GAMIFICATION IN LOGISTICS AND SUPPLY CHAIN EDUCATION: EXTENDING ACTIVE LEARNING

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ABSTRACT

Engagement with users involved in an activity has become increasingly important, particularly in Higher Education. We review the concept of gamification and outline several existing applications. These incorporate game elements into existing systems and tasks in a way that increases user engagement in the process. Current approaches in logistics and supply chain education are discussed in relation to active learning. We develop a framework that combines several gamification elements that can be relatively easily incorporated into existing approaches and learning management systems (LMSs) in ways that aims to increase engagement and extend active learning. This framework and the relationship between the elements provide fertile ground for further research.

KEYWORDS

Gamification, Active Learning, Authentic Learning, L&SCM Education, Process Improvement.

1. INTRODUCTION

The challenge of teaching has increased when faced with increasingly apathetic students and diverse learning styles. Student numbers rose rapidly across Australasia during the 1990s (Martin and Karmel, 2002). While this increased the opportunity for individuals to learn new ways of thinking and to develop inter-cultural skills (Volet and Ang, 1998), it has made engagement in the class challenging. As lecturers we seem compelled to "get as many students as possible to meet professionally/academically acceptable levels of performance at as high a level as we can" with a set of resources (Buckridge and Guest, 2007, p. 144).

Greater engagement has usually been addressed through active learning and the incorporation of activities into the pedagogical toolbox (Wood and Reefke, 2010). However, merely providing these tools do not ensure that they will 'somehow' make things work. Having the right resources and place does not allow the right process to occur so that maximum value is gained from these resources. There have been an overwhelming number of new tools and approaches to use within a classroom environment. While many of these have been adopted many other instructors have been negligent in bringing these advances to the classroom environment. The current state of practice sees adoption in some classes while many instructors still realise that authenticity and engagement in classes is low.

A great deal of work is invested in curriculum design, with an emphasis on ensuring overall learning objectives are met; examination of learning technologies to ensure effective feedback is provided (Dreher, 2006, Venable et al., 2012); and how to improve engagement of diverse classes (Wood and Reefke, 2010). Little work has been completed on the integrated design of intra-unit activities to create a more compelling and engaging learning environment. One approach to achieve this intra-unit improvement in active learning is through 'gamification' (Deterding et al., 2011) of unit design.

The thesis of this paper is that gamification can improve education in logistics and supply chain management through changing the structure and dynamics of unit-level education. We will proceed with background information on the concept of gamification. This will highlight the current trends in the research. We then discuss existing logistics and supply chain management (L&SCM) education approaches. Following from this we will merge the two frameworks and provide some future research directions.

2. WHAT IS GAMIFICATION?

Gamification can be defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011, p. 10). This is accomplished through the use of designs and structures, incorporating game-based practices, to include game-elements, to embed some characteristics of games within non-game contexts (Deterding et al., 2011, p. 13). It is different to other concepts, such as 'serious games', which is concerned with the incorporation of non-entertainment elements into game-environments (Liu et al., 2011) where a task is incorporated into the game so that the task is accomplished (Oja and Riekki, 2012, p. 138). Thus, gamification is not a game for learning purposes, but application of "the motivational properties of games and layers them on top of other learning activities, integrating the human desire to communicate and share accomplishment with goal-setting to direct the attention of learners and motivate them to action" (Landers and Callan, 2011, p. 219).

The term 'gamification' was first used in 2008 but was not widely adopted until late in 2010 and is frequently confused with other terms such as 'game layer', 'applied gaming', 'productivity games', 'funware' 'playful design', or 'behavioral games' (Deterding et al., 2011). The concept is that a designer "takes the motivational properties of games and layers them on top of other learning activities, integrating the human desire to communicate and share accomplishment with goal-setting to direct the attention of learners and motivate" (Landers and Callan, 2011, p. 421).

Small changes to existing educational elements can also be beneficial. Simply changing the wording of a question in a market research survey, to make it a 'challenge', may make respondents engaged and extract more useful information (De Ruyck and Veris, 2011). Some gamification elements have been incorporated into regular activities in ways that are now common place – such as the use of frequent flyer programs, where support is rewarded with points that can be redeemed (Han, 2012, p. 5).

2.1 Current approaches and applications of gamification

Online applications of gamification include Ubi-Ask (image-based social searches) and EcoIsland (CO_2 reduction through social persuasions) (Liu et al., 2011); it has been considered to improve the co-creation of content in an online adventure travel service (Swift and Nitins, 2011). Within education, it has been used at a limited level to create a social game to support learning, through the use of a 'tree' that grows, incorporating several recognised practices in gamification (Landers and Callan, 2011). The development of the Opower Social system allows electricity users to alter their energy use, with strong gamification supporting behavioural changes (Han, 2012, p. 5). Flatla et al. (2011) demonstrate how routine tasks; i.e., users' calibration of equipment, can be gamified to increase user participation. A loss of motivation and reduced self-directed study over a long mission for Astronauts may even be overcome through gamified activities (Cornelissen et al., 2012).

Despite the extensive use in real-life approaches, there has been relatively little academic research directed at gamification. Cronk (2012) used design science (Venable, 2006) to implement a system within a classroom environment. This was through the use of software to support the design elements, although they noted that there were technical challenges establishing the system, and then in the collection of data within the classroom, which would feed into the mechanics embedded within the system. The data collection was time-consuming and would need to be automated in some fashion for their approach to warrant further application. Marks were awarded (removal of marks was not deemed necessary as merely missing out on the accumulation of marks was judged to be incentive to act) and other structures they employed included: achievement badges and levels, challenge/competition between users, a leaderboard to rank and demonstrate inter-student differences, a progress bar to understand intra-student progress, and a system of rewards.

3. GAMIFICATION IN LOGISTICS AND SUPPLY CHAIN EDUCATION

In recent years, the emphasis has shifted in L&SCM education from pure logistics and the movement of material to in increasingly integrated, process-orientated management of materials, money, and information across firm boundaries. It is considered difficult to capture the full scale of the supply chain within the

classroom environment (Reiners and Wood, forthcoming, 2013). Products may be manufactured on one side of the world and delivered by road transport, or rail, before being loaded onto vessels for transportation around the world. However, the mainstay of most logistics and supply chain education remains the use of the lecturing, although examples to exist greater interactivity in the classroom environment (Wood and Reefke, 2010). We will demonstrate that there is ample opportunity for the concept of gamification to improve the learning and educational experience for logistics and supply chain students.

Active learning is a fundamental method to increase engagement with the classroom and is supported through the incorporation of structured in-class activities. While there are a range of activities such as quick quizzes or activities, the use of supply chain- or operations-focused games have been popular. These are often designed around specific learning outcomes and include examples such as:

- The beer game, or the beer distribution game, developed by MIT in the 1960s (Sterman, 2000); this is a simulation of limited complexity that is designed to demonstrate the 'bullwhip effect' (Lee et al., 1997) in a small, simple supply chain. The game can be run in a single class session.
- The Fresh Connection, a team-based simulation of a perishable fruit-juice manufacturing (Cotter et al., 2009); a relatively complex computer-based game that divides the players into focused roles with divergent lines of responsibility. Materials and data are all close at hand, allowing students to interact and determine the best response to changing conditions and how to best use new supply chain functions and options that are offered to them. The game can be run in a one-day session or with a turn every week over an entire semester.
- Supply Chain Game by Responsive.net (see also, Feng & Ma, 2008).
- Supply Chain Risk Management Game (Kuijpers, 2009).
- Port Simulator 2012-Hamburg is a computer game which allows competitive rivalry between players.

Other L&SCM in-class activities can be sourced from books and may involve dice, coins, or even making paper airplanes in class (Wood and Reefke, 2010); immersive tasks also improve engagement (Gregory et al., 2011). Within an appropriate framework, these activities can improve students' understanding through a process of 'learning by doing'. An added benefit is that students find that such "practices empower them in class and create new opportunities for interaction outside class" (Maruyama et al., 2000, p. 78).

3.1 Authenticity

'Authentic learning' as a pedagogical model has the opportunity to significantly improve educational outcomes within the knowledge economy. It addresses processes relating to the transformation of information and key transferable knowledge and human mind processing capabilities. It requires complex communication, judgment, reflection, expert thinking, and advanced problem-solving skills (Herrington and Herrington, 2006). It also addresses higher levels of the cognitive domain, the effective and conative domains (Snow et al., 1996). However, despite the advances in the academic debate regarding education, not all results from research in education have been operationalised. Technology is often used to enhance existing approaches rather than developing new ones; it promotes "learning from" as opposed to aiding learning (Herrington et al., 2010). Higher authenticity in education provides the opportunity to exercise realistic work practices, cognitive processes that are aligned with authentic situations, while receiving valuable feedback, and using more authentic sources and materials (Herrington et al., 2010, Herrington and Herrington, 2006).

Current teaching practices in L&SCM education still primarily rely on abstract textbook explanations, frequently supported with photos, videos, and anecdotal stories. The approach may be inappropriate as students report that they feel unprepared for professional work (Holt et al., 2003). Possible employers agree that students require greater authenticity and the learning experience to ensure that they receive appropriate training (Lombardi, 2007). This is an area where education has lagged requirements and not created correct competencies for students within the new environments (Teräs and Myllylä, 2011).

Authentic education in L&SCM is important to improve students' preparation for their professional careers. One approach to achieving this is through simulation; however, within the discipline, simulation has primarily been used to address large-scale planning exercises, or the evaluation of various scenarios. It is less likely to be used to support the training of an individual operator. This contrasts with other disciplines; e.g., flight simulators are used to train pilots or mannequins are used to emulate medical emergencies the train medical staff. Simulation is used in supply chains to gain insight into complex systems and to understand

weaknesses associated with a given system setup. In contrast, the opportunity exists for expansion of training for individual operators within an operations-, logistics-, or supply chain-oriented scenario. This may involve understanding how machinery is used or how to conduct maritime port operations; in all cases, there is the opportunity for the learner to be harmed in a real environment, or there is the risk of damage to expensive equipment. These elements make simulation in L&SCM contexts ideal. Existing simulation components can provide insight into complex L&SCM operations (Figure 1). L&SCM operations involve complex, subtle interactions between staff and equipment (e.g., new product design (Wood and Lu, 2008)) that are difficult for outsiders to understand, or reflect complex acquisition and use of resources over a network (Lin et al., 2012). Bots and scripted environmental interactions can improve authenticity and support self-directed learning (Reiners et al., forthcoming, 2013).

However, appropriate training can pay significant dividends to firms. TUEV Nord has effectively used virtual worlds-based training, producing savings in excess of US $140,000 in a year. The use of virtual environments can significantly reduce costs in comparison to the use of physical environment and training (Boerger and Tietgens, 2013). This is not merely of academic interest; health and safety is crucial as training and related deficiencies have been involved with 92% of fatalities in one study (MacCarron, 2006).

Figure 1 Second Life projects illustrating simulated scenarios which can be used as building blocks in larger simulations (Wriedt et al., 2008). The scenarios are not yet interactive; this limits the ability of the student to respond and interact in an authentic learning environment.

3.2 Study tours and site visits

Study tours and site visits is a common approach to increase authenticity in many logistics and supply chain programmes. They enable students to understand the context and practical significance what concepts and "the study tour helps to bridge the gap between business theory and practice" (Porth, 1997, pp. 198-199). However, significant disadvantages include geographic constraints, cost considerations, and dificulties locating and accessing to supply chains of interest (Hanna, 2000, pp. 204-205). Additionally, it may not be possible to access appropriate information which would enable students to understand managerial responses. This may be due to disaggregated information or a presentation that doesn't support student comprehension. Data that informs decision-making may be hidden in databases, or may require training to support work-based interpretation, such as data required to use EVA in a project enviornment (Abdul-Rahman et al., 2011).

Whether running a study tour or participating in a class-room environment, a structured learning process helps students to maximise their ability to learn from the activity. Porth (1997) and Do (2006) recognise that there are three phases of learning associated with a study tour, which is a well-defined learning activity:
1. The **pre-experience activities**. Here students generate research and improve their understanding about the background relating to the topic.
2. The **experiences during the activity**. Here the student centric experience relates to the students comprehending and being able to understand what they should be experiencing during the activity.
3. Finally, there is the **capture and consolidation** of what the student has learned. This will usually be facilitated by a staff member and may involve experiential learning (Kolb, 1984).

3.3 From inter- to intra-unit design and incorporation of gamification

The gamification of L&SCM education represents an extreme and carefully-designed active learning process. There is already an element of active and authentic learning in logistics and supply chain classes. This is

supported using games and in-class activities, and with the incorporation of site visits and study tours. Yet, various levels of authenticity exist, and all require careful scaffolding to ensure that the students' learning requirements are met so that activities are not enacted in vain. Reiners and Wood (forthcoming, 2013) suggest a structured sequence of activities, moving the student towards authentic learning experiences situated within the real world where the student will later engage in professional practice (Figure 2).
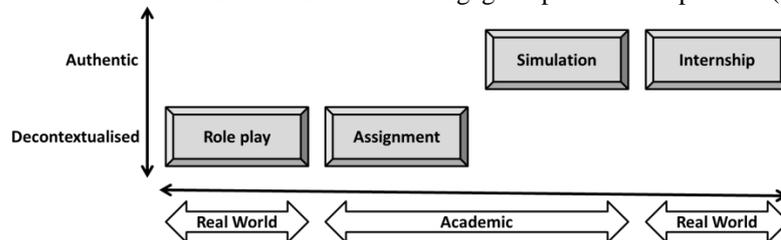
Figure 2 Structuring of course-wide learning activities in Supply Chain education (based on Figure 1, Reiners and Wood, forthcoming, 2013).

A macro-level, inter-unit sequencing of learning styles to support students' authentic education is addressed by Reiners and Wood (forthcoming, 2013), but this does not address intra-unit detail about how to structure learning activities within these learning activities in a way to increase active learning of students. We believe gamification holds the potential to improve the structuring of intra-unit activities to increase student engagement, increase learning opportunities, and improve their outcomes.

4. GAMIFICATION ELEMENTS IN THE L&SCM CURRICULUM

Given the present state of L&SCM, we present some gamification elements and explain how these can be incorporated into the L&SCM curriculum. Many of these elements use established LMSs or leverage existing systems, to ensure greater sustainability of the educational approach (Reiners et al., under review).

Fast feedback – Incorporation of gamification principles also requires much more immediate feedback and many more instances with feedback can be provided. This presents a new issue in the design and structure of units and modules within the course. It may also, depending on the amount of IT support, force greater resources allocation within a given unit.

There are two methods that can be used to achieve faster feedback: automated assessment or smaller, regular activities. First, IT-enabled automated assessment can return feedback to students in an entirely automated and rapid process. The advantage is that the feedback occurs without human intervention, allowing a nearly instantaneous provision of feedback to the learner. However, such systems may require investment of effort to setup in a structured manner and it may require capabilities that academics do not possess (Blayney and Freeman, 2004), or specialised software and administrative setup that is not apparent to the student but which creates an additional administrative layer (Dreher, 2006).

Second, small, regular activities may require less setup than automated assessment, and may allow the assessment tasks to be undertaken relatively soon after the activity, allowing rapid, but not instantaneous, feedback to be provided to the student. Multiple choice questions are one type of assessments that clearly support this approach; students may be provided with answers at the conclusion of a test to allow them to assess themselves; alternatively, the test can be established online and assessed automatically.

Cycle times – The cycle time of the feedback positive experience to the student must be significantly less than their perceived learning time. As an example, researchers are prepared to wait several years with feedback from top journals, as they have significantly longer expected and perceived learning time over the course of any given research project or stream of research, which may occupy us for decades. However, in the classroom environment students often have a much shorter window of expectation. This window tends to be shorter than the normal one semester period, where after they will gain a grade. Therefore, feedback and schools must be provided on a more regular basis.

Gamification emphasises short cycle times, and breaking large tasks into small, manageable, chunks. These can be accomplished in a short period of time, providing a sense of accomplishment. In contrast, many classes seem to offer only a few assignments, of significant size. Combining the concepts of cycle time and

rapid feedback a greater number of smaller tasks should be created with efforts make to ensure rapid provision of feedback occurs soon after.

Fixed structures – The fixed 'structure' of 'how things are done' is a limitation often forced by tradition. These structures are those that immerse us and we subconsciously perpetuate the structures. We set exams at a particular time on a given date at the end of semester. This limits students and their performance by fitting them into a non-individualised structure. Alternatively, a one-week period could be provided during which students attend a special, invigilated, and non-networked computer laboratory to solve problems as their examination. This provides flexibility to attend at convenient times to support their learning needs. Such resourcing may be beyond the control of an individual academic; however, LMS-based activities can be engineered to allow students to complete many of their assessment activities with greater flexibility.

Leaderboards and comparisons – Feedback needs be provided to students so that they can compare and contrast their own performance with that of their peers. It will become necessary to incorporate some form of the leaderboard or publication of results; even if these are not tied to particular students (we do not wish to breach privacy considerations). Such publications would allow an individual to understand where they are in comparison to their classmates; they may be able to determine that they are on the lower end of the class, motivating them to perform better in the future. The incorporation of the leaderboard or results table can easily be accomplished with modern LMSs; e.g., Blackboard or Moodle. The leaderboard can draw on results published within the LMS. These results can be updated in the LMS automatically; e.g., recording and presenting MCQs test results. Alternatively, staff can upload the results soon after assessments, ensuring students can perceive in near-to-real-time, how they are progressing in comparison to their classmates.

Expression of individuality and a sense of altruism – Through tracking student achievement of particular small tasks, students can build up a unique and individualised profile. Further differentiation can be achieved by requiring particular levels of achievement to be invited to participate in sought-after extracurricular activities. A sense of altruism can be embedded through encouraging tutoring or group-based learning activities, providing stronger students with the opportunity to support the learning process of weaker students, and improve their sense of value in the class this way.

Integration of gamification elements – Most of these methods addressed in this section can be applied relatively simply to existing units with no new adoption of technologies or systems that are not already used. However, it may require a significant change to the structure of a unit and may involve greater effort on the part of academics to manage the complexity of burgeoning administrative tasks associated with the unit, if these are not automated and incorporated into existing LMSs.

At the course-level, activities should be broadly structured within a course (Figure 2), over units with set pre-requisites, providing a structured progression of learning and increased authenticity for learners. Within each unit, the sequence of activities considered can be setup and structured so that they are gamified in a way to increase student effort, engagement, and attention. Great engagement comes from addressing interaction that involves recency, frequency, duration, virality, and ratings (Zichermann and Cunningham, 2011).

- Smaller, frequent assessments and activities decreases the average time between one activity and another, improving recency.
- The use of LMSs and incorporating activities into these existing systems that learners can access outside of the classroom improves the frequency of engagement.
- Creating exciting activities can increase the length of time that students participate in activities.
- Including group activities, out-of-class opportunities, and leaderboards and rating systems can improve the virality and ability for the activity to be undertaken with interaction between users.
- Incorporation of wikis and the ability for students to assess and evaluate activities allows the students to include an element of rating within a unit.

5. CONCLUSION

Contemporary process management has emphasised the use of game-elements and gamification to increase engagement with users. As engagement with students in higher educational institutions is always an issue, gamification seems to be a suitable remedy to the problem. The thesis of this paper is that gamification is a useful intra-unit approach to extending active learning and student engagement. We propose a model to integrate the approach into L&SCM classes in a way that minimises work/effort/resources and maximises

outcomes for students. We provide a model that explains how various gamification elements can be combined to support education in L&SCM. Our past experience with virtual worlds and active learning indicates that gamification is a strong mean to support active learning to improve student outcomes.

The theoretical analysis and previously applied experiments in serious business games, virtual games, virtual environments, and educational games indicate gamification provides benefits by incentivising students to become involved in lectures. Further research is planned for the given gaming mechanisms of our model to describe how they interact, making an important contribution to literature in education. We are currently developing and implementing educational experiments to determine the efficacy and relatively importance of components; with attention paid to the experimental design to ensure no students are disadvantaged [a full treatment, regarding the nuances of such a design science approach, is provided by Venable et al. (2012)]. A longitudinal study is anticipated to ensure that the approach maintains efficacy over time within a cohort of students.

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