nDiVE: Gamified virtual reality environment for Logistics and Supply Chain Management training

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CHI'16 Extended Abstracts, May 07-12, 2016, San Jose, CA, USA
 ISBN 978-1-4503-4082-3/16/05…$15.00
DOI: http://dx.doi.org/10.1145/2851581.2851596

Abstract
Virtual reality (VR) technologies have been under development for decades, but latest more affordable and increasingly available technologies have raised unprecedented interest in using VR for enhancing human capacities, also in higher education learning. This paper will report a summary of a three-year project in developing and studying the use of VR for safety training in Logistics and Supply Chain Management (SCM). The training environment, 'nDiVE', with its technological and learning design developments is presented. Also opportunities and challenges that have emerged during the project, in addition to future research and development opportunities are discussed.

Author Keywords
Virtual reality; 3D virtual training environments, Logistics; Supply chain management; Learning

ACM Classification Keywords
H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems---artificial, augmented, and virtual realities; K.3.1 [Computers And Education]: Computer Uses in Education---computer-assisted instruction (CAI).

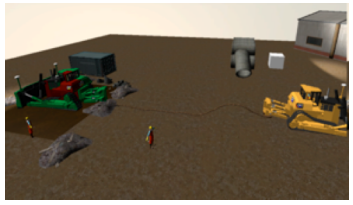

Figure 1: Example for a scenario where an operation (pulling the green bulldozer from the muddy area) is executed in a collaborative setting; i.e. requiring coordination of tasks.

Figure 2: Failure to achieve the final outcome. Here, a worker was fatally injured, as another worker did not pay attention to the environment and the performance of others.

Introduction

The higher education community is beginning to embrace the use of virtual worlds for teaching and learning and to create manifold scenarios to immerse the learner into virtual reality. This benefits the learner as it allows the simulation of specific constellations that would not be possible in the real world, e.g. hazardous situations, changed physics, roles in a new context, and going beyond real world individual limitations such as fear. At the same time, such environments often fail to encompass suitably authentic activities and understanding the nature of the real environments they simulate. To address this, the nDiVE project was developed to explore authentic education in logistics and supply chain management scenarios. nDiVE was built with Unity game engine, coupled with various immersive technologies such as the Oculus Rift head-mounted display (HMD) to create several detailed scenarios of operational working environments. Input from industry and academic stakeholders provided guidance in the development, creating an ideal platform for the development of industry-focused, authentic and immersive learning scenarios.

Four scenarios were created to immerse the learner into a range of hazardous environments, allowing them to become familiar with the risks and challenges of operating in such environments. The scenarios were situated in Logistics and other Operational contexts, and tested with different cohorts of students and young people from a range of backgrounds. Students and industry stakeholders participating in the experimental scenarios created a body of valuable in-world data to be analysed. The results indicate that, while there are a number of design elements that can be improved and refined, nDiVE is a promising space for education and authentic learning for people that need to work in safe environments. At the same time some elements require further research and understanding before a wider integration in the classroom can be effectively achieved.

This report summarizes some of the findings from the nDiVE project and describes an example of an immersive and authentic training environment. More detailed project aims and developments can be found elsewhere (e.g. Reiners et al. 2013; Reiners et al. 2014).

nDiVE Environment

nDiVE stands for "n-Dimensions in Virtual Environments" or "n-dive: enjoy and "dive". nDiVE developed and trialled immersive virtual environments as an innovative and authentic approach to teaching and learning, and for gamified but practical skill acquisition with integrated assessment and formative feedback. It proposes a methodology utilising existing and emerging technologies in creative and innovative ways. The simulation combines emerging technologies to project multiple business dimensions into one space; enabling students from different disciplines to observe, engage, interact, and participate in self-guided or group-based learning scenarios; receiving instant, multi-perspective, rich feedback to support their learning in an interactive safe environment.

Figure 3: Image of the virtual container terminal environment. Users interact with the environment with Oculus Rift and Razer Hydra.

The key features of the nDiVE environment are: technology-generated and psychological immersion, authenticity of the environment and processes, apposite realism, gamification concepts to induce behaviour shifts through playful experiences, self-guided exploration of the virtual space, and semi-automated formative assessment through data analytics. A key research focus was set on the inclusion of human-computer interaction technology to overcome keyboard-mouse barrier limiting immersion and authenticity. Head-mounted display (Oculus Rift) was employed to create a spatial view aligned to real-world head movements. In the beginning interaction took place with a PlayStation controller, but was exchanged to Razer Hydra for better tracking of hands and arms, and to achieve more intuitive grapping and touching of objects.

Multiple scenarios were created to develop and trial an authentic learning scenario, which enabled Logistics and Supply Chain Management (L&SCM) stakeholders to prepare, develop, and evaluate their skill acquisition

and professional readiness in Health and Safety. In the scenarios, the participants received a simple objective (e.g., to walk to a certain location, find an object, or perform their tasks in a collaborative setup) under the constraints of getting hurt or causing direct or indirect damage to others. Despite a verbal or visualized induction on the risks, participants followed a self-guided exploration of the space. The outcome, in summary, showed that the users were generally aware of what caused their virtual injuries, yet in some cases other in-environment distractions inhibited this experience. The replication of experiments demonstrated not only learning of how to behave and react (expected result of our gamified approach) but also how to gain a more intensive awareness of the surroundings. For example, the container terminal contained the risk of fatal injuries by being hit by moving objects in restricted and non-restricted areas, being crushed by objects, experience of faulty materials, being locked in or locked by someone, under-estimate the risk of dangerous goods, the error of others, risk of being shot or attacked by animals, or talking too long to solve an emerging problem.

Opportunities and Challenges

nDiVE included features that seemed to be straight forward but often not in place in the traditional classroom or training contexts. These features provided opportunities to the learner to achieve empowerment and self-confidence and by this a longer learning retention. Among others, these included

- Free exploration of the space. So-called gamified nudges were used to show the learner that they were off-target and should consider a different action.
- Simplified scenarios with scaffolding tasks to direct the attention to the fundamental learning objectives.
- Allowing failure, including virtual death. Preventing failure is often used as a motivational factor in teaching. We experienced the opposite as failures indicated lack of knowledge and missing skills. Failure triggered the users' eagerness (I can do it) to find a solution and also reapply learned skills in similar contexts. This implies that the tasks were designed in such ways that it is possible to see a chance to overcome failure.
- Short modules to experience learnt theory. We noticed that the duration of focus was limited and needs to be acknowledged when designing scenarios.

The following list shows some challenges that were experienced with the environment, setup of technology, and development of learning scenarios:

- Immersion is contradicted by captive boundaries of indirect controls to natural movements; e.g. walking by using buttons.
- Cables or non-direct translations of movements between real and virtual worlds; e.g. holding a device with a hand while having to push a button to release an object in the virtual space.
- Small yet noticeable delays in recognising movements and visualisation of the images; causing disorientation and nausea with some participants.

Future Research

The project has developed and piloted the nDiVE system and learning support materials in a range of

teaching settings – both the university and vocational. Results indicate that the environment and learning approach can work as valuable resources. The next stage of the development in the university sector would be to more seamlessly connect these resources with the curriculum, and have them actively developed and used by the members of the education community. Such development needs to address the fact that new technologies might often affect the evaluation of the learning experience itself: the novelty and the strong immersion of the VR were at the same time a distraction and an attraction of attention.

Our future research will examine, among others, supportive mechanisms and technologies to script self-sustaining narratives with simplified artificial intelligence to react to learners' behaviour and provide just-in-time feedback. This might involve development of bots to populate the space, direct analytics of behaviour to provide the correct responses, and automated formative assessment with detailed feedback of the learning process. Projects in these topics were initiated as part of the nDiVE project as important gaps in these areas were identified in the education literature. However, 'serious games' literature is addressing many of these issues for example with open-world games, and might be a source of new development ideas and research topics for educators.

nDiVE is currently addressing individual learning. Especially with the head-mounted display technology, collaboration needs to be redefined, including the design of learning materials and the later analysis of learning outcomes. While some educators suggest video-based Machinima as a feedback mechanism, we believe that recording scenarios and re-experiencing them from multiple perspectives in a group discussion could even more enhance the learning process.

nDiVE project has also worked as a seed for further research projects. Another study has begun to investigate the user experience of virtual environments (Teräs, Teräs and Reiners 2015). The project takes a phenomenological approach to understand how users experience 3D virtual environments as they are lived in safety training settings in hazardous contexts. This study, initiated in 2014, examines the user experience of employees who work in the minerals and chemicals sector. Rich descriptions of user experience are collected with semi-structured interviews as the participants explicate it in their everyday language. The aim is to maintain theoretical and conceptual openness in order to understand the experience from the users' point of view as it takes place as part of their work context. The data will be analysed with descriptive psychological phenomenological process to understand the common constituents and the essence of the experience (Giorgi 2009; Moustakas 1994). Possibly further human-technology-specific analysis will be undertaken through Ihde's (2009) postphenomenology. This research continues the strand in human-computer interaction (HCI) which advocates the contextual and social nature of HCI, and human experience in general, and argues for phenomenology as a viable approach to study and understand human-technology relations (Dourish 2001; Dreyfus 1992; Ihde 2002; Svanæs 2013; Winograd and Flores 1988). Phenomenological analysis may provide new insights and open new questions in what is the nature of user experience of virtual environments in a safety training context. At the same time, as HCI design conventions and user

experiences go beyond specific contexts, the study might provide new understandings on what affects user experience of 3D virtual environments. This can be applicable for interaction and user experience design. Furthermore, as phenomenology aims to reveal the oddness in the taken for granted (Sokolowski 1999), the study also hopes to contribute to the discussion of often ill-defined concepts used to explain user experience in virtual environments, such as 'presence', 'immersion' and 'fidelity'. The meaning and usefulness of these terms for research and development are still debated (Calleja 2011). Understanding such concepts would benefit from real world user accounts.

Many VR studies have examined the role of graphical fidelity, or life-likeness and how it affects user experience. Another study that is emerging from nDiVE aims to investigate the effect of VR fidelity on learning, now especially from the point of view of other senses than vision. Building on constructivist pedagogy and game-based learning that emphasise learning by doing, it aims to study metrics to address perception of fidelity, and to compare the impact of physical activity versus being an involved user during VR learning events. The aim is also to study how these might affect learning retention.

Conclusions

Especially current social media is filled with messages painting VR as "the next big thing in 'X'". Often the existing practices and policies that affect the 'X' are taken lightly. This can inhibit the development and research of real world VR applications beyond entertainment and one-off prototypes. nDiVE research has shown us that VR, similar to other technologies that might enhance human knowledge and learning, is always implemented in a context which affects its authentic application. Immersive virtual training environments show promise on the level of enhancing learning opportunities. At the same time connecting VR to existing practices and policies, in the industry and academia, is a matter that needs to be addressed if one aims for a wider VR acceptance and implementation. Furthermore, although VR input and output technologies are becoming increasingly available as commercial products, their affordances for group activities needs to be further developed. The social aspect is important in human learning. As long as VR user situations are limited only for individual use, their usefulness for learning and training will be limited.

Acknowledgements

Support for the production of this publication has been provided by the Australian Government Office for Learning and Teaching (Grant: Development of an authentic training environment to support skill acquisition in logistics and supply chain management, ID: ID12-2498). The views expressed in this publication do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

References

1. Gordon Calleja. 2011. *In-Game: From Immersion to Incorporation*. MIT Press, Cambridge, Massachusetts.
2. Paul Dourish. 2001. *Where the Action Is: The Foundations of Embodied Interaction*. The MIT Press, Cambridge, MA.
3. Hubert Dreyfus. 1992. *What Computers Still Can't Do: A Critique of Artificial Reason*. The MIT Press, New York.

4. Amedeo Giorgi. 2009. *The Descriptive Phenomenological Method in Psychology: A Modified Husserlian Approach.* Duquesne University Press, Pittsburgh, PA.
5. Don Ihde. 2009. *Postphenomenology and Technoscience: The Peking University Lectures*. State University of New York Press, Albany, NY.
6. Don Ihde. 2002. *Bodies in Technology*. University of Minnesota Press, Minneapolis.
7. Clark Moustakas. 1994. *Phenomenological Research Methods*. SAGE, Thousand Oaks, CA.
8. Torsten Reiners, Hanna Teräs, Vanessa Chang, Lincoln C. Wood, Sue Gregory, David Gibson, Natasha Petter, and Marko Teräs. 2014. Authentic, immersive, and emotional experience in virtual learning environments: The fear of dying as an important learning experience in a simulation. In *Transformative, innovative and engaging. Proceedings of the 23rd Annual Teaching Learning Forum*. The University of Western Australia, Perth.
9. Torsten Reiners, Lincoln Wood, Sue Gregory, Natasha Petter, Hanna Teräs, Vanessa Chang, and Jan Herrington. 2013. nDive: The Story of How Logistics and Supply Chain Management Could be Taught. In *Electric Dreams. Proceedings ascilite 2013 Sydney*. 734-744.
10. Robert Sokolowski. 1999. *Introduction to Phenomenology*. Cambridge University Press, Cambridge.
11. Marko Teräs, Hanna Teräs, and Torsten Reiners. 2015. *The Lived User Experience of Virtual Environments: Initial Steps of a Phenomenological Analysis in a Safety Training Setting.* In *Proceedings of the 26th Australasian Conference on Informations Systems (ACIS 2015)*. The University of South Australia 2015. Retrieved December 7, 2015 from https://acis2015.unisa.edu.au/wp-content/uploads/2015/11/ACIS_2015_paper_118.pdf