Gamification in Education – A Supply Chain and Logistics Management Perspective

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Purpose: As lecturers, we are continuously faced with the challenge of ensuring student engagement, where we attempt to help students reach professional and academic levels of performance that will set them on a path of success in their careers. This task is further complicated by the ever-changing teaching landscape and students' apathetic attitude towards traditional learning. With advancement in technology and teaching pedagogy, there have been an increasing number of resources and tools designed to encourage and achieve active learning. The question becomes how to best utilise these tools and resources in a way to improve student engagement. This paper introduces gamification as a resource that has been used within a module delivered at the University of Warwick as part of the Supply Chain and Logistics Management MSc course.

Research Approach: The module has been delivered at the University of Warwick, constantly evolving over the past 10 years with a game (The Wolfhound Simulation) being used as an integral part of the module delivery. Students submit a module survey on completion-allowing lecturer and tutors to assess the level of student engagement identifying which module components students considered most engaging. The game is designed to engage, challenge, and stimulate individual and teamworking as the game progresses, finally collecting and displaying comprehensive results from a suite of activities presenting the teams' performance and showcasing students' abilities to interact with the game and with their peers.

Findings and Originality: Taking the usual "Learning by doing" approach, a simulation has been developed for students at Master level to use and optimise a simple supply chain for service parts. A suite of taught procurement and inventory management techniques are available to make operational decisions and see their effects of operational efficiency, service performance and profitability of their company within the game. The simulation has now been run successfully for over 10 years with excellent feedback from participants and shows some interesting insights.

Research Impact: This paper presents a comprehensive approach that has been used to focus on a set of learning outcomes with a supply chain perspective and transform them into a game with emphasis on student engagement.

Practical Impact: A key challenge for those getting jobs in supply chains is to understand the concepts so that they can create the right balance of procurement and inventory. This game allows students to engage with these concepts in a non-threatening, safe learning environment where they can trial different strategies and learn from trial and error.

Key Words: Gamification, Education, Teaching Pedagogy, Supply Chain Management, Procurement, Inventory Management

Introduction

Student engagement and motivation has been a present and developing challenge in higher education (Lee and Hammer, 2011). This can be attributed to the ever-increasing distractions from evolving technology and gadgets, as well as social pressures on students as they start to consider a shift into their working life (Voogt and Roblin, 2012). It can also be attributed to the teaching and learning environment not being in sync with students' needs and expectations. The literature has consistently promoted active learning as a pedagogical mechanism to address issues on student engagement (Wood and Reefke, 2010). With the current advances in technology, teaching resources available, ever changing teaching conditions and constraints brought around by COVID-19, successfully incorporating active learning design in teaching delivery has become far from a straightforward process.

An approach that has been gaining momentum with a focus on fostering an active learning environment targeting student engagement is gamification of unit design. The concept of gamification can be defined as the ability of developing game-based learning activities designed to cover learning outcomes (Deterding, et al., 2011).

From a supply chain and logistics perspective, the need to move away from traditional teaching models is even more prevalent. For students to gain a competitive edge in today's job market, they need to be able to present not just theoretical knowledge and awareness of supply chain and logistics concepts; but evidence of applying such concepts in real or simulated business situations.

This paper aims at presenting a case for a simulation exercise developed within the Procurement and Inventory Management module within the Supply Chain and Logistics Management (SCLM) MSc at the University of Warwick. The case, titled as 'The Wolfhound Military Vehicle Simulation', is a game-based simulation that has been designed to develop students' skill sets specifically for procurement and inventory management.

Literature

A literature review was conducted to gain a better understanding of the current positioning of gamification in education in general and in the field of supply chain management and logistics specifically.

Deterding, et al. (2011) defined gamification as 'the use of game design elements in non-game contexts'. Dicheva, et al. (2015) developed a systematic mapping on gamification in education where they argued that it is still an emerging trend. Putz, et al. (2020) conducted a structured literature review on gamification in education. Such systematic work helped provide an understanding of the current game structures and mechanics currently being used within the education field. This ranges from leaderboards, challenges, badges, game points (Van Roy and Zaman, 2018) across a range of different study areas from English studies to health and social sciences. There is a plethora of evidence in the literature that clearly indicates a positive relationship between gamification in education and student engagement. A question still remained however, if there is a relationship between gamification and student's knowledge retention. Buckley and Doyle (2017) conducted an empirical study on more than 100 participants to investigate whether gamification impacted student's knowledge retention and discovered a positive relationship. Putz, et al. (2020) also identified that gamification enhanced knowledge

transfer and knowledge retention both in the short term through cross sectional studies and long term through longitudinal studies. Their experiments showed a clear positive impact between gamified teaching design and attendance rates, project engagement, and a higher proportion of students passing their modules when compared to standard teaching design.

However, as Dicheva, et al. (2015) discussed there are difficulties and complexities in terms of time, effort and cost when it comes to developing gamified teaching and delivery mechanisms to cover learning outcomes.

In terms of gamification within the supply chain and logistics management field specifically, Wood and Reiners (2012) presented a summary, as can be seen in Table 1, of the various games currently available.

Table 1: Supply chain and logistics specific games (adapted from Wood and Reiners, 2012)

Author	Game	Logic
Sterman (2000)	The Beer Game	This game was developed by MIT in the 1960s to demonstrate the 'bullwhip effect' in a small simple supply chain and can be run in a single class session
Cotter, et al. (2009)	The Fresh Connection	A relatively complex, team based simulation that is computer based. It divides players within the same company into different functional roles between sales, operations, procurement, warehousing and supply chain. The game can be run over a one week time period or over an entire term.
Wood and Reiners (2012)	Port Simulator Hamburg 2012	A simulation based computer game that creates a competitive rivalry between students in managing ports. The game can be run over a one week time period or over an entire term.
Johansen and Mikkelsen (1994)	The Lego Truck Game	A game the incorporates the use of Legos as building blocks to assemble a toy truck. The students are organised to simulate work on an assembly line where they can examine different strategies such as push vs pull models and can be linked to concepts of utilisation and

		production takt time. This game can be run in a single class session.

Research Problem

The objective was to design a supply chain and logistics specific game that focused on the relationship between procurement and inventory management. The specific learning outcomes are as follows:

- Critically evaluate different procurement and inventory management strategies, processes, and organizational concepts and their links to further areas of the logistics system.
- Implement advanced techniques to calculate adequate stock levels for different stock categories considering logistics and financial aspects.
- Manage procurement and inventory risks arising from changes in customer markets and their impact on demand and supply along multiple stages of the supply chain.
- Monitor and assess procurement and inventory performance through the use of specialised performance measurement tools and techniques.

This led to the development of a computer game-based simulation where students managed a range of stock keeping units (SKUs) across two locations within a simplified supply chain model.

The Wolfhound Military Vehicle Simulation

The process of transferring concepts to other people is often slow and difficult. Individuals have background, experience and perceptions. An effective method appears to be to provide the concepts and then for the individuals to try them out; the “trial and error” approach often shows that the n=more error the better the learning.

To this end a case study on supply chain inventory has been created and used for several years. The objective is to model the working of a simple divergent supply chain and show how the use of basic quantitative techniques produce more profitable and effective business.

The design of the case study provides the student with a practical situation chiefly

- The need to work with a team of colleagues (usually 6 in a team)
- A variety of items to manage (21 products)
- Time pressures for decisions
- A variety of supply options
- Historical usage records
- Use of spreadsheets
- Demand at each level in the chain.

In detail, the case study is about providing spare parts to a weapon system (Wolfhound). There are various suppliers with different lead times, costs and batch sizes that supply to a central warehouse. This then supplies to their local repair centre on demand and distributes to a subsidiary store where there is also maintenance demand.

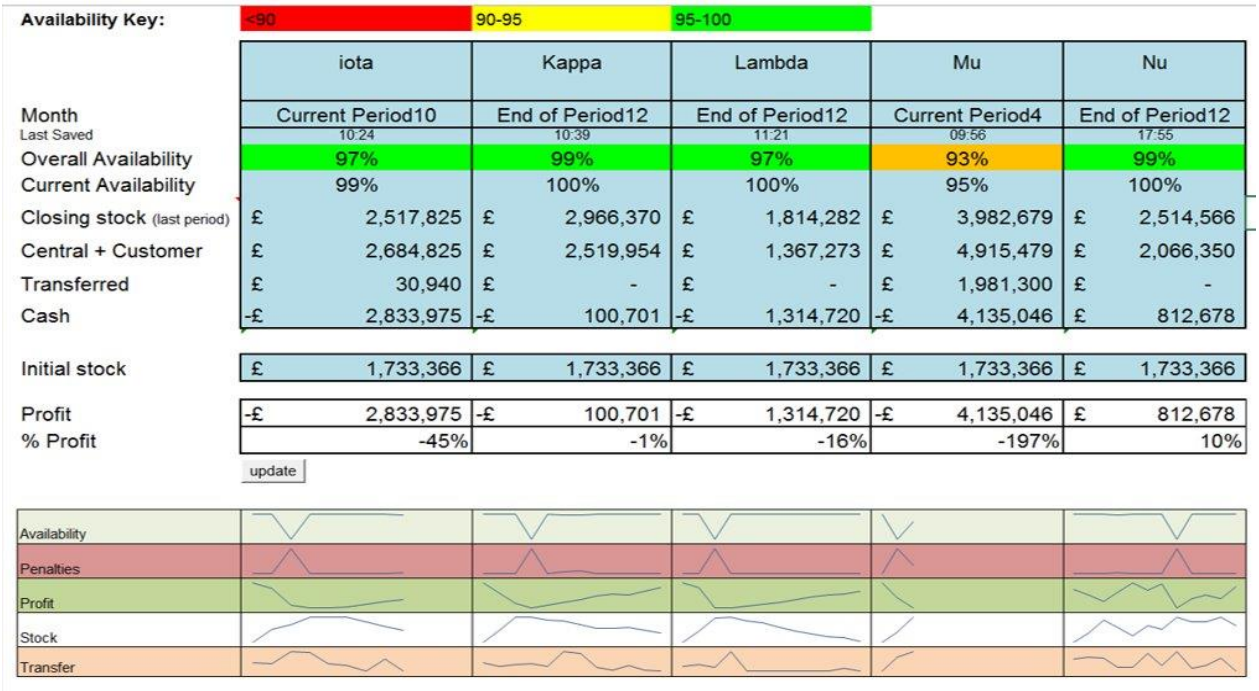
The students are asked at the start to identify operating targets. The simulation is then run over 8 hours starting with a balanced inventory, and the challenge is to maintain good supply without

excessive inventory over 12 consecutive simulated weeks. As the demand is random, the demand for each week is unknown until the end of the week, so ongoing demand forecasting and safety stock calculations are necessary.

The use of an Availability Contract with the customer (at both central and subsidiary stores level) is a simple way to illustrate the concepts. [In this availability contract the business gets a fixed income every week but gets penalised for shortages and the cost of inventory and has the usual purchasing costs.]

The students are encouraged to group the 21 managed products into categories and assign a category manager for each category of items. In managing the category that student is then responsible for forecasting demand for each new period, feeding in the most up to date demand from the previously run period. After the demand for the upcoming period is forecasted, this is then reviewed depending on quantities currently held in stores and quantity enroute from suppliers and accordingly new orders are placed. Students also must ensure that their companies remain cash positive throughout the simulation by balancing the quantities ordered against the potential penalties from being out of stock. Students need to also factor in lead time from the different suppliers and how this would affect their inventory days of coverage against the usage rate.

The students get full operating results as they complete each virtual week so they can make modifications for each new decision period as can be seen in Figure 1 below. The game itself is run on Excel and the coding for the various operations in terms of purchases from suppliers, transfers to stores and customer demand is written using Visual Basic.



Availability Key:	<90	90-95	95-100		
	iota	Kappa	Lambda	Mu	Nu
Month	Current Period10	End of Period12	End of Period12	Current Period4	End of Period12
Last Saved	10:24	10:39	11:21	09:56	17:55
Overall Availability	97%	99%	97%	93%	99%
Current Availability	99%	100%	100%	95%	100%
Closing stock (last period)	£ 2,517,825	£ 2,966,370	£ 1,814,282	£ 3,982,679	£ 2,514,566
Central + Customer	£ 2,684,825	£ 2,519,954	£ 1,367,273	£ 4,915,479	£ 2,066,350
Transferred	£ 30,940	£ -	£ -	£ 1,981,300	£ -
Cash	-£ 2,833,975	-£ 100,701	-£ 1,314,720	-£ 4,135,046	£ 812,678
Initial stock	£ 1,733,366	£ 1,733,366	£ 1,733,366	£ 1,733,366	£ 1,733,366
Profit	-£ 2,833,975	-£ 100,701	-£ 1,314,720	-£ 4,135,046	£ 812,678
% Profit	-45%	-1%	-16%	-197%	10%

update

Availability
Penalties
Profit
Stock
Transfer

Figure 1: Wolfhound Simulation Results.

Based on their understanding and use of data the students have to decide

- Which supplier and what quantity to buy
- How much stock to hold at the Central stores
- How much to transfer to the Subsidiary Stores
- How much to stock at the Subsidiary Stores

Their aim is of course to maximise the total profit over the 12 weeks, while maintaining the inventory for ongoing demand.

At the end of the case study the teams do presentations. These are mostly about what they have learned rather than the excellence of their results. Students are supported throughout the day by tutors who are available to answer any queries on different strategies for ordering and managing inventory for the different categories as well as provide technical support when needed. However, the game is very much run by the students autonomously.

Technical Design

To make the simulation practical, the basic data needs careful design. For instance, the turnover profile has to conform to a Pareto profile and a 9-box distribution. Also, the demand for the different parts should provide a variety of demand profiles The options chosen are

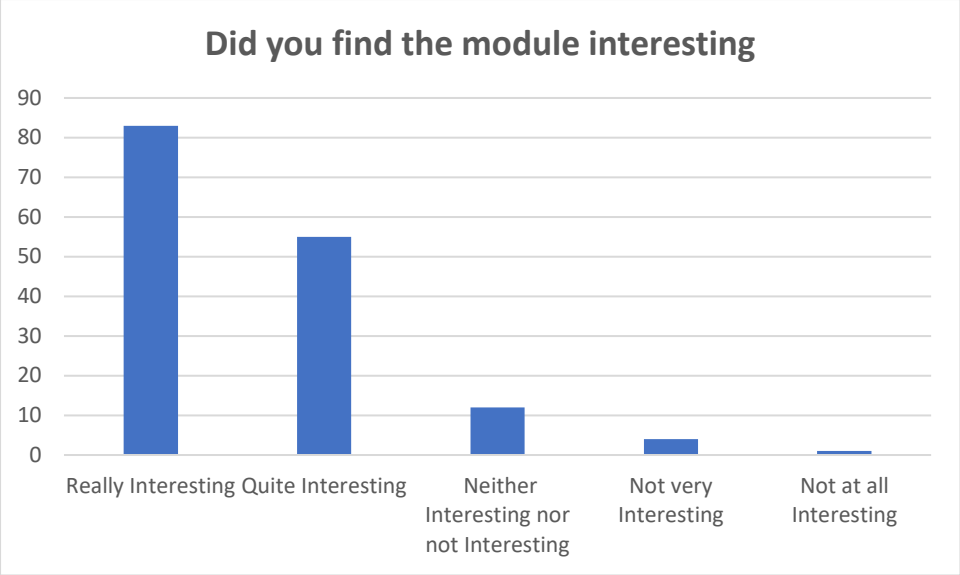
- Normal Variability
- Increasing demand
- Decreasing demand
- Increasing Variability
- Decreasing Variability
- Step Change Up
- Step Change down
- Promotion
- Up then Down
- Down then Up

The number of items was chosen so that it is very beneficial for the students to have an organised approach and make use of the quantitative techniques previously presented to them.

The design of the case study has gradually been refined over the years so that the preparation and the conducting of the simulation provide the learning necessary through discovery of ideas by the students. The design of the simulation has also been configured to be delivered either face to face in a normal class setting or completely online on Teams with files for the game being uploaded and the use of separate channels for each of the student teams.

Discussion and Conclusion

Feedback from the module has been overwhelmingly positive. This can mainly be attributed to the simulation. Student responses for the module evaluation consistently mention the simulation in the ‘what did you like most about the module?’ question. As can be seen in Figure 2 below, the majority of the students either found the module ‘Really Interesting’ or ‘Quite Interesting’. This goes to provide further evidence as to the value of gamification in education in general and in the supply chain and logistics field.



Number of students on module: 231 Number of forms returned: 155

Figure 2: Student Feedback

It is important to note however that the simulation took over a year to develop as a prototype. The simulation itself, even though being run for over 10 years now, is still a work in progress and is constantly being modified to incorporate more challenges and scenarios. This is to ensure it is up to date with current market conditions and to ensure that the learning the students achieve is relevant to market needs.

In conclusion, gamification offers a valuable and much needed solution to enhance student engagement, knowledge transfer and retention in higher education. However, as all good things, a lot of time, cost, and effort go in developing and maintaining the game as an educational tool.

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