disasters and emergency situations, including the participation of facilitators in prevention education efforts for disaster risk reduction.

1 Introduction

Building a culture of safety and resilience requires enhancing knowledge of students, to educate threatened groups that may be affected by disasters. Situated learning may improve prevention and risk reduction outcomes via a process of legitimate peripheral participation of learners (Lave & Wenger, 1991). In this regard, using technological learning environments may play a key role for situated learning within disaster risk reduction (DRR).

In situated learning, acquiring new knowledge deals with contextualized and authentic activities belonging to a “community of practice”, in which novices and learners are promoted to develop higher order thinking skills (Herrington & Oliver, 2000). Because immersion scenarios may simulate problem-solving experiences of real-world disasters, learners can improve their knowledge acquisition by interacting with virtual learning environments, through situated practices based on expert knowledge.

Serious video games (SVG) stand for technological tools with well-defined educational purposes beyond mere entertainment (Zyda, 2005), and usually equipped with simulation environments for teaching and learning strategies (Capuano & King, 2015). Unlike procedural learning, SVG may allow students to learn through participation in authentic contexts (Shaffer, 2004); e.g., realistic emergency situations can be run repeatedly in video games, by adjusting parameters to reduce or increase risk levels.

In spite of SVG’s benefits and potentials, studies have found the need to study their effectiveness and adaptability (Connolly *et al.*, 2012; Clark *et al.*, 2015). Assessment models and frameworks have been proposed, such as the RETAIN model (Gunter *et al.*, 2008), the Four-dimensional framework (de Freitas e Oliver, 2006), and the ATMSG model based on the theory of gaming activity (Carvalho *et al.*, 2015), among others.

The work presented in this article embraces the idea that using a virtual environment for situated learning should focus on a multidimensional process of cultural appropriation, thoughts, emotions and actions (Lave & Wegner, *op. cit.*), along the process of developing legitimate peripheral participation on reducing disaster risks, in order to enable learning by doing in a context of disaster emergency systems.

The main contributions of this paper are designing a virtual learning environment to simulate a realistic context, in which emergencies may take place; evaluating whether the game-based technology is suitable for situated learning,

in the context of hazards; and discussing implications of using virtual environments, as a meaningful tool for situated learning in DRR.

2 Related work

Using serious video games has gained significant importance in recent years, providing opportunities to strengthen learners' capabilities in different areas of human endeavour, spreading to military, medical, business, and education sectors, among others (Zyda, *op. cit.*). It has been claimed that serious video games are situated learning environments for learners acquiring knowledge, skills and attitudes (Hwang *et al.*, 2015). Interacting with a realistic digital simulation makes learners participate in authentic experiences, and able to dive into rich learning experiences to solve applied real-world problems in the process of learning by doing (Gee, 2003).

For instance, epistemic games, a type of video game that aims at developing an epistemic frame of a community of practice in order to sharing knowledge and engaging in a real and authentic simulation (Shaffer, *op. cit.*), are being used by higher education institutions to develop skills in professional practices. The reflective practice in epistemic games occurs through the progressive internalization of cultural tools in an epistemic frame related to knowledge, skills and values of peers and mentors. Epistemic games may allow players to learning concepts and principles, acquiring practices, and developing thinking skills to solve problems; for example, by assuming the role of a professional or expert in a particular discipline. Such communities of practice entail shared knowledge of social and situated learning (Lave & Wenger, *op. cit.*), based on how professionals acquire their ways of knowing, decide what is worth knowing, and add to the body of knowledge and understanding of the community of practice. Epistemic games may lead to the future of learning in secondary education.

The literature review shows that the approach used in this article in emergency management scenarios hasn't been fully explored yet, even though situated learning using SVG is tailored to educational needs in preventing and reducing risks of hazards. For example, the benefits of using virtual environments include more realism and immersion, as well as reducing the costs of training in real conditions, and to facilitate remote access of learning communities, along with adapting different scenarios for training (Haferkamp *et al.*, 2011). In this case, we develop a learning process similar to that proposed in (Jong *et al.*, 2010), to apply situated learning based on SVG technology.

3 Situated learning

The Chilean educational system lacks strategies for providing education and learning in emergencies for sustainable development, so as to prevent disasters. Situated learning describes learning practices to engage learners in contexts related to communities of practice, and legitimate peripheral participation enables them to experience the shared domain and resources. Situated cognition asserts that knowledge is part and product of the activity, context and culture where it takes place (Lave & Wenger, *op. cit.*).

Learning may be more effective if provoked by outstanding students, domain experts or educational facilitators, according to the situated learning theory. On the one hand, the zone of proximal development occurs when apprentices are assisted by more experienced facilitators according to the vygotskian sociocultural approach, unlike trying to solve a problem by their own. On the other hand, by using authentic environments, the learner's interest is built from previous knowledge, based on constructivist strategies and cooperative work.

4 Learning virtual environment for disaster risk reduction

Reducing disaster risks involves analyzing and managing menace factors of disasters, by means of increasing preparedness for adverse events. Decisions may often aggravate the specific emergency situations in dynamic environments, due to the cascading effect and limited and incomplete information. In addition, it has been reported that nontraditional educational techniques have boosted mental structures of experts making decisions in disaster response environments (Thompson & Calkins, 2011).

In spite that virtual learning environments refer to online classroom situations, simulating disaster scenarios reduces the cost of trial and error learning, in situations of large-scale disasters or under realistic conditions. The virtual environment may incorporate DRR education activities, articulating tacit and explicit knowledge in contexts rich in real problem-solving opportunities, including interactions and collaborations that often occur in emergency systems. Thus, learning is more active when students learn by doing and deal with a problem or cognitive conflict (Gee, *op. cit.*); i.e., something they cannot understand or explain with prior knowledge.

Figure 1 represents the conceptual model of a serious video game for disaster risk reduction. The arrow direction indicates the effects of a component on another component of the model. Despite mediating learning, the serious video game is designed in a cultural context that influences RRD. The use of the video game may facilitate the acquisition of knowledge, skills and attitudes (AKSA), which, in turn, may allow learners to activate prior knowledge to engage in

higher order thinking skills (HOTS), such as creation of new knowledge and problem solving in RRD.

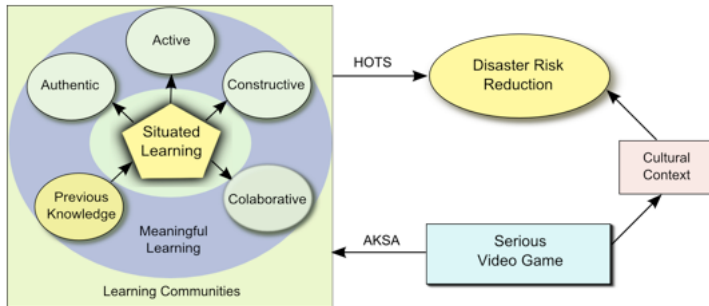


Fig. 1 - Situated learning based on serious video game for disaster risk reduction.

In the model, learners combine new experiences to build knowledge from, and connected to, previous knowledge in a continuous process, leading to authentic, active, constructive, and collaborative learning. Authentic learning facilitates to construct knowledge in learning communities, by taking part in realistic contexts of simulated disasters. Learners play an active role for procedural and problem solving, because of the simulation of activities, roles, artifacts, and collective knowledge of communities of practice. Understanding is constructed by learners, to acquire knowledge and build their mental schemes in the gameplay. Cooperative learning is mediated by an expert on emergency management, to guide students in the situated learning activity based on the SVG, to become part of the DRR community of practice.

5 Materials and method

This section describes the virtual learning environment, the situated learning activity, and an evaluation that was performed by volunteers of a learning community. The study evaluated the virtual environment in terms of the educational setting, along with appraisals and suggestions from an intentional sample of 22 participants who were selected from students of a third year course in high school at the Region of Valparaiso, Chile.

5.1 Virtual learning environment

The virtual environment incorporated a digital terrain model from aerial imagery information associated with urban-rural interface areas to better disseminate risk information, using geospatial information technology (UNISDR,

2015). The terrain model consisted in the topography, including the main species of trees and pasture in specific areas, and buildings' areas, with a sufficient granularity given the vastness of the land covered by the scenario. The virtual environment was developed using Unity 3D.

Figure 2a illustrates the area affected by the Great Fire of Valparaiso, Chile, in 2014, one of the most disastrous in the city's history. A ground level view and a bird's eye view were modeled to facilitate the navigation; for example, Figure 2b illustrates the bird's eye or helicopter view from the main buildings such as Congress and schools. Head-up displays (HUD) reflect the name of the hills belonging to risk areas (See Figure 2c). In addition, hills were marked by a specific color indicating the level of probability of a fire occurrence. Figure 2d shows an outbreak of fire simulated in the virtual learning environment.

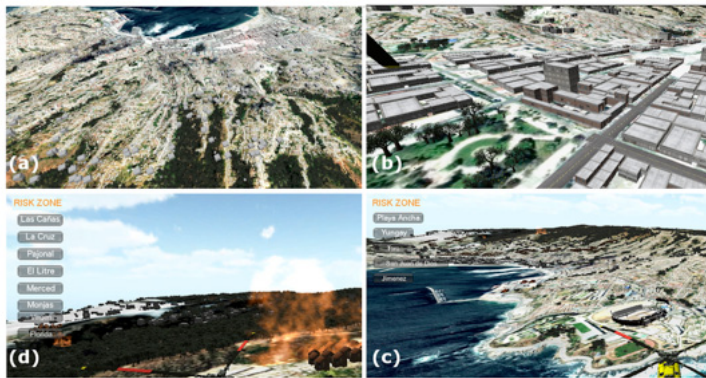


Fig. 2 - In clockwise order: (a) the digital terrain model representing the disaster risk scenario, (b) bird's eye view of the urban area, (c) risk zones displayed by the HUD at the top left corner, and (d) a fire outbreak during the risk map activity based on the virtual environment.

5.2 Situated learning activity

The activity was based on a risk map, and consisted in delivering information on disaster risk reduction, operating and navigating the virtual environment, and a debriefing and feedback. It was aimed to acquiring knowledge, identifying risk areas using the virtual environment, and developing skills to mitigate the impact of hazard risks.

The objectives of operating the virtual environment were to know, understand, explore, and identify risk zones to build a risk map. Two participants were assigned per computer. When navigating, participants should identify hills and its main buildings, and where the threats are, and who and what elements

are vulnerable to damage in the disaster scenario. As soon as a fire outbreaks, students should recognize risk zones that would be affected and identify safe and risk-free areas, as shown in Figure 2d. After playing, participants reflected on reducing wildfire risks.

5.3 Evaluation

In order to assess how well the virtual environment incorporated academic content with regard to situated learning theory, and whether game-based learning is suitable for disaster risk reduction, we used the model of Relevance, Embedding, Transfer, Adaptation, Immersion, and Naturalization, RETAIN model (Gunter *et al.*, 2008), an approach directed toward giving value to learning content and response of educational decisions to the player (Bellotti *et al.*, 2009; Tsai *et al.*, 2012).

This model was adapted to evaluate the virtual learning environment, because the balanced combination of virtual world fantasy and story, instructional delivery processes and learning theories with the development of the serious video game, in the opinion of the researchers, could improve the comprehension of the learning process to evaluate knowledge transfer, and contribute to effective knowledge acquisition for sustainable development, especially in Chile that historically suffer great disasters.

In the RETAIN model, the *Relevance* component assesses if the virtual environment develops a situated learning approach to motivate reluctant learners, providing appropriate cross learning for the school curriculum, with terrain elements that resemble reality for risk areas. *Immersion* evaluates if the player can invest intellectually in the context of a disasters. *Embedding* assess if the academic content is integrated with gameplay and fantasy, and learners are immersed in DRR without being distracted from learning, and play a role and work with others. *Adaptation* evaluates if learning occurs through assimilation, by incorporating the new knowledge to prior schemes, and accommodation, by changing schemes collapsed by new assimilated elements. *Transfer* assesses if previous knowledge can be applied in new situations. *Naturalization* evaluates the spontaneous use of information, and if the player easily get used to situated situations.

Each of the RETAIN criteria is evaluated in four levels. Level 0 refers that the virtual environment design is unsuitable for educational purposes, and Level 1 that insufficiently meets the necessary requirements. Level 2 means the criteria is partially met, and Level 3 indicates a strong correlation with necessary educational purposes. The table 1 illustrates the evaluation distribution of RETAIN model criteria, according to their assigned weight, with values ranging from 1 to 6.

Table 1
DISTRIBUTION ASSESSMENT FOR RETAIN MODEL CRITERIA

	Relevance	Immersion	Embedding	Adaptation	Transfer	Naturalization
Level 0	0	0	0	0	0	0
Level 1	1	2	3	4	5	6
Level 2	2	4	6	8	10	12
Level 3	3	6	9	12	15	18
Ranking (Level x Weight)	3 x 1 = 3	3 x 2 = 6	3 x 3 = 9	3 x 4 = 12	3 x 5 = 15	3 x 6 = 18

Because adaptation and transfer components are considered suitable to promote higher order thinking skills (Gunter, *op. cit.*), the following questions were responded by participants, with regard to adaptation (Questions 1-5) and transfer (Questions 6-10):

1. Knowledge is acquired for developing new ways of thinking in disaster situations.
2. Multiple perspectives are presented for decision making.
3. The digital images deliver terrain knowledge to identify risk areas.
4. The situated learning situation enables cooperative learning.
5. Navigation develops initial understanding and deeper learning.
6. Teacher can actively participate in the learning process by scaffolding and inspiration.
7. Graphic design allows the acquisition of knowledge.
8. Acquired knowledge and developed skills can be applied in other situations.
9. Acquired tacit (implicit) knowledge can become explicit knowledge.
10. Previous knowledge enables learners to identify potential risk areas.

The overall results obtained of the study were 41.49 of a total of 63 points. The ranking scores for each criterion are shown in Table 2. A moderately high level (Level 2) was obtained by all criteria. The virtual environment appears to characterize the context of disaster risks and the cross curriculum integration, and engage learners in the educational content.

Table 2
RANKING RESULTS

Criteria	Ranking	Expected score
Relevance	1.88	3
Immersion	3.70	6
Embedding	6.31	9
Adaption	7.64	12
Transfer	10.18	15
Naturalization	11.78	18
Total	41.49	63

Figure 3 shows responses for adaptation and transfer components. In Figure 3, more than 81% of participants agreed in question 4 that they were engaged in situated learning within the virtual environment, and permitted them to share each other's experiences, in terms of scores on Level 2 (n=8) and Level 3 (n=10). Most respondents were concerned about the facilitator, with 9 responses for each Level 2 and Level 3 (40.91%) in question 6.

At least 77% of participants responded in question 8 that educational knowledge and challenges could be transformed using the video game, for extending experiences in disasters, as regards Level 2 (n=8) and Level 3 (n=9). In question 9, at least 18% of participants responded that the transfer of gained knowledge to new disaster situations was missing (n=4), same as question 2 regarding the different views for taking decisions, in which a similar score was obtained for Levels 1, 2 and 3 (n=6, 27.27%).

It seems that the virtual learning environment ensures learners to use previous knowledge to identify disaster risk zones, because all participants valued it in question 10. Knowledge may be conveyed to identifying risk zones, but for up to 13% was absent in question 3. Orientation was reinforced on the scenario to be transferred, according to the average answer in question 7.

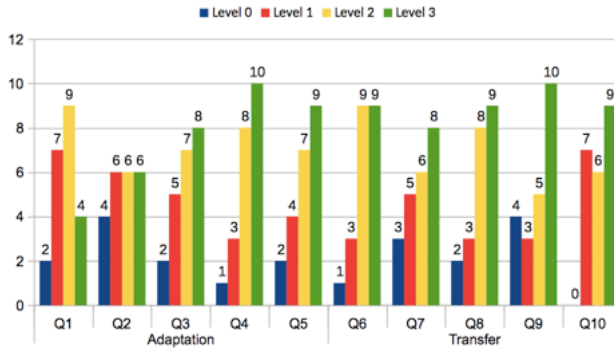


Fig. 3 - Frequency of level scores for criteria components that further higher order thinking.

Knowledge may be acquired to reducing disaster risk, although almost 19% did not observed it for Level 3 (n=4) in question 1. Overall, navigating the virtual environment develops initial understanding and deeper learning in question 5. In the debriefing, participants indicated the low visibility of risk areas, and they suggested replacing them by hills. They pointed out that the activity was similar to a geography class, but more active than the traditional approach. They also acquired contextualized knowledge of the disaster scenario. Although the scenario was easy to navigate, operating the bird’s eye view was slow in relation to the first person’s view.

Conclusion

A virtual learning environment was developed and evaluated to determinate its appropriateness to a situated learning activity in a cultural context of reducing disaster risk. The tool built for this purpose had a moderately high evaluation for the predicted effectiveness of the virtual environment, in a context that has not been previously applied, which has a long experience in disasters. The outcomes of this study are potentially applicable for disaster risk reduction in Chilean educational institutions.

It was possible to apply previous knowledge of hazards in new contexts, and develop higher order cognitive skills using the interactive learning environment. Identifying sources of fire and main buildings in the community allowed to promoting the acquisition of knowledge in real scenarios of emergency management. Risk awareness, challenges and exploration were likely to be embedded in game play, to acquiring knowledge related to disaster outbreaks and topographies, and levels of risk and security zones. The learning activity

was mediated by a facilitator, to keep learners being part of a legitimate peripheral participation, with an interest to complete the game experience.

According to the results obtained in this work, it can be stated that it is feasible for students in Chile to use game-based learning environments to become part of the communities of practices of disaster risk reduction. It is anticipated by the authors of this research effort that students have the potential to become “agents of change”, and innovate in the educational system to develop 21st century skills.

REFERENCES

- Bellotti, F., Berta, R., De Gloria, A. & Primavera, L. (2009), *Adaptive Experience Engine for Serious Games*, IEEE Transactions on Computational Intelligence and AI in Games, 1(4), 264-280.
- Capuano, N. & King, R. (2015), *Knowledge-based assessment in serious games: an experience on emergency training*, Journal of e-Learning and Knowledge Society, 11(3).
- Carvalho, M. B., Bellotti, F., Berta, R., Gloria, A. D., Sedano, C. I., Hauge, J. B., Hu, J. & Rauterberg, M. (2015), *An activity theory-based model for serious games analysis and conceptual design*, Computers & Education, 87, 166-181.
- Clark, D. B., Tanner-Smith, E. E. & Killingsworth, S. S. (2015), *Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis*, Review of Educational Research, 0034654315582065.
- Connolly, T. Boyle, E. Boyle, J. & Macarthur, E. (2012), *A systematic literature review of empirical evidence on computer games and serious games*, Computers & Education, 59(2), 661-686.
- de Freitas, S. & Oliver, M. (2006), *How can exploratory learning with games and simulations within the curriculum be most effectively evaluated?*, Computers & Education, 46(3), 249-264.
- Gee, J. P. (2003), *What video games have to teach us about learning and literacy*, Computers in Entertainment, 1(1).
- Gunter, G. A., Kenny, R. F. & Vick, E. H. (2008), *Taking seriously educational games: using the model to design endogenous RETAIN fantasy into standalone educational games*, Educational Technology Research and Development, 56 (5-6), 511-537.
- Haferkamp, N., Kraemer, N. C., Linehan, C. & Schembri, M. (2011), *Training disaster communication by means of serious games in virtual environments*, Entertainment Computing, 2(2), 81-88.
- Herrington, J. & Oliver, R. (2000), *An instructional design framework for authentic learning environments*, Educational Technology Research and Development, 48(3), 23-48.
- Hwang, G. J., Chiu, L. Y. & Chen, C. H. (2015), *A contextual game-based learning*

- approach to improving students' inquiry-based learning performance in social studies courses*, Computers & Education, 81, 13-25.
- Jong, M. S. Y., Shang, J., Lee, F.-I. & Lee, J. H. M. (2010), *An Evaluative Study on VISOLE—Virtual Interactive Student-Oriented Learning Environment*, IEEE Transactions on Learning Technologies 3(4), 307-318.
- Lave, J. & Wenger, E. (1991), *Situated Learning. Legitimate Peripheral Participation*, Cambridge University Press.
- Shaffer, D. W. (2004), *Epistemic frames and islands of expertise: Learning from infusion experiences*, 6th Int. Conf. on Learning sciences, 473-480.
- Thompson, M., & Calkins, D. (2011), *Uncertainty and risk in wildland fire management: A review*, Journal of Environmental Management, 92(8), 1895-1909.
- Tsai, F.-H., Yu, K.-C. & Hsiao, H.-S. (2012), *Exploring the Factors Influencing Learning Effectiveness in Digital Game-based Learning*, Journal of Educational Technology & Society, 15 (3), 240–250.
- Zyda, M. (2005), *From Visual Simulation to Virtual Reality to Games*, Computer, 38(9), 25-32.