Proceedings of the 2012 Winter Simulation Conference
C. Laroque, J. Himmelspach, R. Pasupathy, O. Rose, and A.M. Uhrmacher, eds

A SIMULATION BASED GAME APPROACH FOR TEACHING OPERATIONS MANAGEMENT TOPICS

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ABSTRACT

Simulation games have been utilized as an educational tool in order to complement the traditional teaching methods. They have been widely applied in the teaching of different subjects such as business management, nursing, and medicine. This paper proposes a new simulation game which simulates a production system that consists of a set of machines, conveyors, and other components. The objective of the proposed game is to enhance the teaching of some concepts of operations management such as capacity utilization and maintenance planning. The game decisions are repeatedly made in two consecutive steps of playing in order to enhance the learning of students. This framework of decision making can be utilized to evaluate the progression of students learning and the educational effectiveness of the game. Students showed a positive response to the game and learning through gaming in an evaluation conducted after playing the game.

1 INTRODUCTION

1.1 Motivation

Students have difficulties to understand the complexity of the Operations Management (OM) subject. The multiple and competing objectives that are linked to the OM decisions are not obvious to people and students that do not have experience in a company operations as students generally have not obtained yet this experience. The theoretical knowledge that OM students acquire in classrooms does not give them full awareness of OM issues or the criticality of the decisions of operations managers (Ammar and Wright 1999). In other words, lectures and explanations provide students with theoretical knowledge but fail to provide them with practical skills required for their future career as operations managers so that students fail to link between OM concepts and their applications. To overcome this situation, the teaching activity in OM is sometimes supported by videos and company tours. This helps but does not permit the typical education approach where the student changes a parameter of the reality and sees what happens due to this modification. The motivation of this paper resides in the opportunity that a simulation model will allow students to easily see the effects of different OM decisions on production system performances. This paper proposes a new simulation game which simulates a production system that consists of a set of machines, conveyors, and other components. The objective of the proposed game is to enhance the teaching of some concepts of OM such as capacity utilization and maintenance planning.

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1.2 Literature Review

The operations management field covers a wide range of subjects from specific areas such as inventory and scheduling to much wider interrelated areas such as lean and supply chain management. Teaching of operations management usually depends on using the traditional teaching methods such as lectures, assignments, and case studies. Although these teaching methods are appropriate for the dissemination of foundational and theoretical knowledge, they may not be appropriate to transfer practical skills to students (Ben-Zvi and Carton 2007). Furthermore, many studies have proved the differences between students' learning styles which lead to the need for different approaches to be adopted when teaching a subject (Chwif and Barretto 2003). Proserpio and Gioia (2007) emphasized also that the learning style of the new 'virtual generation' (V-gen) is very different from that of former generations. It is much more visual, interactive, and focused on problem-solving (Pasin and Giroux 2011). Therefore, instructors have to adopt new teaching aids in order to easily allow the students experience the issues involved in operating and managing a production system. Ahn (2008) argued that experiential learning can be characterized as a learning method that involves immersing learners in an environment in which they actively participate in acquiring knowledge. The required experiential learning can take place through a variety of in-class activities that can be used to complement the traditional theoretical presentation methods (Ammar and Wright 1999, Chang et al. 2009). The new teaching aids for operations management and business fields are proposed to help students gain a new understanding of real industries and enable them to employ the knowledge and theories that are obtained from classrooms in the real world (Chang et al. 2009). Game-based learning is one of these teaching aids where games have been revealed to be very useful pedagogical methods for supplementing traditional teaching techniques (Adelsberger et al. 1999, Chang et al. 2009).

Bloomer (1973) as cited in Pasin and Giroux (2011) defines a game as any contest (play) among adversaries (players) operating under constraints (rules) for an objective (winning). On the other hand, Simulation refers to a broad collection of methods and applications to mimic the behavior of real systems, usually on a computer with appropriate software (Law and Kelton 1991). A simulation is not necessarily a game (Pasin and Giroux 2011) where simulation has been widely used to analyze systems and to compare proposed scenarios in order to improve the systems' performances, but simulation can also be adapted to constitute a game. Simulation Games consist of two components, a description and a simulation model (Adelsberger et al. 1999). The description is an introduction to the game, i.e., to the situation, basic rules, team structure, and various options. The simulation model is used to process the players' inputs and to obtain the reports for each player. Pasin and Giroux (2011) defined a simulation game 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. Simulation games can also be defined as a contest or a competition based problem solving in a virtual reality.

Simulation games as a learning tool attempts to replicate various real world problems in the form of a game for various purposes of training, analysis, or prediction. Chapman and Martin (1995) argued that such types of learning methods can assist in the development of more effective personal transferable skills such as team-work, problem solving techniques, and oral and written communication. Furthermore, simulation games can be used to help companies to identify technical and non-technical problems, and it can also be used to evaluate the required changes in the business processes before the implementation (Forssén-Nyberg and Hakamäki, 1998). Simulation games indeed help students to learn and have fun simultaneously (Anderson 2008) and they have been applied in diverse areas; in training in the military and the aeronautics industry, and in the teaching of medicine, nursing, engineering, management, and several other fields (Pasin and Giroux 2011). For example, Stanley and Latimer (2011) evaluated the effectiveness and suitability of 'The Ward' as a simulation game to promote and support nursing students understanding of decision making, critical thinking and team work in clinical practice situations. Deshpande and Huang (2011) reviewed the different simulation games that have been applied in the education of science and engineering.

Several simulation games have been developed for mastering business concepts in operations management. The main purpose of business games or simulations is to mimic the real decision making process that players will be involved in the future, or they may be already involved in if the players are executives. Haapasalo and Hyvonen (2001) reported that the history of business simulations in general is more than 40 years long. Faria et al. (1998) reported that, in a recent survey of accredited business schools, fully 97.5% of them used simulation games in part of their courses. Sterman (1989) developed the famous "Beer Distribution Game" at Massachusetts Institute of Technology (MIT) to study the dynamics of supply chain and especially the bullwhip effect in which demand variability increases as one moves up in the supply chain. The Beer Game mimics a single product serial supply chain in which each player is assigned to a supply chain position to manage both demand and inventory flows. Other researchers have developed computerized and web-based versions of that Beer Game to study bullwhip effect (Jacobs 2000, Machuca and Barajas 1997). Since then, the Beer Game has been adopted universally as an efficient teaching tool in supply chain courses. In addition, other simulation games devoted for supply chain teaching have been developed such as Mortgage Service Game (Anderson and Morrice 2000) and Blood Supply Game (Mustafee and Katsaliaki 2010). Chang et al. (2009) developed a flexible simulation game environment called SIMPLE (Simulation of Production and Logistics Environment) in order to raise teaching effectiveness and improve classroom teaching in different major business concepts, such as inventory management, capacity management, pricing determination and negotiation, and information-sharing between players. Bringelson et al. (1995) developed a computer simulation game ''NCTB'' to help engineering and business students learn about the inter-functionality of decision making, in an interdisciplinary group. The game focuses on teaching four functional areas; namely, purchasing, production planning and control, quality control, and marketing. Battini et al. (2010) developed a simulation game called "Logistic Game" to assess learning-by-doing and knowledge-sharing in Industrial Logistics and OM topics. The main body of their game is a discrete event simulation model developed for the internal logistics of an industrial plant. Similarly, other authors have adopted the discrete event simulation approach to develop pedagogical simulation games, see, for instance, Haapasalo and Hyvonen (2001), and Chwif and Barretto (2003).

Based on the above literature, it can be concluded that simulation games can be used to improve classroom teaching of OM subjects. This paper proposes a new operations management simulation game to be used for students and professionals of OM. The main focus of the proposed game is to teach the students the main concepts of capacity utilization and maintenance planning.

The rest of this paper is organized as follows: in the following, Section 2 introduces the proposed simulation game, and Section 3 discusses the game organization. Section 4 presents the game evaluation.

2 PROPOSED SIMULATION GAME

This game is devoted to teach and train the students and practitioners of operations management on the main concepts and theories of OM. Students need some way to directly experience the issues involved in operating a production system (Ammar and Wright 1999). Computer simulation games, refined graphics, and multimedia can be developed to present engineering topics in ways that are not possible within the limitations of the traditional lecture format (Deshpande and Huang 2011). The proposed game provides an environment of problem solving which simulates the reality that student would be involved, but in a playful manner. In this game, the players who may be either students or professionals will be asked to make strategic decisions regarding the production system configurations (Figure 1) such as the selection of machines capacities, maintenance strategies, and conveyors speeds. These decisions are classified as strategic decisions that have to be made accurately during the design of the production system in order to assure the efficient performance of the system. The total cost for operating the production system depends on the decisions made by the players where each decision has its corresponding cost. For example, a team may select to buy a machine of high capacity rate although the annual demand is not so high to buy it, so that the team will encounter more cost than it would be to cover the demand. Generally, the objective of each team of players is to operate the production system at the lowest possible cost in comparison to the other teams to win the game. This will allow students to realize the impact of their decisions on both the system performance and the total cost. In this game, the competition among the teams is based on the total cost correspond to their decisions. Therefore, the team who achieves the minimum cost will be considered as the game winner. It is expected that this game will be a helpful aid in order to complement the traditional teaching methods of OM.

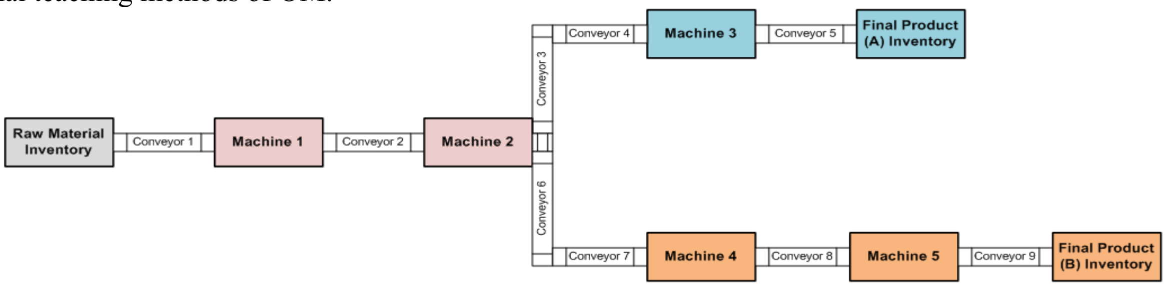


Figure 1: Production system configuration.

2.1 Simulation Model

The proposed game depends on the simulation of popular production system that consists of a set of machines, conveyors, and storage areas. The production system is producing two types of products (Prod. A and Prod. B); each product has its sequence of operations as shown in Figure 1. The simulation model represents a virtual production system that has to be effectively managed in order to achieve the objectives from this system. The simulation model has been built using SIMUL8 software (see Figure 2). The simulation model is linked with an external spreadsheet in order to facilitate the entry of the players decisions. The production line starts with a large inventory of raw materials connected to the production system with a conveyor (see Figure 1). The machines in the production system are also connected together with conveyors (see Figure 1). It is also assumed that the system starts every week with initial raw materials inventory, enough for the predicted weekly demand. The machines and conveyors are exposed to maintenance stops for repairing where these stops may be due to planned or unplanned maintenance.

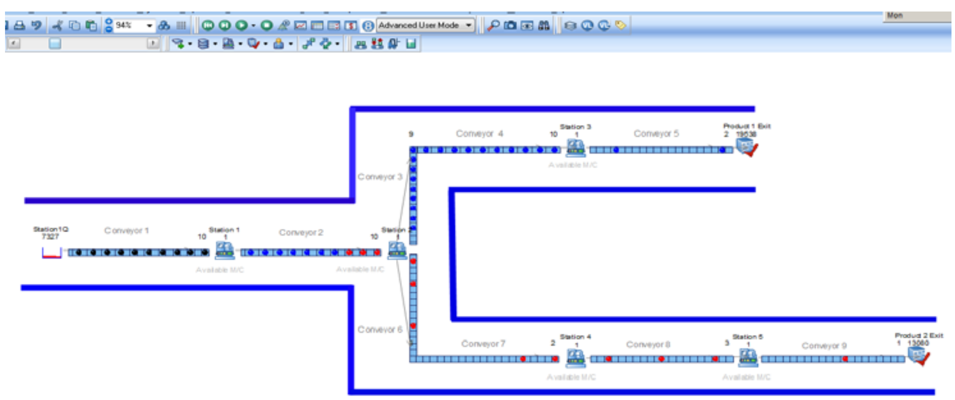


Figure 2: Simulation model flowchart.

2.2 Game Decisions

According to the objective of the game, the production system has to be effectively designed in order to satisfy the weekly demand of each product at the least cost. The decisions that the players are allowed to make and the decisions alternatives that they can select from are summarized in Table 1. The decision about the equipment (Machine/Conveyor) capacity rate may be either fast or slow. The cost of the equipment is the sum of the fixed cost and the variable cost; these costs depend on the equipment capacity rate (see Figure 3). Furthermore, the player can select the equipment maintenance strategy to be either Planned Maintenance (PM) or Corrective Maintenance (CM). Each maintenance strategy has its related cost where in this game the maintenance cost is calculated as the number of stops multiplied by the cost of each stop (see Figure 3). Accordingly, there are 2^{14} combinations, i.e., 2 possible decisions, 9 conveyors and 5 machines, of decisions alternatives that can be made by the players. Those combinations could be considered as a set of feasible solutions that can be made.

The encountered costs in the production system are divided into fixed cost, operating cost and backlog cost; the operating cost includes both the variable cost and the maintenance cost. The variable cost is a function of the served number of products by each equipment. The backlog cost is encountered when the production system fail to satisfy the target demand. The unsatisfied amount of the two products is considered as backlogged demand. It is also assumed that each product has a different backlog cost. The following equations summarize the main costs of the production system that have to be optimized in order to achieve the least total cost.

Table 1: Different decisions alternatives.

Equipment	**Equipment Capacity Rate**	**Maintenance Strategy**
Machine (MC_i)	Fast/Slow	PM/CM
Conveyor $(Conv_j)$	Fast/Slow	PM/CM

$$Total\ Fixed\ Cost\ =\ \sum_{i=1}^{5} Fixed\ Cost\_MC_i + \sum_{j=1}^{9} Fixed\ Cost\_Conv_j \tag{1}$$

$$Total\ Variable\ Cost\ =\ \sum_{i=1}^{5} Variable\ Cost\_MC_i + \sum_{j=1}^{9} Variable\ Cost\_Conv_j \tag{2}$$

$$Total\ PM\ Cost\ =\ \sum_{i=1}^{5} PM\ Cost\_MC_i + \sum_{j=1}^{9} PM\ Cost\_Conv_j \tag{3}$$

$$Total\ CM\ Cost\ =\ \sum_{i=1}^{5} CM\ Cost\_MC_i + \sum_{j=1}^{9} CM\ Cost\_Conv_j \tag{4}$$

$$Total\ Operating\ Cost\ =\ Total\ Variable\ Cost\ +\ Total\ PM\ Cost\ +\ Total\ CM\ Cost \tag{5}$$

$$\begin{aligned} Backlog\ Cost = &(Target\ Demand\_Prod.\ A\ \text{-}\ Actual\ Production\_Prod.\ A)(Backlog\ Cost\_Prod.\ A) + \\ &(Target\ Demand\_Prod.\ B\ \text{-}\ Actual\ Production\_Prod.\ B)(Backlog\ Cost\_Prod.\ B) \end{aligned} \tag{6}$$

$$Total\ Cost\ =\ Total\ Fixed\ Cost\ +\ Total\ Operating\ Cost\ +\ Backlog\ Cost \tag{7}$$

Where $i = 1\ to\ 5$ and $j = 1\ to\ 9$ represent machine index and conveyor index, respectively.

According to the above equations, it is clear that the poor decisions will lead to high cost of production and low utilization of the production system's resources. Therefore, this game aims at learning the players how the poor decisions have a great effect on the production system performance and hence on the total cost.

3 GAME ORGANIZATION

The proposed game is played in teams of players; each team is a group of 3-4 players. The game is managed by the administrator who is responsible to constitute the teams, leads the Simulation Game, and the problem oriented coaching for the participants (Adelsberger et al. 1999). Generally, the essential task of the administrator is to adequately combine the simulation game and other teaching contents. The distribution of different roles among the team members is the team's responsibility where they have to manage this matter by themselves. Each team has to select a team leader in order to link between the game administrator and his team members, and to facilitate the management of the game. This will make the communication between the teams and the game administrator much easier. Teamwork and collaboration are considered as one of the most important educational goals of this game.

The game is designed to be played in two sequential sessions in order to maximize the transferred skills to either the students or practitioners of OM (see Figure 3). The time between the two sessions is at least one week; this can be arranged by the game administrator and the teams' members. The first session, named session 1, is dedicated to introduce the game, the production system, and the decisions that have to be made by the players. Furthermore, the objective of the game will be indicated and the competition basis will be also clarified for the players. At the end of this session, an assignment is distributed to the different teams participating in the game where this assignment has to be delivered to the game administrator in the next session. The administrator distributes to each team a different set of initial values for the production system parameters in order to calculate the expectations of some performance measures (see Table 2). It is intended from this step to give the players more understanding for the problem that they have to solve.

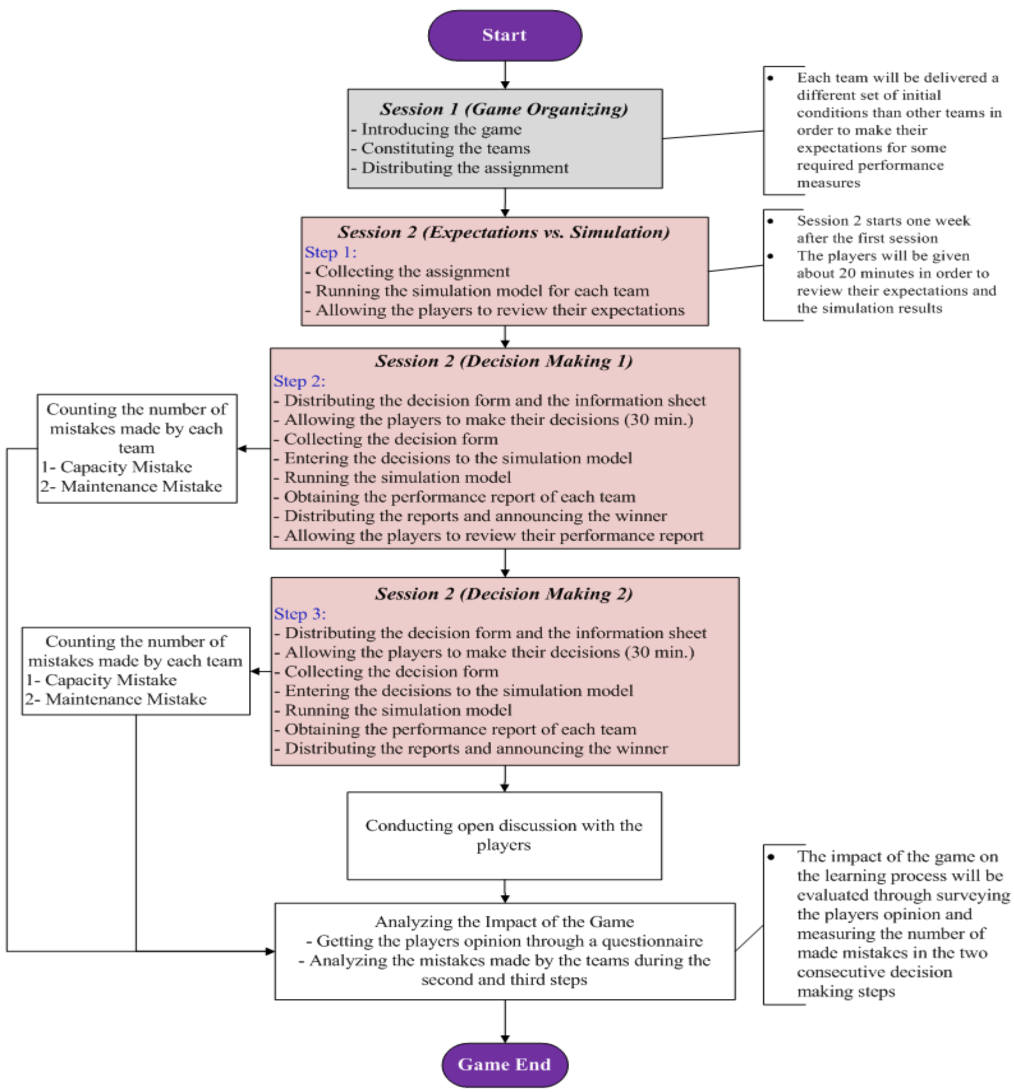


Figure 3: Flowchart of the game organization.

Table 2: Sample of performance measures to be calculated by the different teams.

Measure	Production System Division	Expected Value
Capacity Expected production / week	MC1 → MC2	---
	MC3	---
	MC1 → MC2 → MC3	---
	MC4 → MC5	---
	MC1 → MC2 → MC4 → MC5	---
Maintenance Machine Availability / week	MC1	---
	MC2	---
	MC3	---
	MC4	---
	MC5	---

The main body of the game starts in the second session. The second session, named session 2, is initialized one week after the first session and consists of three steps. At the first step, the administrator collects the assignments from the different teams and then runs the simulation model in the presence of each team separately and with considering to the initial settings that the team used to make their expectations. The monitoring of the simulation model animation will allow the players to realize their errors and mistakes and to inspect their presumptions about the behavior of the production system. The resulted report of the production system performance from the simulation model is distributed to the different teams in order to allow them compare these results with their expectations. The teams will be given about 20 minutes to review the simulation model report with their expectations so that their understanding for the game and their knowledge may be improved. At the second step, each team will attempt to make the best decisions in order to realize the least possible total cost in comparison to the other teams so that they achieve the first position and win the game. The administrator generates another set of initial parameters and then distribute a form of decisions represents the main input to the simulation game. In this decision form, the players will be asked to make decisions regarding the machine capacity (Fast/Slow), conveyor speed (Fast/Slow), and the maintenance strategy (CM/PM) for each machine and conveyor. The administrator also distributes an information sheet including the target production of each product, the related values for the different decisions alternatives and the corresponding cost for each decision alternative (see Figure 4). This information sheet will be the players guide in order to make their decisions where each team will attempt to realize the least cost. Students can use various analytical and deduction tools (some computerized) in order to make their decisions. The duration allowed for the teams in order to make their decisions is considered to be 30 minutes as a start. After the 30 minutes, each team leader has to deliver a filled decision form to the game administrator, and then the administrator runs the simulation model to obtain a performance report for each team (see Figure 5). The report also presents the total cost corresponding to the decisions entered to the simulation model. Based on this total cost, the administrator evaluates the teams and announces the game winner and the rank of each team. The players will be given about 30 minutes to review their decisions and the corresponding performance report. This will help the players understand more the behavior of the production system and make the appropriate decisions in order to optimize the performance of the production system. It will also help them to build their experience which will be useful for their practical work where this game can be considered similar to the real environment. Ahn (2008) argued that experiential learning can be characterized as a learning method that involves immersing learners in an environment in which they actively participate in acquiring knowledge. This concept fits with the proposed game in this paper.

SimGame Input Values

Machine Parameters

M/C	Capacity Rate				Maintenance Strategies					
	Fast		Slow		Planned Maintenance			Corrective Maintenance		
	Avg.	Stdev.	Avg.	Stdev.	TBF	TTR Avg.	TTR Stdev.	TBF	TTR Avg.	TTR Stdev.
MC1	0.03	0.002	0.032	0.003	300	30	2	1000	80	5
MC2	0.04	0.003	0.045	0.003	500	35	2	900	75	6
MC3	0.065	0.003	0.08	0.004	400	32	2	600	60	3
MC4	0.06	0.004	0.08	0.004	600	30	2	900	75	4
MC5	0.07	0.004	0.09	0.004	700	40	2	800	70	3

Target Output

Target Output	40000
Target Output Prod. 1	24000
Target Output Prod. 2	16000
Backlog Cost Prod. 1	0.7
Backlog Cost Prod. 2	0.85

Conveyor Parameters

Conv	Conveyor Speed		Maintenance Strategies					
			Planned Maintenance			Corrective Maintenance		
	Fast	Slow	TBF	TTR Avg.	TTR Stdev.	TBF	TTR Avg.	TTR Stdev.
Conv 1	100	90	600	10	2	900	15	3
Conv 2	80	50	600	10	2	900	15	3
Conv 3	70	40	600	10	2	900	15	3
Conv 4	70	40	600	10	2	900	15	3
Conv 5	100	80	600	10	2	900	15	3
Conv 6	80	50	600	10	2	900	15	3
Conv 7	80	50	600	10	2	900	15	3
Conv 8	75	45	600	10	2	900	15	3
Conv 9	100	80	600	10	2	900	15	3

Costs

M/C &Conv	Capacity Rate Cost				Maintenance Cost	
	Fast		Slow		PM	CM
	Fixed	Variable	Fixed	Variable	(MU/Stop)	(MU/Stop)
MC1	10000	2	8000	2.5	500	600
MC2	10000	2	8000	2.5	500	600
MC3	12000	2	8000	2.5	500	600
MC4	10000	2	8000	2.5	500	600
MC5	10000	2	8000	2.5	500	600
Conv 1	10000	2	6000	2.5	500	600
Conv 2	10000	2	6000	2.5	500	600
Conv 3	10000	2	6000	2.5	500	600
Conv 4	10000	2	6000	2.5	500	600
Conv 5	10000	2	6000	2.5	500	600
Conv 6	10000	2	6000	2.5	500	600
Conv 7	10000	2	6000	2.5	500	600
Conv 8	10000	2	6000	2.5	500	600
Conv 9	10000	2	6000	2.5	500	600

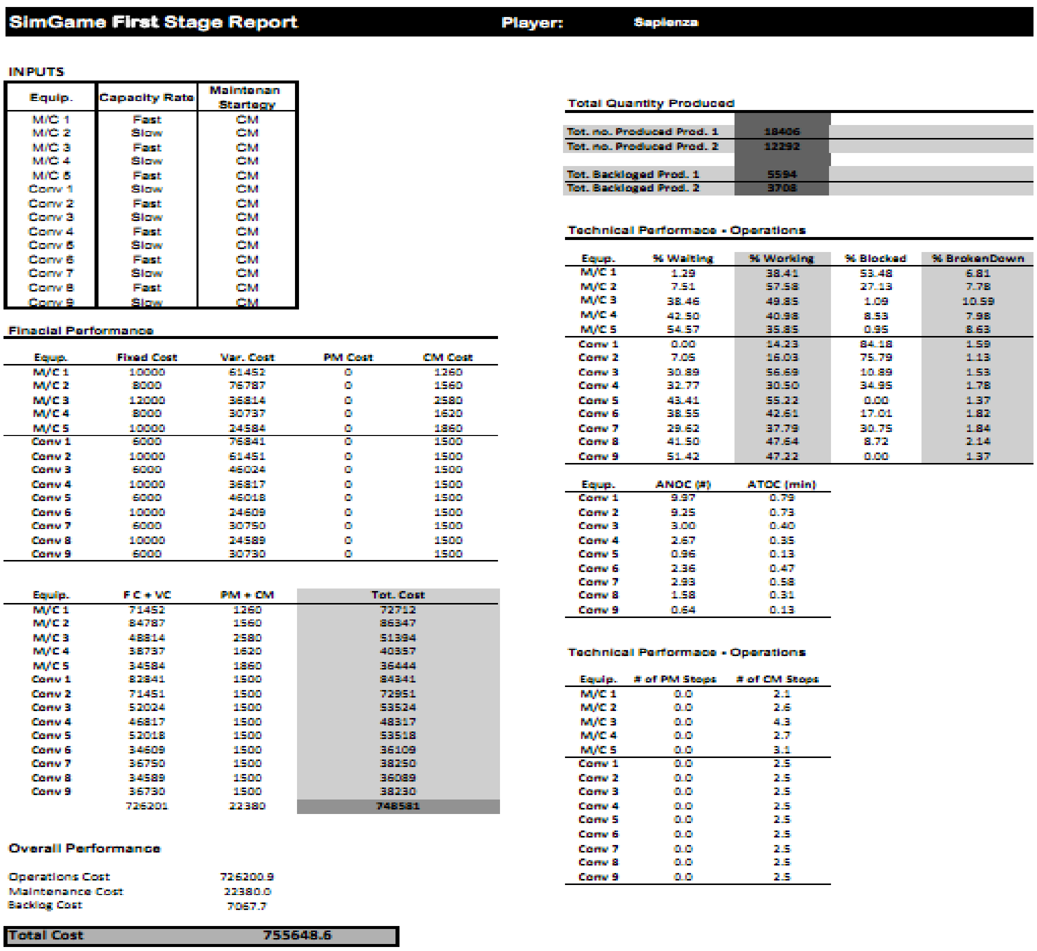
Figure 4: A sample of the information sheet.

The last step (step 3) is similar to step 2 in terms of the required decisions to be made. The players will be asked to change their previous decisions, if they want, in order to improve the performance of the production system, and hence their rank may be improved. The players are not obligated to change the decisions they made, where they can keep their previous decisions made in step 2. At the end of this stage, the administrator announces the final ranking of each team and presents the game winner. A debriefing discussion is conducted after the end of the last step in order to draw the conclusions from the game about the main concepts of the capacity rate, and maintenance strategies. The administrator also discusses with the players their mistakes they made. Normally, this would help the players constitute their own experience and understand the main concepts intended from the game. Additionally, this game realistically allows team members to learn from the mistakes that they may make while playing.

4 GAME EVALUATION

As mentioned earlier, the main objective of the proposed game is to help in teaching OM concepts especially the concepts of capacity utilization and maintenance management. The game goal is to improve and strength the theoretical knowledge that students gain by traditional teaching methods. Therefore, the simulation game should be evaluated in terms of its usefulness and effectiveness for use. It is noticed that the questionnaires are the most common tool to evaluate simulation games. Forssén-Nyberg and Hakamäki (1998) developed a simulation game based on real cases in order to identify the technical and non-technical problems in a production system, and evaluated the game by questionnaires. Similarly, Battini et al. (2010) adopted a set of qualitative measures in a questionnaire form to evaluate the impact of their logistic game and the players' satisfaction with the game. Pasin and Giroux (2011) instead of evaluating a simulated economic performance, they analyzed each of the students' decisions to identify specific technically wrong decisions (mistakes) that their simulation game was intended to reduce. They claimed that this method has never been applied in the field of management.

The adopted methodology to evaluate the proposed game depends on evaluating the progression of students' performance during the playing sessions. Since the game will be played in two turns, the number of mistakes that each team may make in each session will be the basis for the analysis and evaluation of the game. The given decision choices will be including some decisions that have slight differences in their impact on the production system but a significant impact on the system's performance in terms of total cost. This will learn students and professionals how it is important to make the appropriate decision while they are managing their production systems. Therefore, the game could be considered successful if the players succeed to avoid such implanted mistakes especially in the second session of the game. In the first session the players may fall in some mistakes, but it is expected that they will avoid such mistakes in the next sessions especially after they understand the impact of their previous decisions on the production system. Moreover, a new index, named luck index, is under investigation in order to measure if students make their decision by luck or based a scientific methodology. Sometimes students select their decisions by luck without applying what they learnt in class so it is important to classify the successful players from the lucky players. In addition, the participating students in the game will be asked to fill a questionnaire to get their opinion about the game and allow the game's developing team to modify and improve it. In Figure 6, the results of a questionnaire conducted after playing the game shows a positive response to the proposed game and the learning approach. The results in the questionnaire are based on a sample size of 36 students played the game in groups of 3-4 students each.



SimGame First Stage Report — **Player:** Sapienza

INPUTS

Equip.	Capacity Rate	Maintenan Startegy
M/C 1	Fast	CM
M/C 2	Slow	CM
M/C 3	Fast	CM
M/C 4	Slow	CM
M/C 5	Fast	CM
Conv 1	Slow	CM
Conv 2	Fast	CM
Conv 3	Slow	CM
Conv 4	Fast	CM
Conv 5	Slow	CM
Conv 6	Fast	CM
Conv 7	Slow	CM
Conv 8	Fast	CM
Conv 9	Slow	CM

Finacial Performance

Equip.	Fixed Cost	Var. Cost	PM Cost	CM Cost
M/C 1	10000	61452	0	1260
M/C 2	8000	76787	0	1560
M/C 3	12000	36814	0	2580
M/C 4	8000	30737	0	1620
M/C 5	10000	24584	0	1860
Conv 1	6000	76841	0	1500
Conv 2	10000	61451	0	1500
Conv 3	6000	46024	0	1500
Conv 4	10000	36817	0	1500
Conv 5	6000	46018	0	1500
Conv 6	10000	24609	0	1500
Conv 7	6000	30750	0	1500
Conv 8	10000	24589	0	1500
Conv 9	6000	30730	0	1500

Equip.	F C + VC	PM + CM	Tot. Cost
M/C 1	71452	1260	72712
M/C 2	84787	1560	86347
M/C 3	48814	2580	51394
M/C 4	38737	1620	40357
M/C 5	34584	1860	36444
Conv 1	82841	1500	84341
Conv 2	71451	1500	72951
Conv 3	52024	1500	53524
Conv 4	46817	1500	48317
Conv 5	52018	1500	53518
Conv 6	34609	1500	36109
Conv 7	36750	1500	38250
Conv 8	34589	1500	36089
Conv 9	36730	1500	38230
	726201	22380	748581

Overall Performance

Operations Cost	726200.9
Maintenance Cost	22380.0
Backlog Cost	7067.7
Total Cost	**755648.6**

Total Quantity Produced

Tot. no. Produced Prod. 1	18406
Tot. no. Produced Prod. 2	12292
Tot. Backloged Prod. 1	5594
Tot. Backloged Prod. 2	3708

Technical Performace - Operations

Equp.	% Waiting	% Working	% Blocked	% BrokenDown
M/C 1	1.29	38.41	53.48	6.81
M/C 2	7.51	57.58	27.13	7.78
M/C 3	38.46	49.85	1.09	10.59
M/C 4	42.50	40.98	8.53	7.98
M/C 5	54.57	35.85	0.95	8.63
Conv 1	0.00	14.23	84.18	1.59
Conv 2	7.05	16.03	75.79	1.13
Conv 3	30.89	56.69	10.89	1.53
Conv 4	32.77	30.50	34.95	1.78
Conv 5	43.41	55.22	0.00	1.37
Conv 6	38.55	42.61	17.01	1.82
Conv 7	29.62	37.79	30.75	1.84
Conv 8	41.50	47.64	8.72	2.14
Conv 9	51.42	47.22	0.00	1.37

Equp.	ANOC (#)	ATOC (min)
Conv 1	9.97	0.79
Conv 2	9.25	0.73
Conv 3	3.00	0.40
Conv 4	2.67	0.35
Conv 5	0.96	0.13
Conv 6	2.36	0.47
Conv 7	2.93	0.58
Conv 8	1.58	0.31
Conv 9	0.64	0.13

Technical Performace - Operations

Equip.	# of PM Stops	# of CM Stops
M/C 1	0.0	2.1
M/C 2	0.0	2.6
M/C 3	0.0	4.3
M/C 4	0.0	2.7
M/C 5	0.0	3.1
Conv 1	0.0	2.5
Conv 2	0.0	2.5
Conv 3	0.0	2.5
Conv 4	0.0	2.5
Conv 5	0.0	2.5
Conv 6	0.0	2.5
Conv 7	0.0	2.5
Conv 8	0.0	2.5
Conv 9	0.0	2.5

Figure 5: Performance report obtained after the first session.

The game has only been played once as a first test, so the initial results obtained are just about the students' impression about the game (see Figure 6). It is expected to organize well planned official sessions during the next few months in order to collect accurate results and then evaluating the game according to the above mentioned evaluation scheme. The students' impression about the game is that a wrong starting assumptions in the solving process had great effect on the final results, with a good intuition that the more boundaries are established, the more reduced possibility to affect company performances are. The authors, as teachers, appreciated the big involvement of students that the game achieved, with a sincere curiosity and the desire to know more about the topic so to achieve better results. In general, the simulation game will be extended to include other tactical and operational decisions in order to make it close from real life applications. After that, it is supposed to combine this production system in extended supply chain and constituting a more complex game for supply chain students and professionals.

1 = very much disagree 5 = very much agree						
Evaluation Criteria	**Frequency of each rating value**					**Average**
Educational Goals	**1**	**2**	**3**	**4**	**5**	
The game is helpful, and useful for your current course of OM.	0	1	9	19	7	3.9
The game covers important topics in your OM study.	1	0	10	18	7	3.8
The game has increased your knowledge in OM.	0	3	16	10	7	3.6
The game has transefered some practical skills to you.	0	3	4	24	5	3.9
The game would be helpful for your after graduation life.	1	5	14	11	5	3.4
The game is interesting and enjoyable.	0	0	6	11	19	4.4
Game Organization						
The game has been explained well by the game administrator.	0	4	7	12	13	3.9
The game organization is acceptable and well designed.	0	0	8	20	8	4.0
The game is easy to understand and play.	0	2	8	15	11	4.0
The game results are representitative to your decisions.	0	1	8	15	12	4.1
The performance report is easy to read and understand.	0	3	7	13	13	4.0
The time between meeting (decision sessions) is enough.	0	1	4	12	19	4.4
The animation of the simulation model is helpful to the game.	1	1	6	15	13	4.1

Figure 6: The students' impression on the game (rating scale between 1 and 5; 1 = very much disagree and 5 = very much agree; sample size = 36 students).

5 CONCLUSIONS

Teaching of operations management usually depends on using the traditional teaching methods such as lectures, assignments, and case studies. Although these teaching methods are appropriate for the dissemination of theoretical knowledge, they may not be appropriate to transfer practical skills to learners. Therefore, instructors are motivated to adopt new teaching aids to complement those traditional methods. Educational games is one of these teaching aids where games have been revealed to be very useful pedagogical methods for supplementing traditional teaching techniques. Simulation games have been widely used to teach different subjects such as business management, nursing, and medicine. Games and simulations can give students real experiences and make theoretical concepts learned more meaningful. This paper proposed a new simulation game that is directed to students and professionals of operations management. The game basis is a production system that consists of a set of machines, conveyors, and other resources. The players will be asked to make decisions regarding the production system such as capacity selection and maintenance strategy selection. The game structure is designed to be played in two sequential sessions in order to maximize the transferred skills to either the students or professionals of OM. The number of mistakes made during the different steps of decision making is used to measure the impact of the game on the learning process. This game can also be used to show up the impact of changing different parameters on the performance of the production system. Although the game has only been played once as a test, the students showed a positive response to the game and learning through educational games.

The simulation game will be extended to include other tactical and operational decisions in order to be close from real life applications. After that, it is intended to combine this production system in extended supply chain and constituting a more complex game for both educational and research purposes.

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