QPQ: A SIMULATION GAME FOR OPERATIONS MANAGEMENT STUDENTS

M. I. Koukou[1], R. Dekkers[1], M. A. Aldossary[1], Q. Zhou[1]

[1)] Adam Smith Business School, University of Glasgow, Glasgow G12 8QQ, Scotland

Abstract
Interactive learning where students play an active role is seen as key to gaining and retaining knowledge, differently to traditional lecture-based teaching where they are just passive recipients of knowledge. This study presents the QPQ Simulation Game which replicates all the different departments and processes of a manufacturing company that needs to make decisions for accepting orders, setting lead times, dealing with suppliers, assembling products, and delivering them to the customer within the agreed times and quality requirements. Evaluation of the students' performance and learning happens through playing the game and calculating profits, quantity of finished products and improvements on the efficiency of operations. Results show that the students' knowledge and understanding of key operations management concepts was increased, decision making skills enhanced, team-work was boosted, and a realisation of the complex and dynamic environment of a manufacturing company was gained.

Keywords:
Decision making, Education, Simulation Game, Operations Management.

1 INTRODUCTION

Simulation games has been used for years for education purposes in higher education. One of the most famous games that has been used universally for supply chain studies is 'The beer' game that was developed by MIT in 1960s.The main purpose of the game was to simplify the complex principals of supply chain and present it to the students in an easy way for them to understand the concept. There are many studies that have discussed the use of simulation games and the way of helping the participants to understand certain processes. (e.g. Chang et al., 2009; Pasin and Giroux, 2011) Although simulation games has been used in teaching of various courses in nursing, engineering and management (Pasin and Giroux, 2011 p. 1240), their application does not stop there. Many of these simulation games have also been used to teach practitioners. For instance, some companies have integrated simulation games into their interview and selection processes in order to test the candidates on their understanding of the industry environment (Lewis and Maylor, 2007 p. 135). Nevertheless, one of the main purposes of simulation games is to improve the skills and conceptual knowledge of students in class room (Elmuti, 2004 p. 440). For that purpose, academics tend to develop and use simulation games in operations management (and other courses) to ease the understanding and participation of the students (Chang et al., 2009; Chwif et al., 2003).

This paper discusses the design, delivery, and evaluation of the QpQ Simulation Game for operations management students. The main aim is to contribute to the current literature by looking at the decision making that students go through in their process in the game, and evaluating the impact that the game has in to helping students understand basic principles of operations management and the industry experience in real life.

The paper is organised as follows: first an overview of the current literature is presented; after that, on section 3 the simulation game is introduced; section 4 presents the different deliveries of the game; section 5 follows with a discussion on the results of the game and finally the paper concludes with a summary on the implications of the game and next steps that need to be considered.

2 LITERATURE REVIEW

2.1 Simulation Games and Learning

Simulation games for educational reasons started in 1950s when mostly paper based or physical games were used. However, in present time most of the games are heavily IT involved or dependent (Lewis and Maylor, 2007 pp. 135–136). The academic literature has not come into an agreement as to how a simulation game is defined and many of the studies use different concepts for describing simulation games, leading to confusion (Clarke, 2009 p. 448). Undoubtedly, one of the main elements in defining simulation games is related to the learning method. Pasin and Giroux (2011 p. 1241) define simulation games as "challenging interactive pedagogical exercises, wherein learners must use their knowledge and skills to attain specific goals, played within an artificial reproduction of a relevant reality". In this definition, the study clearly shows the important link to learning. However, as already mentioned, it would be false to believe that simulation games have only been used for students' learning; for example, van der Zee and Slomp (2009 p. 20) clarify that simulation games can assist workers to find the best solution for a specific problem.

Simulation games offer the benefits of both experiential and generative learning, as well as they enhance learning experience (Pasin and Giroux, 2011 p. 1243). Haapasalo et al. (2001) also stressed in their study the meaning and the benefits of simulation games through learning and more specifically how they boost experiential learning and decision making. According to Salas et al. (2009 p. 561), while lecture and paper-based learning is important to gain facts and knowledge, the reasoning behind simulation games is to enable learning through practice and to gain skills such as team work and strategic decision making that will assist the students in becoming successful managers. This is also supported by the studies of (Farrell, 2005) and (Li et al., 2007), where they found that students perceive simulation games as a more effective and more superior learning tool than lecture-centred approaches.

Moreover, one of the main benefits of simulation games is to connect learning with real-life situations and getting closer to the realities of a business world (Haapasalo et al., 2001 p. 262). Therefore, one of the main goals of using simulation games in the business and management studies is to give to the students a more realistic view on

how a company operates and the flow of products in a plant.

Another benefit of using simulation games in a class-room is that it allows participants to perform with no pressure on making a mistake or poor decision, as the game gives the opportunity to the participant to perform on risk-free environment (Pasin and Giroux, 2011 p. 1244). Finally, during the simulation game learning experience, skills can be gained through practical learning such as teamwork and oral and written communication between participants; this kind of practical skills would be hard to be acquired only through theoretical knowledge (Costantino et al., 2012 p. 2).

2.2 Simulation games for operations management

Similar to simulation games for other educational courses, using a simulation game for operations management students is aim at assisting the students to link the theory taught in lectures with a more practical representation of the reality. The games basically tie the knowledge with how it is done in real life, and more specifically in an industry (Salas et al., 2009 pp. 564–5).

The idea of using simulation games in operations managements for a better understanding of the concept given to the students in a class room, started from 'The beer' game (Forrest, 1961) and continued with the (Senge, 1990), 'Cuppa manufacturing games' (Ammar and Wright, 1999) and the 'Training factory' (Haapasalo et al., 2001). Those games have been developed over the years in the operations management filed, to help the students advance their knowledge and learn to make the right decision in certain process. For example, the study of Ammar and Wright (1999) mentioned some simple activities that can assist students to understand the concepts of operations management and production; some of them include making products such as chairs and tables and putting a price on them by category. Simple activities like these, can help the student understand some basic concept in operation management.

Simulations games can vary; from paper based to heavily IT supported games. Also there are some role-play simulation games that require physical interaction. Examples include the balancing planes game presented on the study of Ammar and Wright (1999) which makes use of Lego bricks to assemble a plain, and the 'Serious game' aiming to teach to students the concept of lean production (Leal et al., 2017). Similarly, the study of Lean et al. (2006) shows the type of simulations games used in higher education which include role play game, educational games, and computerised based games; as of their study, none computerised games is the most commonly used type of simulation games. However, considering that this study was conducted more than ten years ago, it is expected that there could be a swift to more IT dependant simulation games. Nevertheless, even the use of cards or paper based games could assisted to better interpretation of the information taught during the lecture.

Learning from practice is one way for students to understand operations management and production systems. Experimental learning theory explains how students can benefit the most by the process of the learning regardless of the outcomes as by engaging the student in the learning process can enhance the learning experience (Kolb and Kolb, 2005 p. 194). That was in propositions of the theory, which focus more on the learning process of a student and get the benefit of that process.

3 DESIGN OF THE QPQ SIMULATION GAME

The QpQ Simulation Game is a non-computerised (manual paperwork) production game that aims to help students understand manufacturing planning and control techniques such as make to order (MTO), just in time (JIT), and enterprise resource planning (ERP). In addition, it aims to aid students familiarise themselves with basic operations managements concepts (e.g. production planning, forecasting, labour management, supply chain, quality control, efficiency of processes) and assist them into enhancing their problem-solving skills by applying systems theory techniques. In this sense, the QpQ Simulation Game mimics actual processing of orders in a company and the production of its goods in a simplified manner. The simulation game is based on recurrent processes that do cope less with variety and have difficulty in achieving optimal performance. That requires the analysis of the current situation against (future) requirements. Such analysis should identify root causes and the resolving of these against (future) performance requirements should lead to improvements; the impact of these improvements can be checked by playing a successive round of the simulation game. The QpQ company, rounds and options, and other relevant information of the game are described below.

3.1 The QpQ company and set-up of the simulation game

The fictive company, called QpQ, delivers cars to customers that consist of four basic types: family, pony, sedan, and ayrton. For these four basic cars, four options are available: engine type (diesel, electric, or petrol), headlights (standard, or xenon), GPS, and seats (black, white, or blue). These basic types and the options results in a product range of more than 200 different cars that can be delivered to the customer. In addition to the basic types of cars, the product range also consists of two 'specials' (utility vehicles); the coast guard and the light repair truck. For an impression of the cars to be produced see Figure 1.

Figure 1: The cars produced by the QpQ company

The organisational structure of the QpQ company consists of four departments and a manager. The departments are Sales, Logistics, Manufacturing and Financial Administration. The Logistics department is divided into Production Planning and Goods Receipt (Warehouse) and the Manufacturing department consists of Production and Quality Assurance. In addition to the four departments, there are the Supplier of parts, the AYN Employment Agency, and the YGWYS Consultancy Firm. Though these latter are considered as external entities, the players are part of the game. The AYN Employment Agency provides a flexible workforce that can be called in by the manager. The YGWYS Consultancy Firm is not active during the

rounds themselves, but can provide advice to the manager of the QpQ company between rounds.

Whereas there is a minimum number of players needed to run the simulation game, the actual distribution of players is up to the learning objectives for the game. Table 1 displays the numbers of the players as well as the typical roles of the departments and players. It should be noted that this table is based on the roles during the trial and the first round of the game. For next rounds, players can suggest changes in roles, depending on how they want to improve the operations of the QpQ company. However, some roles cannot be affected by improvements. For example, in all rounds and scenarios, the players in the Sales department receive and register the order, 'negotiate' a contract and pass on the necessary documentation to the next stage of the order processing.

Table 1: Typical roles and number of players

Player	Role	No. players
Financial Administration	Bookkeeping of QpQ company (profit/loss)	1
Goods Receipt (Warehouse)	Checks quantity of incoming goods from supplier	1-2
Manager	Oversight of order processing, corrective actions for quality, delivery of orders to customer, allocation of flexible workforce	1
Production	Actual manufacturing of cars	2-4
Production Planning	Provision of picklists to supplier based on the Bill of Materials	1-3
Quality Assurance	Checks car before delivery to customer	1-2
Sales	Receives orders from customer, records details of order for order processing	1-2
Shop Floor Control	Issues complete jobs to production	1
Total (QPQ)		**9-13**
AYN Employment Agency	Provides flexible workforce to QpQ company	0-1
Supplier	Supplies materials to QpQ	2-3
YSWYG Consultancy	Advises the manager of the QpQ company on improvements	0-2
Total		**10-22**

The game consists of a trial run and two to three rounds, depending on the learning objectives and on how quickly the players identify in successive rounds those solutions that yield a better performance. During the Trial Round only three orders (Figure 2 illustrates an example of an order) are issued by the customer (tutor) to the QpQ company. It is the intent that the group produces at least two out of three orders to understand all processes and forms. The trial run can last between thirty and forty minutes. During Round 1, there are 20 orders issued (one order every one minute). Two of the orders are for two cars (a double order, making it 22 cars to be produced in 20 minutes). Similarly, the next rounds also consist of 20 orders with two orders being for multiple cars. However, the difference is that the players now have the possibility to introduce changes in order to improve the performance of the QpQ company. The improvements that can be implemented can be divided in to two categories: (i) changes and improvements related to staffing (re-training, multi-skilled, firing) and (ii) changes and improvements related to the processes and structures. The second option includes different scenarios that the players can choose from (MTO, JIT, ERP).

Figure 2: Order used during the QpQ Simulation Game

3.2 The three different scenarios

The first scenario represents the simplest form of the game. Make to Order (MTO) is a common practice for companies and it means that all activities for an order are only started when the order of the customer has been received. In the case of the QpQ Simulation Game, those activities cover preparation of documentation for logistics and production, the acquisition of materials, the production of good and the delivery of the product to the customer. Generally speaking, the MTO aims to give flexibility for customising the product, however, this creates an additional wait time for the customer to receive the product. The second scenario is based on the Just in Time (JIT) production system where the production is initiated only as demand requires. That means that the QpQ company should have an inventory of finished components and only when a customer places an order the production of the finished good (the car) will start. Adopting the JIT scenario, would reduce the preparation of documentation and as all the main components of the car are already built, it would make the manufacturing of the car less complicated and less time consuming. Finally, the third scenario that the players can choose from is the Enterprise Resource Planning (ERP) that in an operations context, integrates planning and control with the other functions of the company. For the QpQ Simulation Game that means that with the use of ERP, the players can have an automated picklist that includes all the components and materials needed for the production of the car. As a result, the lead time for a finished car should be reduced, making the production process more efficient.

4 DELIVERY AND EVALUATION OF THE QPQ GAME

The QPQ Game was delivered and tested in three different settings with three different groups of students between November 2014 and November 2016. Before each delivery, a brief introduction to the game was given. In the case of the first delivery, because the simulation game was delivered as part of a business postgraduate course, the students had also the opportunity to attend lectures related to systems thinking and decision making processes. The students were advised to think and make decisions on how they could use basic operations

management concepts for improving the efficiency of the production and the company in total, rather than focusing solely on producing a high quantity of cars. The simulation game was played twice to see if students' performance will improve (only in the second delivery the simulation game was played for three rounds after the request of the students). A trial run, lasting 10 minutes, was played to familiarise students with the game and assist them to make decisions as to how they are going to distribute their workforce among the different departments. Following that, two runs (each lasting 20 minutes) were played within a break of 15 minutes in between. During the break, tutors set up the game and students had brief discussions within their teams to decide any changes that may improve their performance. In order to assess the students' performance as well as the potential of the game, the outcomes from each run were carefully recorded together with comments from participants. The three different deliveries and the outcomes of these are described below.

4.1 First delivery of the QPQ Game

The first delivery of the QpQ Simulation Game was in November 2014 to seven different groups composed of students of a business postgraduate course in the Adam Smith Business School of the University of Glasgow. At that time, only the MTO scenario was available to the students together with the improvements related to staffing (see section 3.1 and 3.2). Figure 3 illustrates the layout of the QpQ company using the MTO production system. In the first round, most of the groups produced between one to two cars, however, most of them failed to pass the quality assurance and therefore zero cars were delivered to the customer (tutor). In the second round, after re-arrangements in the layout of the game and in the position of players, the productivity of the QpQ company was slightly increased with one to two cars being delivered to the customer, and a few others being 'stuck' in the production or quality assurance departments. The bottleneck however was identified to be in the supplier and goods receipts departments as most of the orders did not make it to the shop floor department.

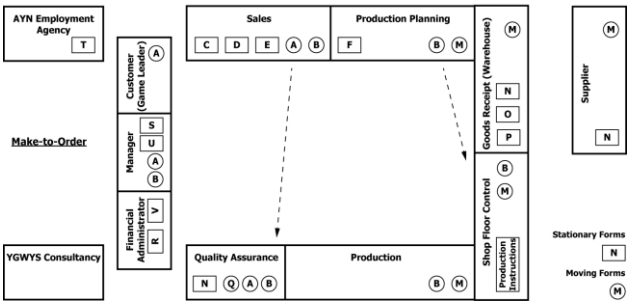

Figure 3: Layout of MTO, including form to be used by the players

The feedback of students regarding the game was drawn from the evaluation of the course where the game is embedded. As a starting point, the purpose seemed to be clear to all the students participated in the game as none of them reported any misunderstanding of why they are playing the game or similar statements in the evaluation. In addition, many of the students recognised the game as a positive aspect of the course, and none of them considered it negatively. To be more specific, terms such as 'interesting', 'engaged', 'novel', 'involvement', 'creative', 'practical', and 'stimulated' had been used to describe the game. There are also students pointed out that the game had enhanced their understanding of the basic concepts of management been taught in the course. Besides, feedback also showed that the game had a clear link with practical problems and how to solve them. As quoted from one student, "*Lego game…better understanding to business problems, decision making and system thinking.*" Overall, the game had provided added value in addition to the traditional style of lecturing and tutorial teaching. For example, when asked how this class can be improved a student stated:

"More workshops and game simulation. These stimulate our thinking better than sitting in lecture for 2-3 hours"

Due to the fact that this was the first delivery of the game, some points of improvements had been required by the students. One thing worth noted is that students thought the material provided for instruction of the game was not clear enough, which created somehow difficulties for them to understand the running of the game. This brought up another issue that since the game is designed to reflect the actual process of a company, which is more of a complex system, students had reported problems to get clear understanding of the game. The feedback from the students motivated the delivery team to make further improvements to the game. These are illustrated in the next two deliveries of the game.

4.2 Second delivery of the QPQ Game

The game was delivered for a second time in April 2016 to one group composed of students of a business postgraduate course and an MBA course in the Business School of the Newcastle University. Students had knowledge on basic principles of operations management but none of them had studied systems theory before participating in the QPQ Game. In this delivery, considering the feedback from the students during the first delivery of the game and with aim to improve the student experience and introduce more concepts of operations managements, the QpQ Simulation Game went through a few changes. First, instructions were developed for the roles and responsibilities of each department and distributed to the students before each round. Second, the JIT and ERP scenario were developed. In the first round, students delivered five cars to the customer. Similarly, to the first delivery of the game, many orders were piled up in the supplier and goods receipt departments. In the second round, students chose to adopt the ERP scenario and that resulted in producing and delivering seven cars to the customer. After the students' request, a third round was played. This time the JIT scenario was selected and the productivity of the QpQ company was greatly increased with the delivery of 14 cars to the customer. However, the company failed to satisfy the customer and to make a profit. The main reason behind that was that the delivery of the orders that were issued first, started after 15 minutes in the game. Although the students had identified a pattern that would make them process the orders more efficiently, that took them time and as a result did not manage to complete all the orders in time. It is estimated that if the students had a few more minutes, they would possibly be able to complete all the orders given by the customer.

The evaluation of this second delivery of the game, comes mainly from the tutors' observation and from the conversations between students participated. Similarly, to the previous delivery, students pointed out that the game had promoted them to understand the complexity of the order process of a company and allowed them to use systems thinking when facing problems. However, it was also noted that students felt that applying system thinking during the game was not an easy task. In terms of the delivering of additional options to the students, it was observed by the tutors that the students were excited about the flow of the game and their performance on processing orders when implementing JIT. Nevertheless,

the students were disappointed when they realised they still did not manage to make a profit by the end of the game.

With more alternatives, provision of instructions and better design of the assembly instructions, students showed greater passion in the game. A positive aspect is that they were asking for an additional round after the scheduled two rounds and commented that this game should be included in part of their regular provision. Consequently, it is noted that the improvements of the game had been successful and had improved the experience of students, but further development that could help students meet the profit point and taste a bit of 'winning' in the game should also be considered.

4.3 Third delivery of the QPQ Game

From the previous two deliveries, it had become apparent that one of the drawbacks was the amount of documentation that had to be produced by the players (e.g. order forms, bill of materials, picklists, etc.). One solution to that would be to partly computerise the process of filling out the documentation used during the game with aim to help students producing more efficient and accurate reports at the end of the game. After discussions with colleagues from the School of Computing it was decided that the QpQ Simulation Game could be well-fitted as part of a semester project for third year undergraduate students from this School. The delivery team had several meetings with two groups of students from the School of Computing and it was agreed that two versions of a software would be designed. The students delivered the final versions of the software in March 2017, when the third delivery of the QpQ Simulation Game took place in order to test the improvements made through the software (Figure 4). This time, the group playing the game was composed mainly of undergraduate students from the School of Computing and some undergraduate students from the Adam Smith Business School of the University of Glasgow. Students from the Business School had studied principles of Operations Management such as JIT, MTO, etc. whereas the students from the School of Computing had no prior experience on operations management. In this delivery, as usual a trial round was played but due to time constraints and the reason that the main aim was to test the software, the other two rounds lasted ten minutes each. The students did not manage to deliver a car in the first round although three cars were at the production stage when the time was up. In the second round, the students produced one car that was accepted by the customer and had several cars in the production and quality assurance departments. Nevertheless, it was very interested to observe and record the experience of the students playing the game, as being students of the School of Computing, the majority of them had minimum knowledge of systems thinking, and business processes or operations management processes in general.

Figure 4: Example of typical layout of the QpQ game

For this third delivery of the game, the delivery team had designed evaluation forms that were filled by the participants-students at the end of the game. Considering the background of the students in this delivery, the first thing recognised is that the game had helped them to understand the management processes better, especially with the '*physical layout*' of an organisation. The interesting feedback from this delivery was that the skills this game helped to enhance, included team working, communication, decision making, problem solving and time management. It was also noted by some students that the relationship between each individual and the whole system was made clear to them, as if someone had make a mistake, the whole process would be affected. In the words of the student:

"It helped me enhanced my team-working skills since I had to share the production planning post with another student and we had to work as a team"

On the contrast, some students reported on a few drawbacks they experienced during playing the game. One of the issues regarding skill development is that the game somehow restricted thinking and decision making. Students commented that "*I did not have to make decisions, however, it has highlighted the importance of following instructions*", which is not the original purpose of the game. Points have also been made about lack of a comprehensive understanding when engaged in only one department and that the 'tension' of the game decreased the chance of interaction within the team, which was also the reason needed for digital system. To sum up, this application was mainly for testing the feasibility of embedding a computer system in the game, however, the points of improvement by students from the School of Computing should also not be ignored, as they provide insights for new directions for the development team.

"I feel students are too involved in the game itself to be able to figure out the solution. …, did not give a very holistic understanding since I only took part in one stage"

5 DISCUSSION

The outcomes of the three deliveries indicate that the improvements made in the second delivery (mainly JIT and ERP) aided students to clearly understand and learn the differences between the three types of production methods as well as to experience the challenges of a real-life based manufacturing organisation. The addition of the software also proved to be beneficial for smoother running of the game and for better production of reports but better conclusions could be drawn when the game will be tested for its full duration (20 minutes per round) and within a group of business and management students that have been taught about operations management and systems thinking.

The students' feedback from the three deliveries of the game have been very positive. One positive aspect of the game is that it has managed to offer to the students a clearer look into the realities of a business world as the study of Haapasalo et al., 2001 has suggested. Moreover, since the QpQ game is mainly paper based, it also shows a promising potential of increasing the interaction between students, and certain benefits of developing relevent skill sets for their future development (Constantion et al., 2012). According to the comments of the students, the QpQ Simulation game also provided usefull in supporting students in getting a clearer understanding of the theories taught in the lectures. In another note, students found the game to be fun and pleasant to play and in all deliveries there were requests for more rounds to be played. Last, similar with the studies of Farrell (2005) and Lei et al.

(2007) our findings suggest that simulation games like this one can act as a positive suplement for teaching puporse, providing diversified teaching and learning environment for the students.

However, it is also clear that there is still space for improvements in the development of the QpQ Simulation Game. One of the issues is that the students' experience decreased if they did not manage to meet the target number of cars that will make the 'company' profitable. Although it is the origion design to cause problems for students to solve, the effect of the alternatives implemented should be more significant. Another improvement to work on is that the ways for students to get an overview of the whole game should be considered; in the current version of the game it is possible that if a student stay only in one departement for the whole duration of the game, it is likely that he or she may loose a comprehansive understanding of the problem.

6 CONCLUDING REMARKS

It has been evident that students enjoyed the game, and acknowledged the positive learning experience and the opportunity to develop a deeper understanding of the concepts that were taught in lectures. In the case that the students did not have a business and management background, the game has proved to be beneficial in understanding the management processes of an organisation and they suggested that they would like to see similar simulation games within the context of the IT concepts. However, it is suggested that in order to assess the new software and the real potential of the QPQ Simulation Game, and its effectiveness on learning, more empirical research should take place within different settings and across cohorts.

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