Authentic, immersive, and emotional experience in virtual learning environments: The fear of dying as an important learning experience in a simulation

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This paper is about the role of authenticity and emotion to aid learning in immersive virtual environments; in particular the occupational health and safety in the operations and supply chain industry. With the introduction of relatively low cost head-mounted displays such as the *Oculus Rift*, it is now feasible to introduce environments that are more immersive and authentic; and allow for further experiments on induced and experienced emotions. This article describes an experimental design to evaluate how different levels of authenticity, immersion, and emotion affect learning retention, and how they relate to each other. The container terminal scenario prepares students for site visits, showing the health and safety risks by simulating the consequences of accidents and mistakes in a work place that may cause injury or death.

The proliferation of information and media technology have created nearly ubiquitous virtual spaces where there seems to be constant acquisition of knowledge, skills development, or gaining new experiences. Both experts and amateurs provide endless streams of do-it-yourself instructions to '*hack your life*' while bloggers create a knowledge base of unimaginable dimensions. This all provides educators, trainers, and self-paced learners with a rich source of material to supplement their traditional educational modules. Yet, passive online learning designs constrain the experience as they often lack practical application and, therefore, hinder the development of embodied coordination and cognition skills needed for deeper understanding (Baum, 2004; Pfeifer & Bongard, 2007). Passively following a cook on YouTube as she demonstrates molecular cooking may be informative but will not compensate for real-world training and experience of being beside a master chef; the apprentice misses learning from their own failures and receiving critical assessments from independent real-world evaluators. The drawbacks of such passive learning become especially precarious when activities do not relate in a simple way to one's tastes or aesthetic preferences but instead involve serious concerns about occupational health and safety. It is also worth recalling that the production of many of the passive forms of online training (e.g. videos, computer-based instruction) is usually a well-orchestrated process, including multiple experts and observers to guarantee focus and simplicity of message and a model of ideal conditions for safety and performance. Moreover, the final composition seen by viewers is the outcome of multiple retakes and attempts; and is not realistic about the required amount of training and practice that is never seen. This is in a sharp contrast with engagement in real-life activities where there is often only a single opportunity to get it right.

Developing confidence in their own expertise and skill set via sophisticated training, which introduces, aides practice and provides feedback that improves performance through multiple trials, is crucial to the success of learners (Bransford, Brown, & Cocking, 2000). While universities and other educational institutions are able to provide theoretical and, to some extent, practical applications for learning, these often remain limited in authenticity; for example, taking place in classrooms instead of real world environments. It is often not feasible to consider every potential environment, scenario, and other workplace aspects that may be encountered later. Here, the use of re-training modules and skills

refresher programs can close the gap as they provide a targeted and efficient assurance of knowledge and expertise as well as induction to new environments. The importance of such programs can be quantified by 337 deadly work-related, traumatic injuries in 2009-2010, in Australia (Safe Work Australia, 2012). One concern is that employees have on average 20% less skill than required for their job (Australian Chamber of Commerce and Industry, 2010) and therewith cause the existing employability gap between university outputs and industry requirements, non-completion of apprenticeships, or health and safety concerns. Similar concerns include the proportion of graduates with the wrong skills (e.g., 40%; Ferguson, 2012); the way that more highly-educated workers often lack practical skills (Jackson, 2009); and the low quality of graduates, relative to organisational expectations (Australian Chamber of Commerce and Industry, 2010). All of these industry-based concerns indicate an immense and pressing need for effective retraining programs and the ability to help staff rapidly adapt to new environments.

These concerns highlight the shortcomings of passive learning. In contrast, many educators have moved towards active learning methods that develop understanding and comprehension through having students' complete tasks and activities, normally within the classroom environment (Wood & Reefke, 2010). However, many of these activities still lack authenticity and lack the real working environment; engaging students with activities and structuring 'gamified' experiences can often be used earlier in educational programs but may later be supplemented by the study tour (Wood & Reiners, 2012). The use of study tours has become an increasingly important in contemporary tertiary education (Reiners et al., 2012). Study tours "bridge the gap between business theory and practice" (Porth, 1997, p. 198), allowing students to connect abstract models and written descriptions with their real-world representations; i.e., comprehending the need for variations and adaptations to compensate for differences in existing business processes. Understandably, study tours might extend the experience for the learner, yet there are significant drawbacks: they offer a limited 'peek' into several 'slices' or 'chapters' of the scenario and the perspective is usually that of an external visitor, limited to predefined walk-ways in defined (safe) areas without access to deeper knowledge or data about the location. Furthermore, site or study tours are limited to certain programs due to high costs (i.e., financial resources and time requirements), access challenges (i.e., confidentiality, safety, and clearance), being able to attend (i.e., disabilities or distance from the location), and maintenance of appropriate learning objectives in well-designed and coordinated visits (Hanna, 2000).

The obvious alternative to study tours and on-site training, where learners are brought on-site, is to instead bring the site to the learner while providing similar experiences, that is, virtual training experience that sufficiently replicate the important features of the real-world environment. Research is beginning to show that the impacts of virtual learning experiences can be as powerful as those experienced in real settings (Blascovich & Bailenson, 2011). Virtual performance spaces for learning and assessment are a relatively new area of research, but show promise for scalable, authentic practice areas with potential for automated assessment and advanced learning analytics (Ifenthaler, Eseryel, & Ge, 2012). Virtual worlds can achieve a moderate level of authenticity while being integrated in the classroom; educators and learning experience designers are yet to explore and understand the untapped potential applications and the contribution that they can make in emerging pedagogical models. We consider an increase in authenticity and perception of higher immersion crucial; i.e., to connect the learner with the business or real world and demonstrate the implementation of theories.

The following section depicts virtual spaces while implementing authentic and immersive scenarios that create learning experiences. We describe an experimental design that places the learner in the role of an occupational health and safety inspector on a container terminal. The design uses a variety of experimental settings, audio-visual technology, and levels of preparations. 3D simulations, partaking in realistic, diverse, versatile, and dynamic activities can be used to effectively emulate real-life situations (Ferry, et al., 2006). Our proposed structured and collaborative scenarios are developed to emulate real-world situations that are challenging to address in a formal learning situation (e.g., accidents), allowing for a range of emotion-induced experiences. The core of this paper is about the experimental design. We describe the activities for the participants in more detail and elaborate the recorded data as well as how these can be used to support the analysis of the learning experiment for advanced automated formative feedback and the computer-supported translation of experience and

knowledge in a new, enhanced, learning setting. We provide preliminary results indicating the efficacy of the recently released visualisation technology, demonstrating the importance of extending the immersion of the learner by introducing personal visual spaces. However, the inclusion of other data streams (e.g. from learning analytics) is an ongoing project in its early stages of development; thus, we will limit the discussion to providing a formal description of what we consider as relevant for inclusion in the experiments and how the data for each individual learning experiment is being analysed. We conclude the paper by summarising our findings thus far, and describe a way forward.

Immersion, authenticity, emotion

Immersion has many meanings within the emotion-focused literature. This paper adopts the definition used by Dede (2009; p. 66) that immersion is the "the subjective impression that one is participating in a comprehensive, realistic experience", independent of how the experience of immersive presence is created. This is similar to Witmer and Singer's (1998) perspective, where they described immersion as a psychological state where individuals perceive themselves to be enveloped in and interacting with virtual environments that provide a stream of stimuli and experiences and referred to as psychological immersion (Schubert, 2009). Immersion can also be classified in two other ways. 1) technical immersion (e.g., "technology that gives rise to presence" (Mel Slater & Steed, 2000, p. 414)), often with reference to the display type (e.g., desktop, less-than-360°, and 360° displays as non-immersive, semi-immersive, full immersive respectively (Kalawsky, 1996)). Under this definition, the Oculus Rift HMD used here would be considered fully immersive and the normal PC non-immersive. 2) The sensory contingency immersion (e.g., with sensory, challenge-based, and imaginative; the SCI-model (Ermi & Mäyrä, 2005)) or "as a property of the valid actions that are possible within the system" (M. Slater, 2009, p. 4); and 3) involvement-immersion involving three steps (engagement, engrossment, and psychological immersion) (Brown & Cairns, 2004; Jennett et al., 2008) which critically involves losing track of time. The intensity of being immersed does not necessarily correlate with being exposed to reality as the experience can conflict with the expectations; i.e., if noise and disturbances are present. On the other side, a simulation can take the expectations into account and create a highly immersive space using advanced means to stimulate the sensory system and react accordingly on the input of the user; the greater the immersion, "the greater the participant's suspension of disbelief that she or he is 'inside' a […] setting" (Dede, 2009, p. 66). People can be captivated in movies, books, or games and not realise that they have not moved for some time or maybe even eaten (Reiners, Wood, & Gregory, under review). Immersion can be achieved, to a degree, by skillful writing in a novel or a film. Subjective presence questionnaires such at the ITC-SOPI were developed to be applied across media (Lessiter, Freeman, Keogh, & Davidoff, 2001) not just virtual reality and the 'suspension of disbelief' is considered a factor in models of spatial presence; e.g., (Wirth et al., 2007) and according to Lee (2004) this argument was first made by (Coleridge, 1984) in his analysis of literature.

Authentic learning is the interface between 'true to life' tasks, activities, and practices and their replicated counterparts in virtual environments or classrooms, such that learners are forced to engage and react in a similar manner as they would in a "real" situation. (Dalgarno et al., under review, and see Blascovich & Bailenson, 2011) for a series of studies that demonstrate that reactions to virtual experiences are the same as reactions to real experiences). Authentic learning puts the learning into a context where the learner can make contextual mistakes without real life consequences (Brookes & Moseley, 2012) yet while being supported in understanding and imprinting the right behaviour under realistic conditions (Herrington, Reeves, & Oliver, 2010). Truly authentic learning can be costly, dangerous, or administratively difficult to arrange (Reiners & Wood, 2013). However, to be authentic, learning does not have to take place in the actual workplace setting. What is important is that the learning situation requires students to employ similar cognitive processes and behaviours as they would in the real-world context. (Herrington, Reeves & Oliver, 2010). In fact, field tours and site visits often do not qualify as examples of authentic learning – although the setting is real, students usually only get a predefined tour and a glimpse of the site, instead of being provided the opportunity to engage in authentic tasks of any kind. Therefore, using technology to create authentic learning environments can be more beneficial for student learning and skills acquisition. Simulations provide a very powerful way of supporting authentic learning. However, simply using technology does not create an authentic learning scenario, but thought must be put into implementing a pedagogically

sound authentic learning design. (Teräs & Herrington, forthcoming). Moreover, the technology should not interfere with the authentic learning in such a way that it does not reflect the reality anymore. If the movement of boxes is mapped into the virtual space it is important to use the same means of transport and handling procedures as in real life; even while in a virtual reality space we have the possibility to use teleportation devices or zero-gravity beams. If the handling of an object with the operator's hands is required, technologies like data gloves or Sixsense motion trackers are an option to track the physical movements of participants so that the virtual avatar responds appropriately. The limitations of haptic feedback (e.g., vibrations and shocks) and input (e.g., keyboard or mouse for motion) are challenged by wearable technology. These emerging technologies are capable of transferring the observed motions of the user into the virtual environment and allow a perceived solidification of virtual objects. Technology can detach the user from reality, matching the virtual movement with the input device; e.g., eschewing the use of keyboard and mouse and recognising the corresponding hand movements using VR haptic gloves or camera systems like Kinect. True and accurate 3D representations and 'natural' controls can also heighten learner engagement with the activity while increasing the authenticity of the learning experience, delivering significantly more value.

Emotion is essentially intertwined with experience whether affective or cognitive. Media such as books and films can induce moderate levels of emotion such as amusement and sadness (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Immersion can be used for inducing emotions such as when using the Velten (1968) procedure. Virtual environments have also been shown to be an effective medium (Baños et al., 2008; Riva et al., 2007) and immersive CAVE environments have demonstrated fear responses using virtual pits (M. Slater, Khanna, Mortensen, & Yu, 2009; Usoh, Catena, Arman, & Slater, 2000) or treating anxiety disorders (Juan & Pérez, 2010; Krijn, Emmelkamp, Olafsson, & Biemond, 2004; North, North, & Coble, 1998). Whilst other aspects such as narrative may also induce emotion within virtual environments (Gorini, Capideville, De Leo, Mantovani, & Riva, 2011), relatively low cost Head-Mounted Displays (HMD) such as the Oculus Rift (http://www.oculusvr.com/) may make many of the advantages of the more expensive and immersive CAVE environments more widely available and more able to be used within the wider educational context. This is valuable as variables that are difficult to control or duplicate in real-world settings are amenable to control in virtual realities due to the unique affordances of the digital world. We can deliberately modify the environment to induce specific situations including real-world emotional states such as stress or anxiety to evaluate the effectiveness of education and training in real-world situations. This ability to trigger emotional feelings by stimuli within the virtual environment becomes relevant as we discuss below the relation of emotionally laden learning and the speed and depth of retainment (Bennett, 2010; Pekrun, 2006). These affordances are especially noteworthy in gamified 3D spaces, where the control of goals, performance boundaries, and emotional characteristics are key aspects. The gathering of data from small learning modules allows understanding of individual learning behaviours and customising the learning experience. We thus intend to explore the design facets of creating emotionally compelling situations in safe virtual workplace settings, where we can employ one's physical, emotional and cognitive responses for specific situations and variety in the degree of physicality, emotionality, and cognitive complexity of the problems.

Authenticity, immersion, and emotion are interesting by themselves; the challenging part is to merge them in one space. We target an environment that is not predefined and linear such as a book or film, but reacts to the input of the learner by presenting them with appropriate reactions. Such a process creates improved transferability as the participants increasingly take the scenario for real. As stated by Arsenault (2005), the first step is the elimination of barriers that might cause distractions in the experience. Just as poor reading or language skills would limit a reader's immersion in a scenario outlined in a book, it is crucial to match the quality of input and output devices to the experience. For the experiment scenario below, simply displaying everything on monitors may work, but the sense of immersion will not be aided by the encroachment of reality such as the sense of the living room to your left side, the cat on the couch next to you, and the noise of children playing in the background. While using monitors, even looking around the virtual environment is in-authentic; it does not involve the neck muscles but the cursor keys instead. Combining various technologies to support immersion can result in improved authenticity and therefore, stronger emotions. We use the Oculus Rift HMD that projects the appropriate view based on where the users' head is turned and updates the image

according to head movements. Such an approach may even surpass the use of CAVEs and other expensive equipment and enable educators to more readily enhance their practices with more engaging and immersive tasks. Adding headphones with surround sound and noise cancellation would further eliminate the external audible environment; e.g., the telephone conversation from the person in the next cubical in the office.

This can create a truly intense experience that allows participants to take scenarios more seriously, increasing the authenticity of learning tasks. Is it required to have a realistic representation of the virtual space? Regarding the authenticity, a process can be highly authentic, but in a non-realistic setting. Our first experiments indicate that simulations can be authentic and immersive despite the low resolution and fidelity if the perception is focused on other sensory impressions (Bastiaens et al., under review). For example, the Oculus Rift provided an extended depth that participants approached edges with more caution and also considered the resolution and quality of the visualisation as irrelevant, despite the fact that the resolution and quality of the image of the Oculus Rift was significantly surpassed by the monitor used in comparative scenarios in a preliminary experiment (Reiners et al., under review).

Experimental design

The experiments are part of the research project nDiVE (www.ndive-project.com) which focuses on immersing learners in an authentic n-dimensional environment to demonstrate, simulate, and control real-world situations in a format that allows students to grasp the highly complex and interwoven processes in Logistics and Supply Chain scenarios and other situations requiring movement of goods or materials. The learning material is encoded as an interactive story to support the establishment of suitable scope and narratives while leaving the learner free to explore the space and create their own perspective on the established learning outcomes (Reiners et al., 2014). The holistic approach in nDiVE accommodates the natural complexity of the supply chain by breaking it into multiple chapters and using a personalised narrative through the storyline (Reiners et al., 2014). While the overall story is continuously carried forward, the chapter design integrates specialised 'missions' and challenges relevant to the context of the chapter scenario; similar to TV series presented over multiple seasons. In the example described here, the focus is set on occupational health and safety within Logistics infrastructures, with the intent to train the user in being able to identify high-risk situations and behave accordingly. Regarding the experimental design, we are interested in finding the answer to the following research questions:

- How can a learning experience be designed so that it taps into and uses the best mixture of inputs and outputs to achieve states of flow, creative tension, and concentration?
- How can the appropriate level of authenticity, immersion and induced emotions be defined in situation X and learning environment Y?
- How do the levels of authenticity, immersion, and emotion affect the learning retention specifically, focusing on interactions in these relationships?

The scenario presented here was designed with the intention to evaluate six closely related elements:

1. learn about dangerous situations in a specific context;
2. effectiveness and efficiency in identifying situations and suggesting solutions;
3. self-efficacy;
4. evaluating whether specific scenarios improve the learning effect and long-term retention;
5. increasing fun, passion, and emotional connection with the learning environment; and
6. encouraging the learner to take the training seriously.

This is accomplished by triggering a stronger ambition to 'survive' the scenario. To achieve this, we decided on the following minimal specifications for the scenario used in the experiments:

- Existence of serious health and safety risks that must be identified.
- Available in different media formats; traditional learning material in form of books and classroom presentations.
- Expert knowledge explaining identified situations; and the consequences of failure to identify situations.
- Being able to induce emotion; e.g., the fear of dying or guilt felt when someone else comes to harm due to your actions or inactions.

The participants in this experiment are divided randomly in four groups; each group receiving instruction and training by different media formats; i.e., considering different degrees of authenticity and immersion (Table 1). While the final evaluation of the learning and training outcome is conducted in the same scenario, the original environment consists of either printed material without further training in a 3D space, printed material and using a 3D training space, no printed material but the training space and performing the training in the later evaluation scenario. We further randomly select participants to use a 2D monitor to display the 3D virtual space or the Oculus Rift HMD for an intensified experience.

Table 1: Experimental design to accommodate various elements

	Learning	Training	Waiting	Evaluation	Post measures
Group 1	yes	-	yes	yes	interview/survey
Group 2	yes	yes	yes	yes	interview/survey
Group 3		yes	yes	yes	interview/survey
Group 4				yes	interview/survey

The primary learning objective of the experiment relates to the identification and comprehension of occupational safety and health risks within a container stack on a terminal. Figure 1 shows the layout of the scenario and indicates the location of the eight potential safety and health risks designed for this experiment. The scenario is small and can be fully explored; artificial boundaries are used to restrict learners' freedom to relevant areas. This is feasible and represents the focus of the inspector during the investigation. The following list explains the risks (numbering refers to Figure 1) in greater detail, focusing on how the participants can identify hazards and report them.

1. **Being hit by vehicles while emerging:** Missing floor markings can lead a worker to believe that it is safe to continue walking. If the worker continues to walk, the forklift will hit and injure the worker.
   Outcome: Injury or death.
   Method of prevention: Stopping at the end of the aisle and look out for traffic.
   Identification: Centering the view on the area with the missing marks and taking a photo/screen shot (built in camera)

2. **Hit by a crane in an aisle:** Cranes and straddle carriers operate in container stacks and the aisle may be blocked during operation as the operator does not have clear view at all time.
   Outcome: Injury or death.
   Method of prevention: Contact should be established with the operator via radio before entering the aisle.
   Identification: Use either the radio to report the hazard or the computer to mark the aisle as blocked so that operations in the area are placed on hold.

3. **Crushed under a container:** While moving in the container stack or accessing a container, the crane might place a container on you due to poor visibility.
   Outcome: Death.
   Method of prevention: Contact the operator via radio before entering the apparently empty area.
   Identification: Use either the radio to report your location or the computer to check on operations in the area.
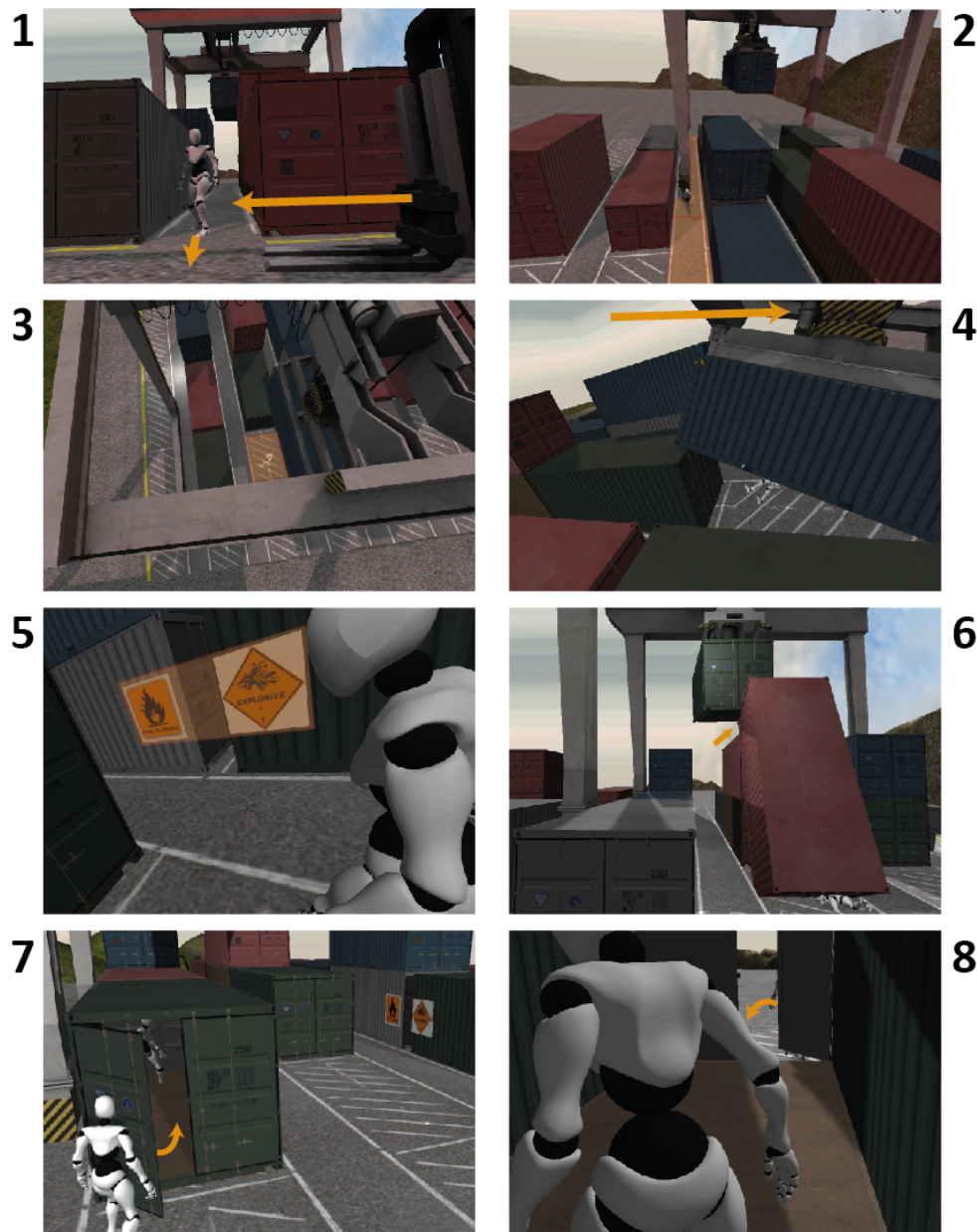
Figure 1: Visualisation of the different situations on the terminal. (1) hit by emerging vehicle; (2) hit by crane in aisle; (3) crushed under container; (4) faulty material; (5) dangerous goods; (6) error by humans; (7) endangering a colleague; (8) being trapped

4. **Faulty material:** Cable or locking bolts might fail if regular maintenance was not undertaken. Here, the cable snapped and the container dropped at a location deemed to be safe.
   Outcome: Injury or death.
   Method of prevention: Prioritise maintenance and check for irregularities; e.g., sounds or suspicious constellations.
   Identification: Use the computer to check maintenance dates and report suspicious sounds/sights.

5. **Dangerous Goods:** Dangerous goods require special handling and may not be located within certain proximities to some locations or objects. Failure can cause tremendous danger and damage; e.g., if containers are broken and contents emerge.
   Outcome: Injury or death.
   Method of prevention: Verifying content and location before placing the container, inform appropriate co-workers about health and safety issues regarding container classification.
   Identification: Centering the view on the area with the labels while taking a photo/screen shot.

6. **Error by humans:** Even after identifying and marking the risk areas, risks remain in most environments. One immediate problem is human error; e.g., incorrectly estimating the height of the container stacks resulting in one container knocking another off the stack and onto a passing worker.
   Outcome: Injury or death.
   Method of prevention: Stay alert and observe the surroundings. Have someone else to support you doing this.
   Identification: Writing a report identifying additional risks. Taking a photo/screen shot of the area that is associated with the report.

7. **Endangering a colleague:** Inspection of containers requires workers to open and enter containers. Non-communication can cause a colleague to close an open door, whereby their colleague may be trapped inside.
   Outcome: Psychological harm (to co-worker); injury or death (to yourself).
   Method of prevention: Inspecting the container before closing the door. Colleague might not react to your voice as they may be wearing "noise-cancellation" headsets. Instead, use visual signals like a flashing light. Require employees to indicate with a sign when someone is in the container.
   Identification: Centering the open door while taking a photo/screen shot.

8. **Being trapped:** Similar to scenario seven ("endangering a colleague"), but in reverse, where a colleague endangers the learner.
   Outcome: Psychological harm, injury, or death.
   Method of prevention: Stay alert and observe the surroundings. Have someone else outside monitoring activities.
   Identification: Writing a report identifying additional risks. Taking photo/screen shot of the area that is associated with the report.

Experiments

During the experiment, only the participant and observer will be in the physical experiment room to minimise extraneous disturbance of voices from outside of the virtual space as these decrease the immersion. The participants will be informed that the time in the scenario will be restricted; however, the limit will be set far beyond the longest likely time observed for task completion within preliminary studies. In the training as well as the evaluation scenario, the participants are asked to identify the situations as shown in Figure 1. Before and after the experiment, short interviews are conducted using a set of prepared questions as a general guide to ensure consistency over the interviews and to reach out for the main objectives of the research as well as the objectives for this scenario. This semi-structured interviewing process ensures that the interviews remain focused on exploring the phenomena of interest. The interview schedule consisting of open-ended questions initiates questions and discussions, allowing the participants to express their own concepts, interpretations, and perceptions about immersion. We will also use Likert-type scales to rate the scenarios (in terms of being realistic, useable, interesting, engaging, and compelling) with seven levels of agreement from strongly disagree to strongly agree. The data collection includes further sources as shown in Figure 2.

1. Camera recording to observe the participant behaviour, gestures, and reactions while using the learning material or performing the experiment;
2. Efficiency data from the virtual environment such as movement of the avatar, viewing direction, or interaction with the environment;
3. Biometric data such as level of perspiration, heart rate and data from an eeg scan to detect emotional changes as a reaction to the environment.

The hardware and software for the experimental environment was chosen for its applicability to our experiment and context, but also to meet the requirements for a consumer on a low budget (or universities that require multiple setups in different classrooms without having to consider major

project budgets). Including the Oculus Rift, Emotive, camera, controller and Kinect, we stayed below 1500 AUD (excluding computer and monitor which we assume to be available); the development software is the free version of Unity 3D (www.unity3d.com). Developing cost and time are not consider here, but can be done in student projects as the Unity 3D requires only a short induction time if programming skills are present. The consent for the data collection is requested from the participants; the entire experiment requires ethics approval.
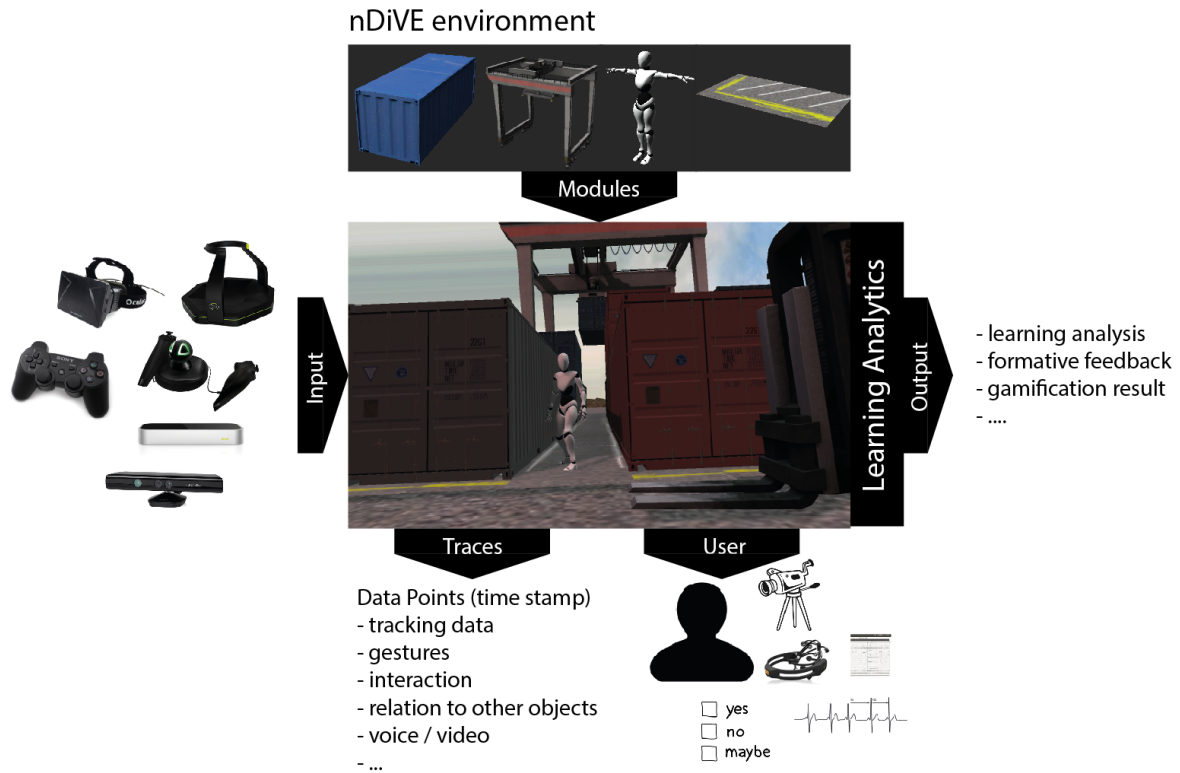
Figure 2: Input and output of the experiments

Figure 3: Oculus Rift used by one of the authors

The assumption in this experiment is that the participants are not experienced with the scenarios being presented to them and most likely never set foot in any similar situation. We provide a short tutorial explaining the main controls, input devices, components, and processes. We support different control options as it is important that the participant feels comfortable. Next to specialised input devices like Sixsense Motion control and Kinect, we also offer the traditional mouse and keyboard option; however, the output device is determined by the experimental design (Table 1). The experiment is not about training or evaluating experts doing occupational health and safety inspections; rather, the focus is on how people in general react to the space depending on the use of different media formats, the usability and interactivity of the scenario and an understanding if there is a common sense or general capability to identify dangerous situations. These factors are all relevant on site visits with students. This paper covers the experimental design including the input and resulting output to derive a formative feedback for the participant and a first evaluation of whether this context is feasible for

inducing and detecting emotions. The experiments are planned to run over a 2-3 month period as we include the evaluation of learning retention based on the used input and output device. However, preliminary studies focusing on the use of the head-mounted display have been undertaken to better understand how this affects the degree of immersion and authenticity compared to using 3D virtual worlds on a 2D monitor.

In these preliminary studies (reported elsewhere; see Reiners et al., under review) a small number of participants (n=13, 6 male, 7 female, wide cross section of all working adult age categories) partook in an experiment using the Oculus Rift. On a five-point Likert-type scale (from 1=no to 5=extensive), the participants indicated their gaming (M=2.85, SD=1.46) and virtual world (M=2.23, SD=1.23) experience (the correlation is 0.39). All participants had heard of head-mounted devices but had not yet used them. The range of scenarios covered Second Life (2D monitor), a 3D environment without fast motions (Oculus Rift), two scenarios with fast movements without control (roller coaster and helicopter flight using the Oculus Rift), and some scenarios were the participant took over control (racing simulation, 2D monitor and Oculus Rift). More details on the experimental setting and the analysis can be found in Reiners et al. (under review). Importantly, these experiments with the Oculus Rift confirmed our expectations about the intensity of experience and the effects on the participants. The observation of the participants revealed a strong immersion as we could infer as they matched their physical movements to the avatar's movements; this was not the case when they used a 2D monitor. Participants felt present in the scenario that they either almost lost their balance or had to stop the experiment as it was too intensive. The physical reactions based on observation and interview afterwards includes the following (n=12):

- Perspiration: 4 (33.3%)
- Strong tension: 2 (16.6%)
- Heavy breathing: 1 (8.3%)
- Heart beat increasing: 4 (33.3%)
- Strong movements: 7 (58.3%)
- Trying to hold to something: 7 (58.3%)
- Closing their eyes: 2 (16.6%)

All participants claimed that the experience felt real, indicating that immersive visualisation technology can compensate for low fidelity (non-real setting, low-level of graphics resolution). In relation to the roller coaster scenario, one participate reported being "really surprised how the brain and balance sense are fooled although the picture was not 100% real [and I am not really riding on one]." All participants had anticipated these feelings and agreed that this would not influence their affinity to continue or to use the device in the future; 62% explicitly mentioned they would become accustomed to the new experience. It should be noted, that we did not adjust the Oculus Rift for an optimised experience for each participant but used the most general settings.

Way forward and discussion

This contribution introduces nDiVE, our ongoing research project about the creation process of an authentic immersive space to study the complexity of Logistics systems as well as being prepared with respect to health and safety risks. Preliminary experiments demonstrated the advantage of emerging technology (e.g., Oculus Rift HMD) to increase authenticity and immersion, and this has influenced the abovementioned design of the environment and the intended experiments. We further extend the experimental scope by not limiting ourselves to the observation of the behaviour in performing the requested tasks but also analysing the participant with respect to their emotions and how this influences the later behaviour. The experimental design includes a second stage, where randomly selected participants repeat the experiment after a period of 2-3 months to evaluate the learning retention with and without short refresher modules beforehand.

The participants can see a strong potential for applications using the Oculus Rift (or future HMDs of similar quality) in education, training, entertainment, and tourism (order indicates the relevance stated by participants). The same scenario experienced using a monitor fails to have such an immersive

effect; the restricted 2D window into the virtual environment causes too many conflicts with the perception. Nine participants (70%) investigated scenarios with more care and seriousness when using the HMD; despite the knowledge that it is a game-like environment and they were not in imminent danger. Seventy-seven percent believe that using the Oculus Rift for an induction to an industry site (e.g., demonstrating possible incidents that can occur on this site that may lead to injury) would create greater awareness and thus more care while being in the real environment. The majority of participants mentioned that it would add value to the classroom. These preliminary results indicate that the aforementioned technologies will enable safe, secure, and sensible classroom visits to "real enough" environments and scenarios, mediated by virtuality. This creates an interesting potential to create more fluid transitions from safe learning environments to real ones, and the research group will continue studying this in future publications. As the title of the paper suggests, fear of dying is an important learning experience in a simulation as participants are immersed in authentic learning scenarios where they are able to learn the real consequences of their actions.

Acknowledgment

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