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Operationalising gamification in an educational authentic environment

Torsten Reiners, Lincoln C. Wood, Vanessa Chang
*School of Information Systems, Curtin University
Bentley, WA, Australia, t.reiners@curtin.edu.au*

Christian Gütl
*Institute for Information Systems and Computer Media (IICM)
Graz University of Technology, Austria*

Jan Herrington,
*Murdoch University
Murdoch, WA, Australia*

Hanna Teräs
*Tampere University of Applied Science
Tampere, Finland*

Sue Gregory
*University of New England
Armidale, NSW, Australia*

ABSTRACT

This paper addresses the largely ‘inauthentic’ pedagogical approaches in current classroom and distance-learning environments, and will propose a methodology that utilises existing technologies to provide an immersive and authentic experience in education; that is to bridge the gap between the academic perspective and the real-world requirements. Industry postulate that recent graduates lack requisite skills, are often ignorant of the workings of company cultures, and are uncertain how to transfer their university-acquired theoretical knowledge to effective practice. We propose an environment that increases authenticity through inclusion of real-life complexity modelled in an immersive scenario, links scenarios into a comprehensive supply chain that supports exchange of information and repercussions/effects from actions between modules, and includes gaming mechanisms to increase student engagement further. In particular, the gaming mechanisms encourage student engagement (and better manage their interaction/learning process with in a step-wise fashion, rather than ‘throwing them in the deep end’), reflection, and learning from the flow-on effects of an interlinked immersive, authentic, virtual, awesome, environment.

KEYWORDS: Skill training, virtual environment, game mechanism, engagement, authentic learning

1. INTRODUCTION

Our increasingly globalized world is faced with fast developing and changing situations that require all members of the society to constantly keep pace with ever-changing demands. This calls for the adoption of a range of skills and soft-skills, and a reconsideration of learning and training approaches. The mobility of learners and educators, the difficulty of aligning availability across all time zones, the need for customisation of learning to employ authentic scenarios and skills, and the need to engage learners despite the lack of immediate personal contact, are just some of the challenges (Chang & Gütl, 2010). The concept of virtual (reality) environments mapping real-world processes in an accessible confined space for educational purposes has already achieved significant market penetration, particularly with the increased perception of advanced technology in the upcoming digital generation (Prensky, 2001). Installations at various international

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educational institutions emphasised the beneficial nature of allowing learners to experience scenarios that might be out of reach (e.g., space walks or isolated places) or impossible to explore from an internal perspective (e.g., internal processes in a fuel cell (Boerger & Tietgens, 2013)). Some prominent examples for realising virtual experience of real-world situations are coming from health science (Thompson & Hagstrom, 2011), engineering (Bresciani et al., 2010), and education (Gregory et al., 2011), but also specialised areas take advantage of simulating hazardous situation for training purposes.

In our research, we address the acquisition of specific skills in preparation for real-world application with a focus on Logistics & Supply Chain Management (L&SCM). The challenge to transfer complexity into environments for engaging education is approached in many ways; yet the reduction of complexity or limited coverage while enhancing engagement is more challenging and may require the use of gamification or game elements (Wood & Reiners, under review). The use of game mechanisms and active learning has been used in L&SCM classes to improve engagement (Wood & Reefke, 2010), with the Beer Game as one of the best-known and accepted supply chain simulation, used to demonstrate and analyse the bullwhip effect in supply chains (Lee, Padmanabhan, & Wang, 1997). While these simulations are successful, they still frequently fail to reach high levels of authenticity as they are simplified computer-based simulations; or operate using pens, paper, boards and tokens, forcing simplification to make the simulation feasible. For learners, the overall impact of decisions, and flow-on effects along the supply chain, between different components is not visible and understandable due to the lack of experience – the repercussions may be felt only months later. Our research addresses this issue in different ways as we: 1) increase authenticity through inclusion of real-life complexity modelled in an immersive scenario, 2) use scenarios linked into a comprehensive supply chain that supports exchange of information and repercussions/effects from actions between modules, and 3) include gaming mechanisms to increase student engagement further. In a nutshell – we are shrinking a supply chain down into multiple, relatively-realistically represented, simulated, supply chain components for defined skill training; which then are linked for a collaborative and comprehensive understanding of the systems' complexity.

We elaborate gaming mechanisms to encourage engagement, and thus sustainability of the learning process. Gaming is a currently a growing market with a potential of US \$2.8b in 2016 (Peterson, 2012) and proliferation of 60% at “midsize-to-large organisations deploying at least one gamified application by 2021” (Burke, 2011). In this process, non-game, real-world contexts are enhanced with technology and mechanics from games to engage, encourage, focus, and guide users addressing the predisposition in gaming (Radoff, 2011). Mechanics of gamification include rewarded achievements (badges), leader boards, progress bars, or competitive challenges (Bajdor & Dragolea, 2011); augmenting tasks with motivational objectives to fight against the inner temptation of quitting. Even though the level of abstraction is still high, students are more likely to learn effectively (Lainema & Hilmola, 2005; Rosenberg, 2006). Groh (2012) points out that gamification has not yet lived up to its hype and despite the promise of an almost-natural methodology for engagement, “proper scientific studies about the benefits as well as the side-effects of gamification” must be conducted to demonstrate the long-term benefits (Groh, 2012).

2. AUTHENTIC AND IMMERSIVE LEARNING ENVIRONMENT

Technology enables us to recreate reality in a virtual space and provide a degree of authenticity that allows almost complete immersion of learners in given scenarios. Authentic learning is often misinterpreted as meaning that students need to experience authenticity in real-world settings, such as might occur in field trips, apprenticeships, internships and practicums. While it is true that authentic learning can and does occur in these settings, the model is primarily one that can be utilised in any classroom or higher education setting, as it employs pedagogical strategies to enable students to act as if they were operating in a real environment, and provides opportunities for them to think and act as if they were experts in that field or discipline (Herrington, Reeves, & Oliver, 2010).

Strategies used in authentic learning include: providing an authentic context within which to situate the learning; creating an authentic task that requires considerable time and effort in its completion; providing access to expert performance and the modelling of processes to enable students to observe and critique; providing a range of resources to enable students to access multiple perspectives; providing opportunities for students to collaborate with their peers in the creation of genuine and useful products; provide opportunities

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to reflect, and articulate (spoken and written) their growing understanding; provide scaffolding and support; and use authentic assessment to evaluate students' products. The design of a learning environment that incorporates these elements ensures that student activity will incorporate thinking and problem solving as if they were performing in a real-world environment.

Immersive simulations and virtual environments, while not required to support authentic learning, can be significant enablers to authenticity. In particular, interactive simulations in highly specialised areas can facilitate safe learning in consequence-free environments that enable cognitive mastery prior to engagement with the physical real-world challenge. Moreover, expert performance can be captured in a consistent manner to meet industry standards, and in some environments (depending on the activity), students can practise skills to show improved performance. Such environments are not only pedagogically and theoretically sound; they are more sustainable as they allow successive cohorts of students to benefit from the embedded expertise that often evaporates when a single, expert teacher moves on.

Virtual worlds (VW) are a closely related concept of immersive, multi-user virtual environments but they also represent a persistent online environment, where a large population of users can interact over time and are represented by avatars. 3D environments facilitate re-creation of real-world scenarios or to create complete new ones following with real physical concepts (such as gravity) or different ones (such as enabling avatars flying around) (Gütl, 2011). Those 3D worlds may be applied to understand things and concepts, explore, learn and train as well as to socialize or purely have fun. (Bailenson et al., 2008; Chittaro & Ranon, 2007; Jacobson, Kim, Miao, Shen, & Chavez, 2010). 3D environments, similar to the aforementioned gamification, are still growing markets and therefore represent an interesting as well as future-oriented technology (forecast by (KZero, 2009) to be US \$9b value in 2013; see also (Gartner Research, 2011) and (IEEE VW Standard Working Group, 2012)).

3D worlds offer various dimensions to support the idea of an engaging and immersive learning environment: (a) multiple communication channels where both verbal and non-verbal communication can increase the social awareness and improve the knowledge transfer and understanding; (b) the presence which is meant to be the feeling to be part of the virtual environment, that can effect suspension of disbelief and increase motivation and productivity; (c) the awareness of other avatars, the environment and activities that can have positive impact the dynamic of group communication; (d) decreasing barriers between students and instructors, and (e) the facilitation of collaboration on 3D artefacts or other content (Gütl, 2011).

NDIVE: N-DIMENSIONAL IMMERSIVE VIRTUAL ENVIRONMENT

nDiVE is about extending the 3D environments by core tools functionality to promote sustainable, comprehensive, and authentic learning, skill training, and transfer of tactic knowledge. It creates a scenario- and situation-specific space within the 3D environment that inherits functionality but also places rules on how perceptions and interactivity with containing objects is defined (see Figure 1). For example, with our focus on L&SCM, the mass of objects has to be accurate to simulate capabilities of transportation vehicles (e.g., to demonstrate the risk of being injured or killed after entering restricted areas). The introduction of game-mechanism and game-rules is affecting the virtual world as the open characteristics (associated with VWs) are reduced by the introduction of educational structure to increase accuracy and authenticity.

The area of L&SCM was chosen as supply chains exhibit attributes challenging the provision of superior skills training: 1) activities are geographically distributed around the world (*they are difficult to observe for the learner*), 2) sequences of activities have long lead-times of several months (*long time-periods without events before the outcome of decisions becomes visible*), and 3) there are numerous opportunities for unexpected events that cause major disruptions or erroneous outcomes (*consequences that are not desirable to replicate in real-life environments*). Decisions, made without understanding the complexity of the interconnected system, can cause millions of dollars in damage or trigger a chain of events that degrade the quality of life for people, the wider environment (*such as oil spills*), or food supply chains (*such as poisoning or health scares*). Regarding the training of skills to recognise and handle such situations, learners have to understand the manifold dimensions of the problem space such as space, time, costs/budget, environmental risk factors, sustainability measures, technology, and IT systems. It might be possible to teach some material in classroom settings (e.g., *whiteboards, slides, photos, or videos*); but generally not without losing some authenticity. We use a constructivist approach to provide learners with authentic experiences and skills, and

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built on assessment and feedback that reflect the complex, diverse, and multi-faceted nature of L&SCM in real-world settings. This will improve student engagement and motivation, establish authentic scenarios and situations, create distinct targeted skills, and provide institutions with educational tools to enhance (continuous) teaching and professional training. We intend to leave the *clean, ordered, and structured* academic environment with idealist models and capture the real-world ‘messiness’ as it is a more authentic replication of real-world situations. “Conventional problem solving does not explicitly consider the *context* of the problem. Systems thinking, in contrast, acknowledges the *messiness* of the world and views a problem in the context of its environment” (Maani & Cavana, 2000, p. 37; emphasis in original).

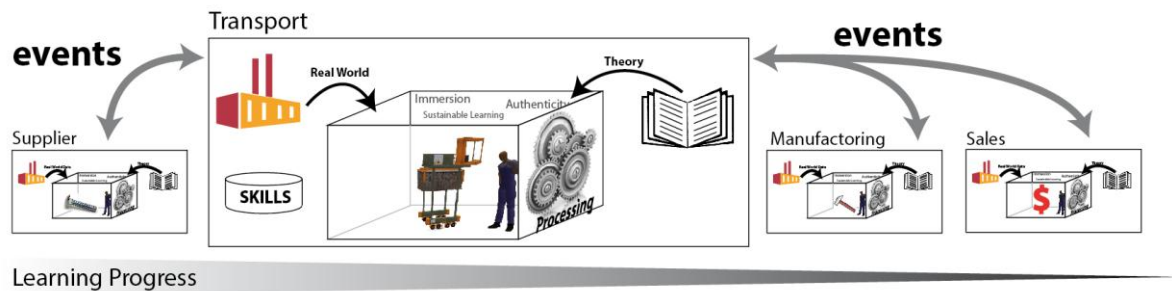


Figure 1: nDiVE decomposes complex scenarios (components) into learning modules, in which learners train specific skills in an authentic and immersive virtual environment. The components influence each other such that the learner receives feedback on actions on the complete supply chain; see also (Reiners & Wood, forthcoming, 2013) for more details.

Establishing an authentic virtual learning environment still requires the learner to be motivated using nDiVE. Thus, we use further features to encourage engagement such as learning to fail, gaming mechanism, and sustainability as described below.

LEARNING TO FAIL: Learners require the experience of failure to learn, that is, to fail by leaving the feasible operational space, stepping over boundaries, applying the wrong method, or getting in serious problems. In real-life, failure is commonly associated with high-risks situations, where applying the wrong tool could result in death. To reduce the risk, most education transfers the real-world to an abstracted model and visualises them by different means like textbooks, reading, video presentation, or restricted site-visits. Doing this, the understanding as well as retention of knowledge is massively reduced. A key difference between VWs and the real-world is that avatars can be reinitiated after being hit by a transport vehicle. Real people cannot be.

VWs traditionally define themselves as being ‘not games’ (Constable, 2008); in contrast, we suggest that game-elements can supplement VWs for educational purposes. It would not be in the best interest of the learner if the lack of physical constraints resulted in unrealistic transport times and virtual-truck capacities that were significantly different to their counterparts in reality. The establishment of gaming rules define the scope in which the learner operates to achieve given objectives and the metric by which the skills and learning outcomes are assessed against. Established gaming mechanisms mark the difference with traditional learning experiences, particularly in motivation, engagement, and benchmarking.

GAMING MECHANISMS FOR LEARNING: In games, the failure of achieving the specified requirements results in a so-called *game over*; a state were the player is informed that the rules were violated too frequently or egregiously; in education this may occur when the anticipated learning outcome is not achieved. While every event in the real-world leaves an imprint on the environment, games and therewith virtual environments create a *sustainable space* that can be leveraged in multiple ways for learning enhancement, increase of motivation, and engagement. The following game mechanisms are beneficial as they provide effective support and sustainability for the learner and educator in the context of nDiVE (Wood & Reiners, under review):

- **Next life:** In some scenarios, the risk of injuries or death cannot be completely excluded and require learners to take precautions and special training. Authenticity requires training in extreme situations, whereas real-world experiences allow this only to a certain limit while guaranteeing safety. In nDiVE,

the line between safety and death can be explored (e.g., counter-measures for extreme situations like a vehicle tilt due to centrifugal forces). During the training process in nDiVE, the learner can ‘re-spawn’ with a new avatar and retry, without setting the life counter to zero.

- **Rewind:** Repeating crucial moments repeatedly builds confidence. This process can be used to ‘reset’ a scenario (e.g., after physically moving all the items from point A to point B we can instantly restore the original scenario), impossible (disposing toxic waste), or resource intensive. In virtual environments, it is not required to restart entirely, instead we can go back just enough to repeat the required session.
- **Slow motion:** Operating high-speed machines (e.g., newspaper presses) doesn’t permit an observer in the real-world to observe distinct, single steps; reality prevents us from slowing the process to a point where steps become observable. nDiVE can be used to slow the motion down to comprehend the process, and learn about safety protocols in areas with heavy machinery.
- **Save points:** In games, save points are associated with the conclusion of a stage or the start of something extraordinary. Regarding skill training, save points can and should be used before an event to allow a 1) a restart in case of failure or 2) revisit at a later moment. It encourages learners to recognise achievements, take a break, and prepare for the next learning stage.
- **Awards:** Employer incentives for non-wasteful behaviours are commonly used (e.g., truck drivers held accountable for their fuel use or managers undertaking virtual meetings instead of travelling).
- **Multi-player:** Early VW learning environments emphasised single-learner experiences which lacked multi-person collaborative experiences. This has led to unsatisfactory results with high average dropout rates and low level of quality learning because of (a) a feeling of isolation, (b) procrastination, (c) lack of multiple communication channels, and (d) difficulties related to self-regulation (Bernard, Rojo de Rubalcava, & St-Pierre, 2000; Gütl, 2008)
- **Ghost images:** Experts can undertake a single demonstration – this is retained (using machinima) and archived for future learning experiences. Bots, computer-controlled avatars interacting with the environment, record and extract an ‘expert system’ set of rules for how to respond, based on the trainers/experts actions. This creates an interactive, future-proofed record for – effectively creating a simplified ‘copy’ of the expert’s core ability to respond to key environmental elements.
- **Non-player characters (NPCs):** Carefully scripted and programmed bots can take the place of non-person controlled characters that learners can interact with. Effective learning scenarios require precisely programmed responses to human-initiated events.

All the described gaming mechanisms are not possible in real-world settings; the gaming mechanisms conflict with physical restrictions as any action changes the environment. In that context, nDiVE provides a sustainable learning and teaching space where resources are harvested and used without depleting or damaging them. Scenarios can emulate environments where highly specialised skills training can be authentically conducted using technology, resulting in resources that are innovative, effective, and sustainable.

SUSTAINABLE LEARNING: nDiVE implements educational sustainability along multiple dimensions; including: 1) using virtual environments to keep the need and usage of resources low; 2) preservation of expert knowledge; and 3) recording and analysing the learning path and progress (Figure 2).

1. Learners have to be confronted at one point during their training with a real-world scenario with all its challenges. Training sessions in the real-world can be highly resource intensive; i.e., in cases like machine operating units or vehicle driving, lessons must be conducted, preventing use of the equipment for productive purposes. The training creates opportunity costs by affecting the business operation (damage, lower workload, and lower quality) or duplicating equipment. In addition, the training requires costs for running the equipment, getting to the workplace, and including the full measure of the expert’s time and attention. An exemplar of low-risk and efficient use of resources during training is the aircraft flight simulator – as the learner can be confronted with exceptional scenarios not necessarily possible or desired using real equipment. With L&SCM, training for rare but extreme situations seldom occurs due to the lack of opportunities; thus, the learner is not prepared to confront the situation.
2. Simulation environments often have no other people (avatars) walking by, generating constant background activity of others to promote “a sense of being alive” (Ullrich, Bruegmann, Prendinger, &

Ishizuka, 2008). Bots could fill that gap and become the needed background, acting as props that set the stage for the simulation. These bots are easily realised as they do not interact but follow rules like walking a given path, demonstrate objects, or sit next to users in a bar (Reiners, Gregory, & Knox, forthcoming, 2013). However, bots in learning scenarios generally cannot be based on simple behaviours as learners also need feedback on non-expected actions. Imagine a lecture in Logistics, where students must learn about container terminal processes, that is, how containers are discharged from the vessel. In a self-study setting, the learner might control the container bridge, forcing straddle carriers to be controlled by bots rather than by other learners, as they still have a crucial role to play. Workmen on the vessel controlling the discharge process would further increase the level of realism. Simple bots are adequate to a certain level; however, if the learner must be exposed to critical situations, the bots are required to interact appropriately. Imagine what would happen if the learner drifted into a routine and failed to scan the surrounding environment for risks. Bots can intentionally generate dangerous situations by stopping a straddle carrier at the wrong location, or causing a bot on the deck to wander too close to the container being discharged. The injection of an unanticipated confluence of elements forces learner attentiveness.

3. Reviewing a scenario from different perspectives is important to support analysis and reflection; yet, even multiple cameras filming the training would restrict the observation to a defined set of perspectives, not accounting for the overhead in case of vehicle training or problems aligning video feeds and data streams. In a virtual setting, recorded sessions can be reviewed from any perspective, allowing time dilation or contraction or the visualisation of important events from different locations. Driving straddle carriers on a container terminal requires many skills, fundamental to which are the capabilities to pass through narrow lanes in container stacks, managing centrifugal forces while turning corners, precision in container placement. Similar to flight simulators or racing simulations, the learner can navigate through a recorded session, move the camera to any perspective, and add live visualisation of data into the stream (e.g., an accurate report on the distance between containers or physics forces acting on the vehicle).



Figure 2: Multiple perspectives on the same scenario within the logistics component: 1) supply manager decides on order quantities to be ordered to the warehouse; 2) the controller on the container terminal receives the information and decides on shipment orders; 3) operations managers analyse the performance of the movements on the terminal; 4) engineers plan on improving equipment to increase performance (Burmester, Burmester, & Reiners, 2008; Reiners, 2010; Wriedt, Reiners, & Ebeling, 2008).

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3. CONCLUSION

Learning should be about *fun*, *play*, and *passion* (SAP, 2012). Instead of sitting in lectures and retaining perhaps only 5% of the given knowledge, we get up and practice our acquired knowledge to achieve a salutary 75% retention of knowledge (Middleton & Price, 2001). This would further benefit learners by allowing acquisition and demonstration of real-world skills rather than being ‘theoretically capable’ of performing activities as requested by employers. This is not to say that most educators and learners would not prefer a strong connection between theory and practice, it is merely part of the ongoing research to achieve realistic solutions. Recently, simulations in different environments, especially virtual worlds and virtual reality, have gained prominence as they address several requirements for a close-to-perfect learning environment (e.g., authenticity, unrestricted availability, and interactivity without requiring educator involvement).

Several publications state that virtual environments are capable of engaging students and encouraging them to repeatedly use the technology, increasing their overall learning performance; yet, student engagement remains lower than expected and desired (Gregory, 2012, under review). In this paper, we have suggested several crucial components to further engage students and also bridge the gap between the academic perspective and the real-world requirements. The nDiVE framework is designed as an authentic virtual environment for skills training, which incorporates game mechanisms to motivate students to further engagement and higher achievement. Even though the term gamification and game mechanisms have been used for a long time, the deep integration of these concepts in learning and teaching commenced only in the last couple of years. The first outcomes suggest that they can significantly improve to student engagement and success.

Further studies are required to demonstrate the effectiveness of gamification in the context of teaching and learning. Serious games provide a demonstration of the beneficial tendencies to improve students’ engagement; yet, the success of casual gaming apps, particularly how they captivate attention and hold gamers in a thrall, over all age groups, while sensitising learners to innovative, immersive, gamified environments. Educators have the tools, the content, and the methods; now we have to bind learners so they behave like fully immersed players who are compelled to complete “just one more level”.

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