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# **Didactical Concepts and Evaluation of a Supply Chain Management Serious Game**

## **Abstract**

It's a couple of decades since Serious Games (SGs) started to be implemented for both educational and professional purposes, especially in the engineering sector. The interest in virtual SGs has risen even more in the last few years due to their ability to be used from anywhere, apply theoretical knowledge, and involve users in a challenging way. Since the beginning of the project Open Digital Laboratory For You (DigiLab4U) in October 2018, the University of Parma started to develop a brand new SG with a strong focus on Supply Chain Management (SCM). This paper presents the didactical background and the feedback received that led the University of Parma staff to the creation and improvement of the SCM SG scenario.

## **Keywords**

Serious Game, Operation Management, Didactical Evaluation

## **1 Introduction**

Nowadays, enterprises increasingly need to add to their organic new resources with enough skills to cover many functions. Among these functions, production, logistics, suppliers, and customer management are the most requested. The knowledge required for these functions is taught in Operation Management and Supply Chain Management (SCM), which are courses held in bachelor's and master's degrees in Management Engineering. Up until 2019, at the University of Parma the courses were held as a combination of theoretical teaching and practical exercises carried out on sheets of paper or with informatic support like MS Excel. However, it highlighted a gap in the acquisition of practical, technological, and soft skills. So, in 2018, corresponding to the beginning of DigiLab4U, the University of Parma started the design and development of a Supply Chain Management Serious Game (SCM SG). The SCM SG has been designed as a multiplayer

cooperative/competitive game in which players are divided into different companies competing in the production of e-bikes. Students individually play at conducting day-to-day operations and collaborate with others to take strategic decisions. The rest of the paper is structured as follows: Section 2 presents an overview of the state of the art in the SCM SG; section 3 presents the methodology adopted to design and refine the SCM SG. Section 4 presents the didactical scenario created for the serious game. Section 5 presents the beta testing evaluations performed and the summative evaluation carried out after the alpha release. The results are discussed in section 6, with conclusions and future works in section 7.

## 2 Serious Games in Supply Chain Management

The definition of SG can be expressed as games that provide both entertainment and learning, by making the users deal with complex problems, dilemmas, and challenges combined with the fun resulting from gameplay (Burghardt, Ferdinand, Pfeiffer, Reverberi, & Romagnoli, 2020). With the rise of virtual laboratories, distance learning, and online services, this tool has been reconsidered and implemented in the education and training of engineering students and professionals (Galli et al., 2021). Also, the fact that SGs are based on learning by doing represents a significant advantage as it is considered one of the most effective teaching styles by numerous teachers and it allows learners to operate in a real-world environment. This characteristic of SGs enables students to make mistakes without causing real damage, thus making SGs ideal tools for the teaching of Operation and Supply Chain Management (Reese, 2011). As already existing examples of SCM SG, it is possible to find the Beer Game (Kaminsky & Levi, 1998), which is card-based and probably the most known and used. AUSUM (Crowe, 2011) is a game focused on the dynamics of supply chain management in the automobile sector. Also, the Fresh Connection (De Leeuw et al., 2015) is based on strategic decisions to be taken and highlights how these decisions influence different functions within a company. On the other hand, among the operation management SGs, Learn2Work represents one of the main examples by making available three different scenarios in which the user has to lead the company to success. Practice Operation<sup>1</sup> is the last example: here, the users face a 3D game where they have to manage a

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1 [https://www.mhpractice.com/products/Practice\\_Operations](https://www.mhpractice.com/products/Practice_Operations)

clothing company by managing orders, resources, and the procurement of raw materials to complete different production orders and sell clothes.

### **3 Methodology**

With the SCM SG being a brand new tool, and a totally new technology at the University of Parma, its development started with a phase involving the definition of Learning Objectives (LOs) and Research Questions (RQs). The definition of LOs was driven by two different requirements, namely (i) the targets of the Operation Management course, and (ii) the knowledge required in the day-to-day actions carried out in the company's functioning. These are defined as (a) the ability to schedule a production order with different shops, (b) the connection between quality, quantity, price, and due date in a deal with customers and suppliers, and (c) the ability to design a replenishment plan for resources. Nonetheless, the LOs are also connected to soft skills like teamwork, the ability to achieve common goals, and problem-solving, to face unexpected events and react in the proper way considering significant KPIs. Similarly, RQs were formulated to evaluate the design of the serious game. With its creators having the objective clearly in mind, the design and development of the game started with the first beta testing run internally in June 2020. This first session represented the initial step in an iterative approach composed of testing and feedback collection and repeated for different months and different test groups. The first official version of the game was released to coincide with the courses in Operation Management held at the University of Parma and the University of San Marino in the summer semester of 2021. In order to test the alpha release of the game, a pre-test and a post-test were conducted, on the first and on the last day of lessons.

#### *3.1 Game development and testing*

The first working implementation of the SCM SG, released in spring 2019, was not optimized at that time; to solve any problems that arose, a beta testing phase was conducted. This phase was composed of two different iterative approaches (Figure 1) to test the effectiveness of the game and the right combination of parameters. In the first, lecturers and researchers played the SCM SG to prepare it for student testing; this first iteration was repeated twice.

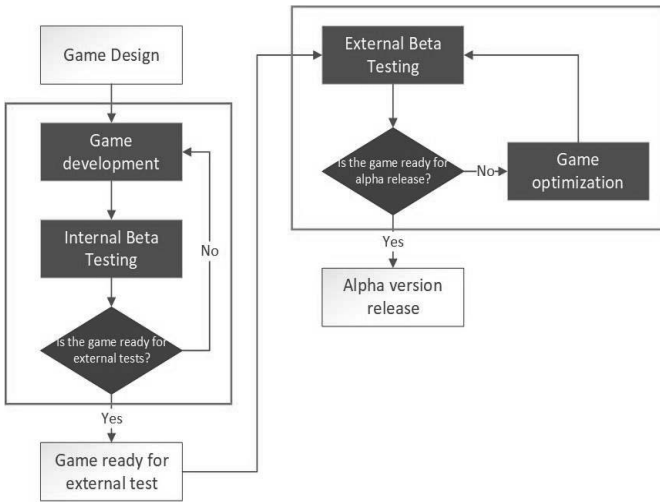


Figure 1: Beta testing process

These contributions led to the detection of major glitches and bugs in the first iteration, and the proposals for the optimization of parameters the second time. Subsequently, the game was evaluated as ready to be submitted to students. The second phase was replicated twice with two different groups of students. Once these two iterations had finished, the game was evaluated as ready to be released as an alpha version. The first users of the game were the students enrolled in the two bachelor's degree courses in Operation Management at the University of Parma and the University of San Marino. In order to best evaluate the SCM SG and the students' willingness to use it, two tests were conducted. Pre-tests aimed to investigate the perceived usefulness of SGs, the willingness to use them, and the perceived added value of this type of learning tool. The post-test was structured by using a framework validated by Iten and Petko (Iten & Petko, 2016), which is based on a Likert scale and aims to investigate characteristics of the game like (i) usefulness, (ii) simplicity, (iii) fun/enjoyment, (iv) personal ability, (v) fear of use, (vi) intention to use, (vii) clarity of the goal of the game, (viii) strategic approach, (ix) use of prior knowledge, (x) flow, (xi) feedback, (xii) help/assistance, (xiii) enjoyment of the game, and (xiv) competition.

## 4 SCM SG Scenario

The scenario is structured as a universe comprising different companies competing in the e-bike market. This universe simulates a semi-real-life scenario in which every company is an e-bike manufacturer buying raw materials from the suppliers, using these materials to produce final products, and selling them to customers. This design of the game, which reproduces manufacturers' day-to-day actions, enables the users to deal with real-life and real-time dilemmas, developing hard skills required in Operation Management and in manufacturing companies. Also, SCM SG has been designed as a multiplayer game where companies are composed by two to three students playing different roles and cooperating in order to achieve a common goal. The three roles are: purchasing manager (PM), operations manager (OM), and sales manager (SM). The PM role is in charge of managing inbound operations, the OM manages the scheduling of production, and the SM runs outbound operations, as described by Galli et al. (Galli et al., 2021). The collaborations and cooperation between these functions are fundamental to achieving optimal company management. To do so, the users have to share their function information and decide altogether on the strategy to follow. Indeed, the serious game does not foresee a common way of achieving optimal management; it is up to the players to decide if producing with a make to order (MTO) strategy, a make to stock (MTS) strategy, or a hybrid combination of them is most effective. To take such decisions, coordinate each function to achieve the common objective, and maintain the strategy chosen, communication and coordination are a fundamental part of the game. Another peculiar characteristic of the SCM SG is its high level of customizability, which enables the players to create different levels of difficulty and different scenarios to be played. An important parameter to be considered is the duration of the game in order for the players to benefit from mistakes-driven learning and change their roles.

## 5 SCM SG Evaluation

In the beta testing phase, two different types of feedback were gathered. Firstly, the observations made by lecturers and researchers were managed with open discussions due to the limited number of participants and the diverse number of bugs, glitches, and parameters to be fixed and balanced. Once the testing passed from the professionals to students, feedback was enhanced with a questionnaire with the scope to investigate the perception of different parameters. For all the parameters investigated from here on

a Likert scale 1 to 5 (1 = very low, 5 = very high) was used. This survey revealed that the overall difficulty level of the game is perceived as medium; among the roles played, OM was perceived as having a slightly higher level of difficulty (Galli et al., 2021). Also, the user interface (UI) was evaluated as well designed, and game practice was adjudged to be in line with theoretical lessons. The perceived competition was high: 90% of the students reported a grade higher or equal to 4, and the game was evaluated as enjoyable. However, the discussion highlighted the possible benefits of an integrated chat system, which was not provided by the game itself at that time. A summative evaluation was carried out by submitting a pre- and post-test in the two courses. As result, the pre-test was submitted to 176 students and the post-test to 102 students; 37 of them participated as players; the rest represent the control group. The pre-test highlighted the high perception of added value that SGs can bring to the teaching methods used, with 80% of the interviewees voting higher or equal to 4 in response to that sentence, and more than 70% of the students expressing their feedback in the same way in terms of their willingness to use the game and of its perceived usefulness. On the other hand, the post-test investigated all the parameters which characterize the serious game in more depth. The test is composed of 46 different sentences, divided into the 14 parameters which students can evaluate. In Figure 2, the average evaluation of every parameter is divided into the two groups, University of Parma (UNIPR) and University of San Marino (UNIRSM), and the average value given by all the players. In general, the parameters with a score higher than 3 can be considered evaluated positively, around 3 as neutral, and lower than 3 as negative (Iten & Petko, 2016).

The feedback received in the post-test can be considered generally positive. Important results were the vote received in terms of Usefulness (4.42), Fun/Enjoyment (4.57), Intention to use (4.2), Clarity of the goal of the game (4.31), Enjoyment of the game (4.53), and Competition (4.25), which all ranked highly. The only parameter with a low evaluation was Fear of usage (1.66), which cannot be considered a negative evaluation due to the purpose of the game in which students are afraid to make mistakes. Having no fear would represent a self-defeating attribute in the usage of mistakes-driven learning.

## 6 Discussion of the results

The beta test results outlined a good evaluation of the SCM SG and its design, which peaked in terms of the relevance between practice and theory

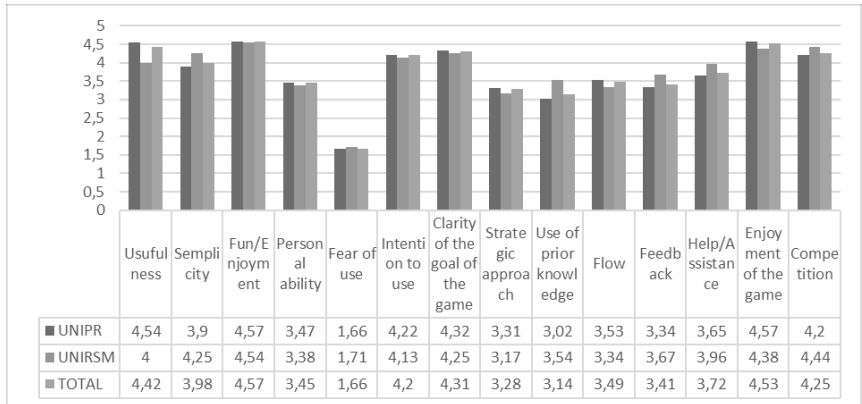


Figure 2: Post test evaluation

taught, and perceived competitiveness. The game’s UI and playability achieved good grades. In the pre-test, the willingness to use SGs and their perceived usefulness achieved positive feedback, which was confirmed later by the post-test. The beta test results were confirmed by the post-test, in which the game was evaluated as a good give-and-take between usefulness and fun, in which competition and the clarity of the objective represent key aspects of success. However, personal ability, the use of prior knowledge, and strategic approach received a neutral vote in contrast to the mark received for the relevance between practical aspects and theory. The perceived difficulty of the roles in the game was in line with the results of the beta test, with the OM function being considered more challenging than the SM and PM.

## 7 Conclusions and future works

In conclusion, the feedback received on the SCM SG was positive. The data indicates that the aspects of competitiveness, enjoyment, and usefulness were achieved, which indicated that the participants highly intended to use the game. Plus, the students who played the game gave on average 12.5% marks higher than the students who saw only the introductory video. This last statistic can be interpreted as an excellent result which confirms that the game surpassed the expectations of the students. Also, the difference in the evaluation of the roles’ difficulty underlines the need for the learners playing in the same company to change roles during the game. In contrast

to these positive outcomes, the game has to be improved in the usage of skills taught in the Operation Management and Supply Chain Management courses. As a next step, pre-set scenarios will be defined in order to address both long game sessions and short game sessions in an appropriate way.

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