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The role of gamification and game-based learning in authentic assessment within virtual environments

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Gamification is the application of game-based elements to non-game systems. Within education this can incorporate many game-based mechanisms. We review the use of some of these specifically: rewind, ghost images, save points and multiple lives, and time and space control. The opportunities to use these game-based mechanisms to assist assessment have remained under-examined and under-exploited. However, these game-based elements are particularly pertinent within an authentic learning framework supported by virtual environments, or virtual places. Thus, we identify how these game-based mechanisms can improve assessment while increasing efficiency and providing new opportunities for educators. This longitudinal study spans from 2012 to 2015.

Keywords: Gamification, authentic learning, assessment, authentic assessment, virtual environments.

Introduction

The use of e-assessment has continued to rise, while the number of students using technology both within and outside of the classroom continues to grow. Coupled with new approaches in education and particularly gamification this presents opportunities for new forms of assessment that may provide a more accurate picture of students' achievements. The design of authentic assessment tasks is becoming increasingly important as education moves away from moribund classroom-based approaches to more authentic learning. This forces a change in assessment types, from paper-based essays to assessment of increasingly authentic activities. Virtual environments present a highly authentic, but controlled place forcing the need for new types of assessment patterns when used within university classrooms. Indeed, traditional, 'one-off' assessment activities no longer provide suitable structures for assessing student learning, and the game-based mechanisms not only provide improved engagement but also provide the opportunity for a range of new, assessment of authentic learning tasks. This

approach seeks to move away from the traditionally adopted knowledge-transmission approach to learning towards a constructivist (Jonassen & Rohrer-Murphy, 1999).

It has been argued that authentic tasks in authentic situations provide a solid foundation for adult learning (Huang, 2002). The context that students learn in must be incorporated into the design of the learning environment (Brown, Collins, & Duguid, 1989); although a distinction should be made between the two (Petraglia, 1998). Task design is crucial as prior research indicates that authentic tasks and authentic context or environment must be considered separately and as distinctly different; simply using an authentic environment may provide no additional benefit to students even when authentic tasks are being assessed (Gulikers, Bastiaens, & Martens, 2005).

Discussions about gamification and gaming mechanisms are common in the gaming industry for entertainment and competition; yet, are not generally applied in education. These mechanisms are rewind, ghost images, slow motion, save points and multiple lives, and time and space control (Reiners & Wood, 2013; Reiners et al., 2012). We examine their classroom integration in assessment and highlight opportunities for incorporation in future assessment strategies. This provides a foundation for future research to test the effectiveness and ‘fit’ of these strategies within authentic education environments.

Literature review

Provided is an overview of authentic learning for motivating the use of virtual environments; assessment, a key focus in education; and gamification tools, detailing what can be accomplished.

Authentic learning

Although technology has been widely integrated in education during the past decade, in most cases the technologies adopted in universities focus on course management and promote very mechanistic and unauthentic ways of content delivery and assessment. Instead of making use of technology as a powerful cognitive tool that students can learn with, it is often harnessed to serve as a platform for linear, teacher-centered delivery of information and simple, computer-assisted ways of assessment that tend to address the lowest levels of cognition: remembering and, at its best, understanding (Anderson & Krathwohl, 2001). In this light it is no wonder that some researchers and practitioners have found that increased technology use can lead to deterioration in learning and teaching (e.g., Brabazon, 2007).

Authentic learning as defined by Herrington, Reeves, and Oliver (2010) provides an alternative approach that allows for an engaging and student-centered learning design. It is very thoroughly researched and is based on constructivist and situated learning theories. In authentic learning contexts, technology is used as a cognitive tool for problem solving and knowledge construction. Authentic learning takes place with technology instead of from technology (Herrington et al., 2010).

There are many definitions and perceptions of authentic learning, one of them being that learning should take place in the real world (Lombardi, 2007); e.g., work placement or practical training. However, the opportunity for this in today’s tertiary education is more often an exception than the rule, as in many cases learning in the real world setting could be very costly, difficult or even dangerous to arrange. Learning can be authentic even if it does not take place in the actual work environment. According to Herrington et al. (2010), a central

characteristic of authentic learning is not the place where learning happens, but that the learning context reflects the ways the knowledge will be used in real life. In other words, students should be engaged in similar processes of thinking, problem solving and delivering required outcomes as they would in a real-life situation relevant to their field of study.

Authentic tasks and authentic assessment are essential cornerstones of a successful authentic learning design. Herrington et al. (2010, pp. 46-48) define ten characteristics of an authentic task:

1. has real world relevance and it matches as nearly as possible with the tasks performed by expert practitioners of the field.
2. is not oversimplified but rather ill-defined, requiring and promoting problem solving and higher order thinking rather than memorizing correct answers.
3. requires significant investment of time and intellectual resources.
4. offers an opportunity to examine a problem from different perspectives, using multiple resources.
5. requires collaboration.
6. offers an opportunity for the student to make decisions and reflect on their learning.
7. can be applied across subject areas and require interdisciplinary perspectives.
8. is seamlessly integrated with assessment.
9. creates a polished product that is valuable in its own right.
10. allows alternative solutions and outcomes instead of a single right answer.

When comparing these characteristics with the typical learning tasks and assessments used in online learning environments (e.g., multiple choice quizzes or individual reports submitted to the teacher), it is clear that they do not match. On the other hand, many of these features are inherently part of games and game environments. This makes the authentic learning framework a particularly interesting and promising companion for gamification in learning design.

In order for the authentic learning design to be successful, the tasks should not only meet the above criteria but they should be aligned with assessment. This part is often the Achilles' heel of the learning design. It is often neglected, which results in the negation of the impact of the authentic tasks (Herrington & Herrington, 2006). Even the most authentic of tasks will fail if it is followed by inappropriate, traditional assessment methods. Assessment is vital for the learning design as it directly affects - if not dictates - the learning strategies of the students. Unfortunately, this is a pit particularly hard to avoid because many traditional university practices tend to limit the use of authentic assessment (Herrington & Herrington, 2006). With this in mind, we seek to explore the potential of incorporating authentic learning and assessment with gamification to improve the sometimes dated e-assessment practices.

Assessment

Assessment has been recognised as crucial to supporting students' improvement (Ricketts & Wilks, 2002) through either learning activities in classes where students reflect and learn from their and others' actions in a process of active learning (Wood & Reefke, 2010), or more commonly through the formalised process of providing comments after reviewing student work. The type and form of assessment may change over an entire programme as a course-level approach would match levels of authenticity and relevance to different phases of the students' learning (Reiners & Wood, 2013) and is linked to learning outcomes structured using Bloom's Taxonomy (Krathwohl, 2002).

Feedback is categorised as ‘formative’ or ‘summative’. Formative feedback involves “information communicated to the learner that is intended to modify his or her thinking or behaviour for the purpose of improving learning” (Shute, 2008, p. 154). Greater focus on the process of teaching is related to formative feedback (De Vita & Case, 2003) and is improved using gamification principles, whereby frequent and small segments of feedback are provided to improve engagement (Wood & Reiners, 2012). While formative feedback monitors and aids to improve student achievement, summative feedback provides evaluation of student progress, usually at the conclusion of learning segments.

Virtual environments enable learners to work through both routine situations and also enable rare, uncommon, catastrophic situations to be modelled for training and assessment (Chodos, Stroulia, & King, 2011; Reiners & Wood, 2013; Wiecha, Heyden, Sternthal, & Merialdi, 2010). However, effective assessment in virtual worlds has remained challenging due to the way the increasingly authentic nature of the learning environment has challenged the approaches to teaching; thus, assessment of the learning tasks has also fundamentally changed. This has been addressed using observational assessment of students engaged in authentic learning tasks; e.g., role-playing in virtual environments (Gregory et al., 2011). Yet, it cannot be effective without a thorough understanding of what a gamified curriculum looks like, how it is best applied, and why it engrosses students.

Gamification

There are discussions whether learning outcomes for students are enhanced by using serious games for education. While individual studies have provided indicators of a positive relationship, meta-analyses indicate mixed results (Girard, Ecalle, & Magnan, 2012). The inclusion of game-based components or gamification mechanisms require careful design to ensure an effective implementation (Werbach & Hunter, 2012) and past experiments may have been poorly designed to encourage learners and provide the context for immersive learning. Gamification might be able to trigger intrinsic motivation, yet it relies on multiple internal and external factors that must be aligned. That is, the identification with learning tasks, creating an environment where multiple participants can receive comparable scores or badges, and having the opportunity for authentic gamification; built on and integrating the objectives of tasks and strategic aims of the organisation; and creating energising and engaging experiences. The aim is to merge the gamification elements with the authentic learning tasks in the same context so that the participants’ perception is not biased towards achieving badges but working towards overall objectives.

Another application of gamification is assessment, well-recognised in the research community but not yet explored to its full potential. While some approaches use the outcome of the gamification as criteria for assessment (e.g., positioning on the leaderboard, number of badges for attained levels) (O’Donovan, 2012), game elements can support assessment by influencing the learning task either dynamically (e.g., changing the context) or having scripted events that are triggered by certain activities (e.g., reaching a certain milestone). The idea goes back to the Dungeon Master series (see, for example, dmweb.free.fr), where a story teller played the role of the Game Master, responsible for guiding players through the defined narrative of flexible quests. In a classroom, the teacher plays this role and selects quests (i.e., topics in the course) of increased difficulty according to achieved learning goals; even using multiple player concepts by incorporating group discussions to evaluate answers.

Transferring the learning tasks into a virtual environment allows for increased immersion by creating objects that previously had to be imagined. Importantly, the virtual environment can contain carefully integrated and designed bots (or non-player characters, NPCs) allowing an instructor to manipulate the environment and scenarios to support learners' experiences and assessment activities (Gregory et al., 2011). While technically challenging to implement, carefully scripted and designed scenarios minimise instructor effort in NPC implementation (Wood & Reiners, 2013). These structures can be managed hierarchically to increasingly engage students in a sequence of learning activities over their programme (Reiners & Wood, 2013; Gregory et al., 2011). NPCs support role-playing scenarios so that interaction with NPCs, rather than classmates, creates safe learning environment (Reiners, Gregory, & Dreher, 2011); with role-playing in virtual environments proving effective (Masters et al., 2013). Bots in scenarios provide interactivity controlled by the assessor, particularly during stress-inducing scenarios to test learners' ability to respond and resolve particular challenges.

In this paper, we investigate the following gamification elements as suggested by Reiners et al. (2012) and Reiners and Wood (2013):

- rewind;
- ghost image;
- save points and multiple lives; and,
- time and space control.

The first two items influence learning tasks by allowing learners to draw on past experience, particularly by analysing the causes of imperfect learning outcomes. The others affect learning processes as save points prevent repetition of understood steps, while the control of time and space provides an opportunity to skip over what would have been, in the real world, long-lasting tasks; i.e., transport of components by ship.

The 'rewind' function provides a sense of fairness and second chances and allows learners the freedom to experiment with new approaches to established problems while knowing they can 'fail' with impunity. Within virtual places scenarios can be reset, with all objects, items, and relationships returned to an earlier setting to facilitate using the scenario again. Replay enables learners to gain insight, attempt to solve problems using new methods, and learn from past mistakes in a rapid, iterative process. This is facilitated coupling rewind with feedback; e.g., by marking potential steps (i.e., mistakes) or showing statistics relating to where rewind was initiated. Recording of every repetition can be used later for different kinds of assessment (e.g., self-, peer-, or teacher-based) and eventually to improve the learning tasks; i.e., by having the learner explore situations using rewind. An example of the value of rewind is learning the best way to drive around a corner in a racing game. After an attempt, the system visualises the speed and acceleration over time so players can identify points for improvement; e.g., breaking before the corner. Rewind allows the player to go to precisely the right moment where they must act differently.

Ghost functions are an on-the-fly replay option where a pre-recorded attempt is overlaid on the environment, allowing observers to see what occurred and what was going on at the same time. This provides opportunities for self-based learning building on past performance and through observing expert performances. Using a ghost function, a learner can observe their past achievements at a learning task, complete with observation of simultaneous events poorly perceived in the heat of the moment. External influences may be responded to by instinct in the throes of action; yet, the ghost function allows the learner to observe and reflect on how

they responded, at their leisure while in a safe environment. Additionally, ghost functions can record expert performances where an ideal or perfect method of solving the learning objectives is demonstrated and observed (or, in contrast, an ‘anti-expert performance’, where a poor attempt is demonstrated), providing a benchmark for learners to improve on, critique, or improve.

The use of a combination of ‘save points’ and ‘multiple lives’ provides learners with the sense of empowerment to explore and experiment with different approaches, safe in the knowledge that if they get something wrong, they can try again. Traditionally associated with computer games, positioned at the commencement of significant quests or challenging phase, they are a ‘safety net’ for participants enabling them to re-start at a particular point if, during the quest, they make an error or their new approach fails. This is been demonstrated in the VirtualPREX project where bots are triggered to build on their reaction to the teacher depending on what the teacher says/does. VirtualPREX role-plays also provide students with the ability to practice to “get it right” before embarking on their teaching in a real classroom (see www.virtualprex.com). They also function as break in activities, allowing participants to recuperate before re-immersion in the activity. This contrasts with the traditional ‘examination’; a one-shot chance to succeed in a class. Indeed, within virtual environments, the clock can be wound back to the last save point, providing learners with the opportunity to succeed through multiple attempts, resulting in experiential learning, otherwise unobtainable by students doing ‘the best’ they can with one shot. Save points also identify the starting point for learning tasks. Similar to the partition of units into different lectures, save points are defined points in the storyline before discrete tasks. Thus, a unit outline could be represented as a set of save points.

The ability to manipulate both space and time in virtual worlds opens exciting new possibilities to educators. The constituent components and interactions within a process that may be too fast, small, or distant in the real world can be altered and adjusted to make it accessible to a virtual observer. Examples include the discovery of the inner workings of a fuel cell (Boerger & Tietgens, 2013) and condensing global supply chains into a smaller space (Reiners & Wood, 2013) where activities take place instantly rather than over a series of months. Learners gain a new perception of the process, which can allow them to cognitively make a ‘cause and effect’ connection, helpful to their overall learning. Slow motion (possibly perceived as a subset of time and space control) can be required to understand some physical activities on a technical level; e.g., the extreme speeds observed on a newspaper printing press exceed comprehension of observers as the sequence of activities ‘blur’ into a single, condensed process. The ability to take a given process and reduce the speed during a virtual replication can support students to learn about dangerous environments and safety protocols surrounding heavy equipment (e.g., that found within factories, container ports, or warehouses). Within sciences, slowing interactions can allow greater comprehension of how physical processes can change (e.g., the fuel cells).

Given the predominance of neo-Bloomian hierarchies with the ponderous emphasis on ‘higher level’ assessments, game-based elements in virtual environments may be suitable aids to the assessment of learning at higher levels. The significant importance of ‘application’ and ‘evaluation’ in assessment tasks as observed in prior research can be enhanced deliberately through careful assessment design; i.e., in carefully selected and designed virtual environments (Vallance & Martin, 2012).

Framework for incorporation of gamification mechanisms in scenario-based assessment

At first glance, the incorporation of the gamification elements (reflecting the ability to rewind and have multiple attempts supported by a virtual safety net) appears cognitively inconsistent with the concept of authenticity. However, the tasks to be undertaken, the (virtual) settings, and the assessment tasks can still be designed to be authentic (i.e., supporting authentic learning) while the gamification mechanisms can simultaneously contribute to student engagement and ability to progress through their coursework. Incorporating these elements provides several opportunities to aid educators in their efforts to improve student learning by careful design of assessments.

For assessment there are additional benefits. Self-assessment can occur as the student is able to evaluate the success of certain approaches to a problem and attempt it again. Attempts can be saved and rewound for further attempts, presenting the opportunity for a range of data to be collected and self-, peer-, or instructor-evaluated. Where a learner attempts to control a large vehicle (e.g., those operating in a maritime port) they can make an erroneous assumption about the speeds they can turn a corner, with the ability to rewind and re-attempt the scenario again.

Similarly, the use of **ghost images** enables a range of assessment activities. For reflective learning, a range of ghost images can be applied to a scenario for a learner to reflect on what they were doing each time, why, and what provoked particular changes in their approach. Ghost images of others can be included, allowing the learner to challenge themselves against others (i.e., creating rivalry) and enabling assessment of peers' capabilities and outcomes.

Save points and **multiple lives** can be combined to enable learners to progress through a sequence of increasingly difficult scenarios, enabling an assessment to be undertaken multiple times in a process of self-assessment or peer-assessment. This overcomes the need for a one-off assessment, creating the way for an assessment architecture of progressive difficulty, allowing multiple efforts and reflective improvement.

Slow motion enables learners to analyse particular moments in detail and is useful in conjunction with rewinds and save points to support investigation of challenging scenarios to improve comprehension of complex or rapid interactions. It can be integrated into scenarios to allow perception of subtle differences where nuances would be lost at full-speed.

Assessments incorporating **time and space control** and manipulation involve the tracking and analysis of a chain of interrelated activities (e.g., between several companies or countries); a particularly useful feature in logistics and supply chain classes. This allows students to observe and reflect on the chain of events portrayed. Manipulation of events allows the creation of solutions to various observable problems. The provocation of a disruptive scenario can also be planned by the assessor, where students attempt to rectify or resolve identified problems that may be spread over a globe-spanning supply chain.

These approaches allow assessment to break free of the constraints imposed by institutionalised practices, perhaps allowing student progress to improve. Many institutions force or require examinations (or invigilated tests) to be undertaken at a particular time and place which may disadvantage students that do not perform well at particularly times of day; e.g., a 'morning person' may perform poorly or feel disadvantaged doing an 8.00 am exam!

Instead, the use of save points and multiple lives in a virtual environment enable design of tasks that can be undertaken from various positions at different times, ultimately in a way that suits the learner, creating an exemplary, flexible, learner-centric environment.

Effective assessment in virtual worlds incorporates layers of these elements; a scenario-based foundation supports the use of multiple attempts by students that can be captured to create, or measured against, ghost images. The foundation is provided by the use of scenarios that can be created in a virtual environment with a range of game-based elements incorporated to support learners. Scenarios can incorporate NPCs in a spatially condensed, virtual environment to portray a sequence of events that may occur over a long duration, condensed into a short span of time. Once scenarios have been established, instructors must establish a sequence of save points and include both multiple lives and rewind features. Together, these integrated elements free students from the fear of failure, may even teach them how to fail, and allow them to experiment with novel approaches as they strive to understand how to apply theory in authentic contexts. Finally, ghost images can be created by instructors and enabled within the environment to support self-based assessment, expert instruction, and peer-assessment within the designed scenarios.

Limitations and future research

These concepts have not been fully trialled and data is limited; thus, there is no empirical validation for these assertions other than anecdotal evidence and past experience. We are, however, undergoing extensive development in this area, focusing on logistics and supply chain management classes. The framework, as described, is to be implemented and used to explore the impact on the learning process and assessment. The proposed gamification elements define an extension to the current understanding of the scope of gamification; i.e., in the context of virtual environments where badges and leaderboards fail to exploit the full potential of the virtuality.

The present plans call for investigation into how assessment may be designed and supported using gamification features, in authentic learning scenarios. Qualitative and quantitative data will be collected and analysed, incorporating elements of both ‘snapshots’ combined with a longitudinal study from 2012-2015. This will enable determination of whether learners’ perceptions of the designed assessment tasks match expectations and how supportive the design has been in reaching authentic learning goals as part of the class design.

Conclusions

In this paper we have sought to discuss the design of assessments within virtual environments to aid in authentic learning, supported by gamification elements. The support that these elements (rewind, ghost images, save points and multiple lives, and time and space control) provide to assessment is investigated and outlined, providing several suggestions for assessment design that leverages these benefits. This allows us to identify how these game-based elements are able to support assessment in authentic learning, increase efficiency, and thereby provide new opportunities for educators. Several brief examples and ideas are provided, along with some suggestions for inclusion into assessment design for a range of assessment types.

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