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Using Simulation Software to Support Learning: Empirical Findings from Teaching Key Supply Chain Management Concepts

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Abstract

Lesson planning is a tough task of teaching. Teachers exploit appropriate techniques for the students to meet goals and objectives that enable learning and meet their different learning styles. Although simulation is a learning technique that has been deemed suitable for educational purposes, teaching is dominated by lectures. In this work, we present the findings of implementing a lesson we planned that employs simulation for teaching key supply chain management concepts. The lesson is based on an exercise that we have designed and developed using a free to use web application. The examined sample refers to eighty three students coming from four Secondary Technical and Vocational Schools in Thessaloniki, Greece with a wide range of ages. The results indicate that the educational intervention had a significant positive effect on students' comprehension on the subject independently of their age, gender, type of school and previous working experience. In addition, findings proved that the education process of supply chain management oriented courses is more valuable when simulation technology is involved. Finally, suggestions concerning features that software must meet to be a modern teaching tool are presented.

JEL Classification: R30, M53.
Keywords: Simulation software, Education, Logistics, Supply Chain Management, Vocational Training, Lesson plan, Effective Learning Styles.

1. Introduction and Related Literature

Lesson planning is a tough, complex and expected task of teaching (Parker et al., 2017; Mutton et al., 2011). Since the late 1970s most of research on lesson planning was either addressed to a practical audience or included 'how to design a lesson-plan' articles, while today's most of work investigates particular educational techniques or subject areas

(Uhrmacher et al., 2013). According to Shen et al. (2007), lesson planning is a primary factor in the quality of a lesson, as it helps teachers set the goals, define the learning objectives, select appropriate techniques and activities for the students to meet goals and objectives, and select proper assessment methods to verify the mastering of students of the new subject (Trim, n.d.). As de Frece (2010) highlights, the key components in a lesson structure are: (a) the anticipatory set that motivates students and connects to past learnings, (b) the development phase, where the new subject is presented, (c) the application phase, where practice takes place and (d) the closure and evaluation phase, where the mastering of the new subject is assessed.

Teachers are encouraged to use Bloom's Taxonomy of Cognitive Processes as a planning tool for their lesson, in order to write objectives using higher level thinking skills (Pedagogyideas.com, 2013). Bloom's Taxonomy consists of 6 levels, namely Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation, regarding learning objectives. Each level is more complex and demands more advanced cognitive skills in the order of Knowledge to Evaluation (Bloom et al. 1956).

Regarding teaching techniques, the most significant, employed also in the context of Secondary Technical and Vocational Education, are: Lecturing, Question posing & Brainstorming, Group Work, Discussion and Debating, Personalized and Programmed Instruction, Case Studies, Roles and Simulations, Research Papers, Visiting Tutors – Lecturers and School Conferences, Use of Manuals and other written material, Business World Ties, Visits to Factors and Field Research (Whitehead and Makridou-Bousiou, 2000). Teachers can teach more effective by exploiting the aforementioned pedagogical alternatives that enable student learning and meet their different learning styles, while covering the curriculum (Grossman 1990; Shulman 1986). In particular, the use of technology in the teaching process can make it more coherent (Hammerness 2006; Trim, n.d.)

The involvement of information technology lends more value to the teaching, offering a lot of opportunities to raise educational experiences and enlarge academic chances. Information technology transforms the role of the educator from being a simple transmitter of knowledge to an associate and organizer of learning, having great potential to create competition among groups of students with a specific target (Warschauer and Healey, 1998), while the classroom becomes a lively environment where learners feel that they are in charge of their education (Dawson et al., 2008).

To that effect, the use of specialized software applications in the educational process must assume a central role. The application of simulation is of particular interest. According to Vratsalis (2002) simulation is "*the construction that depicts, based on some theory, what is real*". In educational process one may define simulation as a software application (usually) that aims to recreate the characteristics of the real world. Simulation is considered to be a key educational tool that allows educators to control the learning environment and adjust its basic parameters depending on the educational objectives and by means of executing or running different scenarios. Tsaboukou-Skanavi (2004) suggest that the goals for simulation in the educational process are: "*1) For students to learn and apply in practice the taught concepts; 2) to train their rational reasoning; 3) to juxtapose their ideas with those by other students and 4) to train them in the decision-making that utilizes all of the above*".

There are many applications of simulation for supply chain problems in literature. One can indicatively cite the research work of Brooks and Tobias (2000), Terzi and Cavalieri (2004), Bruzzone and Williams (2004), Gagliardi et al. (2007), Gopakumar et al. (2008), Jahangirian et al. (2010), Johnson (2011), Ma et al. (2011), Wanhphanich et al. (2010), Chan and Zhang (2011), Hewitt (1997), Alessi, (2000), Cherry et al. (1999), and Rehmann et al. (1995) and

Finke et al. (2012). A common feature of the aforementioned papers is that the simulation software they employ is exclusively used to support decision making by executives of companies and organizations (at strategic, tactical and operational levels through visualizing, understanding and analyzing the dynamics of the supply chain) and not as educational tools and especially focusing on real case studies.

A great work has been made by Feng and Ma (2008) who introduces a simulation game (The Supply Chain Game; an internet based supply network simulator, which was developed by Professors Sunil Chopra and Philipp Afeche at the Kellogg School of Management at Northwestern University and adopted by schools in 2005) for teaching SCM concepts into an undergraduate supply chain management class at an AACSB school. Also, a recent work by Vanany and Syamil (2016) who first propose a simulation game that employs a set of toy building blocks such as LEGO® blocks and has the rules of the game, responsibility of each player, product descriptions and bill of materials. The game is tested by many undergraduate students who are taking SCM and Logistics Management courses. In both papers, the (undegraduate and postgraduate) students who played the games reached the higher scores of assessment testing than students who didn't play the games.

A significant question arising is how can such applications be exploited to the secondary education level and particularly to the Secondary Technical and Vocational Schools (a.k.a. Vocational High Schools). During the last decade many Vocational High Schools have introduced supply chain management courses in their curricula. For example, over the past five years an introductory curriculum has been brought in Secondary Technical and Vocational Schools in Greece trying to link theory with practice in a major business area in Greece. In these courses students learn to use SCM practices and tools, such as Just-In-Time, Vendor Managed Inventory and Demand Forecasting, in many business sectors' problems.

Greek Vocational High Schools offer many different specializations for their students. Courses taught in Vocational High Schools to students of the Economics and Management Department can be divided into three groups. The first includes those courses with a theoretical orientation which, due to their nature, include a large number of calculations, accounting entries etc, while they apply mathematical models. The courses falling in this category include Mathematical Economics, Statistics, Accounting and Supply Chain Management. The second group includes courses with a sociological orientation that focus more on individual and social economic behaviors, such as Public Relations, Civic Education and the Principles of Organization and Management, while the third includes mixed courses that parts of require calculations, data and the application of mathematical methods, while the rest is based on the study of the behavior of individuals, such as the Principles of Economic Theory. For courses with a scientific orientation the use and utilization of computer software and design skills is required and applications like spread-sheets, graphics software, accounting software and databases are common. The courses on Accounting Applications – Computer Accounting and Logistics require the application, use and utilization of professional simulation software, specifically adjusted to the educational process, so that the graduates can be well-prepared and ready to successfully enter the labor market.

Motivated by: (a) the significant role of simulation in learning, as it has been deemed suitable for educational purposes, (b) the recent introduction of supply chain management courses in the curricula of Greek Vocational High Schools, (c) the fact that teaching of economic courses in the examined institutions is dominated by lectures, the purpose of this paper is threefold. First, to demonstrate a comprehensive paradigm of teaching key supply chain concepts through simulation software; second, to accentuate the usefulness, importance and necessity for simulation applications in the educational process through our case study; and third, to capture significant features that software must meet to be a modern teaching tool again through our case study.

More specifically, in our work we: (a) design a lesson plan that employs simulation as its major teaching method for teaching three fundamental supply chain management concepts, namely the Inventory and Demand Management, the EOQ and the Just-In-Time System, (b) design an exercise based on a free to use web-based simulation application, namely 'The Distribution Game', (c) implement the lesson in four Secondary Technical and Vocational Schools in Greece, and (d) investigate and present the findings of our case study. Our investigation is supported by a structured questionnaire we designed and asked students to answer twice; once before playing the simulation game and then after completing the game. The examined sample refers to eighty three students coming from four Secondary Technical and Vocational Schools in Thessaloniki, Greece with a wide range of ages (studying in both morning and evening schools) and focusing in key concepts of SCM.

The rest of the paper is organized as follows: The second part presents the taught key concepts the exercise addresses, the third part formulates the learning objectives and the design and implementation of the case study, while the findings are presented in the fourth part. Finally, all these are followed by discussion of lessons learned and useful insights and conclusions.

2. Concepts Taught

The application of the simulation software is intended for the students to understand the basic concepts of Supply Chain: (a) Replenishment and demand management; (b) Economic Order Quantity and (c) Just-In-Time philosophy.

2.1 Replenishment and demand management

Replenishment includes all actions aimed towards the continuous balance between offer and demand. It is one of the most critical parameters in the total management of market demand and an important "weapon" in the arsenal of every company not only for its survival but also for the acquisition of a considerable competitive advantage. Executives usually rest on historic demand data (sales) while continuously making decisions in the present to deal with demand in real time (when demand transubstantiates into orders) as well as future demand, by means of the short- and medium-term planning of the scheduling for the entire supply chain.

2.2 Economic Order Quantity

A key question of demand management is: "What quantity must a company keep for every code it sells in order to satisfy demand in real time and for the immediate future?" This question is not an easy one. On the one hand, businesses are under pressure to maintain low inventories so that they can reduce the operating costs for maintaining and managing their inventories, while also reducing the risk of their products not been disposed. On the other hand, the same businesses are under pressure to maintain high levels of inventories in order to be able to cater fully and, principally, immediately for market demand. It is well known that in case an order is not satisfied, the customer will simply contact another company. The Economic Order Quantity (EOQ) calculates that quantity which corresponds to the lowest possible cost. This cost includes the cost for maintaining the inventories and the cost for placing orders. There are strict requirements for the application of the EOQ model. Demand must be fixed, there should be no delays in resupply, and there should be no quantity-dependent discounts, while the only costs taken into account are the cost for maintaining the inventories and a fixed cost for every order. Unfortunately, nothing of the above holds in practice. Despite this, EOQ is a useful and easy to apply method for the calculation of the quantities to be stocked as well as of the time orders should be placed.

2.3 Just-In-Time

Just-In-Time (JIT) is a philosophy where inventories are acquired at the moment of demand (in time). The key principles of the JIT philosophy are the following: (1) its main objective is to minimize inventories and reduce all types of waste inside a business and (2) the collection of materials (raw materials and semi-finished products) by suppliers is performed only when they intend to process these materials, namely when there is demand for them (where only the quantity of goods the market demands are produced), while the assembly of the final products is carried out only when these products are to be delivered to customers. This philosophy has been put to wide use by business today for a more efficient and effective management of demand, while quantity is often calculated using the Economic Order Quantity.

3. Teaching Key Supply Chain Management Concepts: A Case Study

The planned lesson is about the three fundamental concepts presented in Section 2, namely the Inventory and Demand Management, the EOQ and the Just-In-Time System. The new material is first introduced and presented and then practiced through a simulation-based exercise we designed. The exercise explores several scenarios, which are scrutinized both separately and comparatively.

3.1 Learning objectives of the lesson

The cognitive objectives of the lesson expect students to: 1) define and describe the three fundamental concepts taught (knowledge and comprehension), 2) apply the concepts taught in real (stochastic) systems (application), 3) make reasonable judgments by comparing and analyzing the examples (analysis), 4) generalize the results of the exercise to draw conclusions (synthesis), and 5) interpret the conclusions, in order to make decisions (evaluation). The psychomotor objectives of the exercise expect students to develop skills for the use of simulation software and, finally, the emotional objectives expect students to develop a positive attitude towards the use of simulation software and realize the importance of decision making. As a result, students succeed to learn experientially using the simulation-based exercise that covers the learning objectives in cognitive, sensory and affective domains (Bloom et al., 1956).

3.2 Brief lesson plan

The lesson has been planned to take place in four parts: (1) introduction, (2) presentation, (3) application and (4) evaluation. At the introductory part, we presented pictures that we found on the internet showing markets with empty shelves, messy warehouses with no free space, overloaded transportation means etc. and then we asked students questions about inventory and demand management.

Having captured their attention, we moved on to the presentation part, where we introduced the new material by giving a lecture and posing questions that lead to a discussion. Specifically, we introduced the three fundamental concepts, namely the Inventory and Demand Management, the EOQ and the Just-In-Time System. It should be noted that the presentation activities intentionally referred only to deterministic inventory systems to make the three fundamental concepts at first easier to understand. Stochastic inventory systems have been then briefly presented, where the behavior of demand and the need to maintain a safety stock were explained in a few words.

After checking comprehension, we asked students to respond to a structured questionnaire we gave them. Then, we moved to the third part of the lesson and asked students to form groups. We described the exercise, defined the rules and after that asked the students to share responsibilities in each group and implement the exercise. Finally, we moved to the last part of the lesson. A summarization of the lesson and a discussion on key issues of the exercise took place in order to investigate the achievement of the objectives of the lesson. Additionally, students were asked to respond again to the structured questionnaire.

The time duration of each activity of the lesson is exhibited in Table 1. Moreover, it should be noted that we followed the systematic process proposed by Scoullos and Malotidi (2004), in order to implement the simulation-based exercise, as it can be seen from the third and fourth parts of the lesson. In particular, the following steps were taken successively: 1) Preparation, 2) Definition and description of the rules of the exercise, 3) Sharing of responsibilities, 4) Implementation of the exercise, 5) Discussion and 6) Summarization.

Table 1: Duration of lesson activities

Activity	**Duration (in minutes)**
(1) Introduction	8-10
(2) Presentation	
(2.1) Lecture & Discussion	43-45
(2.2) Questionnaire	13-15
(3) Application	
(3.1) Preparation	13-15
(3.2) Implementation	55-60
(4) Evaluation	
(4.1) Discussion	8-10
(4.2) Summarization	8-10
(4.3) Questionnaire	13-15

3.3 Design and implementation of the simulation-based exercise

A web-based simulation game, namely 'The Distribution Game', was used to create the exercise. There are many sofware applications available today for the simulation of logistics and supply chain management processes and functions. 'The Distribution Game' was selected, because it is user-friendly, it is running online - via the web, it has simple and very common scenarios and it is highly connected with the corresponding theory. The game is available at http://www.gwylan.info/cp/DistGame/ Distgame.html# and it was designed by Peter L. Jackson and John A. Muckstadt of the Cornell University, USA. 'The Distribution Game' is a simulation game of a distribution system for managing and satisfying random demands at multiple locations. Specifically, the supply chain can consist of a supplier, a central warehouse, a co-located local warehouse and multiple retailers. There are six different scenarios offered. In some scenarios, the central warehouse replenishes its inventories from the supplier and the retailers replenish their inventories from the warehouse, while in others the retailers can be dual sourced both by the supplier and the central warehouse. In addition, there are scenarios dealing only with direct shipping, which means that no central warehouse is included in the supply chain. In all scenarios there are defined means of transportation, such as trucks, airplanes, ships and/or forklifts, that carry orders with defined lead times. The players deal with ordering decisions, i.e. they decide on appropriate order quantities and reorder points for each entity of the network, by controlling shipments from the supplier and/or the central warehouse. The simulation lasts for 200 days and the objective of the game is to maximize the total profit of the network by achieving high order fill rates, while avoiding sales losses and excessive inventory holding costs.

Since the game parameters regarding costs, lead times and demand distributions are defined for each scenario, we were able to determine the economic order quantity (EOQ) and the reorder point for each entity in each scenario. In addition, we were able to exploit these results in order to set and investigate alternative ordering policies. In our exercise we decided on working with the first two scenarios: a) the 'Direct Ship – No Central Warehouse' scenario and b) the 'Base Game – Central Warehouse' scenario. These scenarios deal with common simple supply chain networks. Specifically, in the first scenario, there is no central warehouse and the three retailers replenish their inventories directly from the supplier, while in the second scenario, the central warehouse replenishes its inventories from the supplier, while the three retailers replenish their inventories from the warehouse.

3.3.1 'Direct Ship – No Central Warehouse' scenario

In this scenario there is a single supplier who replenishes the inventories of three retailers. Each retailer starts with an initial inventory of 45 units and faces a mean demand of 2 units per day. The demand coefficient of variation is equal to one for all retailers. The trucks need 18 days to satisfy an order. Taking into account the defined cost parameters, we calculated the economic order quantity (EOQ) and the reorder point. Regarding the latter, we increased the average lead time demand by an empirically determined safety stock to avoid sales losses due to the random demand. Both the EOQ and the reorder point are the same for each retailer. Exploiting these calculations for introducing EOQ to the students, we set three different ordering policies for the learners to investigate:

- *The single shipment policy:* We used the calculated reorder point and set the level of the order quantity so that only one shipment of inventories is required. We expect the learner to record low order costs, availability of stock at all times and high inventory holding costs.
- *The optimal policy:* We set the economic order quantity (EOQ) and the calculated reorder point and expect the learner to capture tradeoffs between order and inventory costs.
- *The Just-in-Time policy:* We used the calculated reorder point and set the level of the order quantity so that a JIT system is implemented. We expect the learner to record low inventory holding costs, high order costs and the higher probability of stock-out events compared to the other two policies.

Students were then asked to play the game 3 times; once for each of the alternative policies. After each game, they were asked to fill in Table 2 using the results announced at the end of the game. After that, the students were encouraged to answer specific questions. Particularly, the instructions and requests for the exercise were as follows:

Start with the first scenario, namely the 'Direct Ship - No Central Warehouse' scenario. Play the game for 200 days three times, once for each of the three proposed policies, and fill in Table 2 by entering the results announced at the end of each game.

- A1 Policy: *'Order 400 units when the inventory position of each retailer reaches or is reduced to less than 38 units'*.
- A2 Policy: *'Order 129 units when the inventory position of each retailer reaches or is reduced to less than 38 units'*.
- A3 Policy: *'Order 38 units when the inventory position of each retailer reaches or is*

reduced to less than 38 units'.

Table2: Results matrix

	Policy					
	A1	A2	A3	B1	B2	B3
Sales						
Cost of goods sold						
Gross Margin						
Order costs						
Inventory costs						
Operating profit						
Daily profit						
Order fill rate						

Then, answer the following questions:

- What are the strengths and weaknesses of each policy?
- What are your conclusions from comparing the cost elements of each policy?
- What are your conclusions from comparing availability of stock of each policy?
- What are your conclusions from comparing the total profit of each policy?
- If you were the decision maker, what policy would you choose and why?

By playing the games and completing Table 2, the students essentially identified the strengths and weaknesses of each policy. More specifically, for A1 policy, the low order costs and the availability of inventory at any given moment have been pointed out as beneficial. On the other hand, students highlighted the high inventory holding costs and the lower net profit as disadvantages of A1 policy. In A2 policy, students identified the EOQ policy at first and then identified as an advantage the achievement of the optimal total profit. Additionally, they highlighted the achievement of the optimal total cost while fully satisfying demand. Disadvantages have not been identified, while students captured the tradeoffs between order and inventory costs and commented that the optimum total cost is achieved by a mixture of a "moderate" order cost (greater than A1 policy and lower than A3 policy) and a "moderate" inventory holding cost (lower than A1 policy and greater than A3 policy). In A3 policy, students identified the JIT philosophy. In addition, they highlighted the low inventory holding costs and the low capital investment in capture as the advantages of the policy. On the other hand, the high order costs and the large number of shipments were pointed out as disadvantages. Furthermore, the students captured the higher probability of stock-out events compared to the other two policies. As a result, students have chosen A2 policy as their optimal pointing out the optimal total profit combined with a high fill rate.

3.3.2 'Base Game – Central Warehouse' scenario

In this scenario there is a central warehouse that replenishes its inventories from a single supplier and three retailers who replenish their inventories from the central warehouse. According to the game parameters, each retailer starts with an initial inventory of 20 units and faces a mean demand of 2 units per day. The demand coefficient of variation is equal to one for all retailers. The trucks need 5 days to transit an order from the warehouse to each retailer. Additionally, the central warehouse starts with an initial inventory of 120 units and the truck needs 15 days to deliver an order from the supplier to the warehouse.

Taking into account the defined cost parameters, we calculated the economic order quantity (EOQ) and the reorder point for the warehouse and for each retailer and used this scenario to introduce the safety stock issue to the students. Again, each reorder point was calculated by increasing the average lead time demand by an empirically determined safety stock. It should be noted that we estimate the safety stock empirically, because at this stage we do not aim to present or assess the alternative estimation methods, but we intend to highlight the significance of safety stock in managing stochastic inventory systems. Since all retailers are characterized by the same demand and cost parameters, both the EOQ and the reorder point calculated regarding the lowest echelon of the supply chain are the same for each retailer. As previously, we set three different ordering policies with regard to the retailers for the learners to investigate:

- *The no safety-stock policy:* We set the economic order quantity. In addition, we set the policy reorder point to be equal only to the average lead time demand, i.e. we subtracted from the calculated reorder point the safety stock. We expect the learner to record the multiple stock-out events.

- *The increased order quantity policy:* We set an increased order quantity compared to the EOQ, while still using the average lead time demand as the reorder point and expect the learner to record that the stock-out events have not been tackled.

- *The increased reorder point policy:* We set back the economic order quantity and now use the calculated reorder point, which means that we now take safety stock into account. We expect the learner to record that the problem of stock-out events has been addressed.

It should be noted that in all three policies, we set the calculated economic order quantity and the calculated reorder point for the warehouse, regarding the replenishment policy of the central warehouse from the supplier.

As before, students were asked to play the game 3 times; once for each of the alternative policies. After each game, they were asked to fill in Table 2 and answer specific questions. Particularly, the instructions and requests for this exercise were as follows:

Go on with the second scenario, namely the ‘Base Game – Central Warehouse’ scenario. Play the game for 200 days three times, once for each of the three proposed policies, and fill in Table 2 by entering the results announced at the end of each game.

- B1-B3 Policies: *‘Order 244 units when the inventory position of the central warehouse reaches or is reduced to less than 96 units’* and:

- B1 Policy: *‘Order 15 units when the inventory position of each retailer reaches or is reduced to less than 10 units’*.

- B2 Policy: *‘Order 25 units when the inventory position of each retailer reaches or is reduced to less than 10 units’*.

- B3 Policy: *‘Order 15 units when the inventory position of each retailer reaches or is reduced to less than 15 units’*.

Then, answer the following questions:

- What is the B1 policy issue?
- Is the higher order quantity (B2 Policy) a good solution?
- Is the higher reorder point (B3 Policy) a good solution?
- If you were the decision maker, what policy would you choose and why?

By playing the B1 policy game, students faced a crucial problem. Although they confirmed using EOQ as the order quantities for both warehouse and retailers, the students identified an undesirable response from the system. In particular, they encountered many stock-out events at the lowest level of the supply chain and, therefore, noted a low demand fill rate. Some of them ruled that EOQ is not suitable for stochastic demand; others questioned its calculation and rushed to verify it, while few were concerned about how the reorder point was set. Then, following B2 policy, students concluded that there was no significant improvement either in net profit or in demand fill rate. In addition, they pointed out the lead time demand as a critical factor and correlated the average lead time demand with the inventory held during that period (reorder point). In policy B3, students confirmed the above conclusion and found that the low fill rate problem can be solved, if the reorder point is not only determined by the average lead time demand but is increased by a safety stock. At the same time, they recorded a higher net profit while fully satisfying demand. Regarding the last question, students assessed B3 as the best policy, concluding that a higher reorder point can cope with demand variability.

3.4 Questionnaire

As stated earlier, the students were asked to respond to a questionnaire twice; once before playing the simulation game and then again after completing it. We used the answers of students to investigate the impact of the educational intervention on their understanding on the subject of the three fundamental concepts taught.

The questionnaire consists of 26 questions that test the fulfillment of the learning objectives in the cognitive and affective domains. In particular, there are ten questions checking students' comprehension of the three taught concepts, four questions investigating whether students could make reasonable judgments by comparing and analyzing the different applications of the taught concepts, four questions checking whether students could generalize the results of the exercise to draw conclusions, four questions checking if students were able to interpret the conclusions, in order to make decisions, and four questions checking if students realized the importance of decision making.

4. Findings

The data collection was carried out at the school year 2016-2017. Eighty three students participated in the study, 37 male (44.6%) and 46 female (55.4%), attending Vocational High Schools operating in the morning (55, 66.3%) or in the evening (28, 33.7%). All the students that were attending morning lessons were aged 15 to 24. On the other hand, the majority of the students in the evening school were female (21, 75%), over 25 years old (26, 92.9%) Thirty seven of the students (44.6%) had working experience and the majority of them (34) were attending morning lessons. The sample demographics are presented in Table 3.

4.1 Statistical analysis

All data were analysed using predictive analytics software (SPSS), version 20 (SPSS Inc., Chicago, IL, USA). Students' comprehension in Logistics and SCM theory was quantified as the difference of the correct and wrong answers in the 26 questions in the supplied questionnaire, while the number of non-filled questions was considered to be a measure of students' self-confidence in answering questions on Logistics and SCM. The distribution of the comprehension index was approximately normal and no significant outliers were presented (Figure 1) thus the parametric method of repeated analysis of variance (Repeated ANOVA) was applied in order to investigate whether the educational intervention had a significant change in the student's comprehension. On the other hand, since the distribution of the self-confidence index was non normal but symmetrically shaped (Figure 2), the Wilcoxon signed rank test was applied. Spearman's rho was reported in order to demonstrate the relationship between the two measurements for both indexes. A two sided level of significance was set at 0.05 for all statistical tests.

Table 3: Sample demographics

Factor		N (%)	
Gender			
Male		37 (44.6%)	
Female		46 (55.4%)	
Age			
15-24		57 (68.7%)	
	25-34		5 (6%)
	35-44		7 (8.4%)
	45-54		12 (14.5%)
	>55		2 (2.4%)
>25		26 (31.3%)	
Type of Vocational High School			
Morning		55 (66.3%)	
Evening		28 (33.7%)	
Experience			
Yes		37 (44.6%)	
No		46 (55.4%)	
Total		83 (100%)	

Figure 1: Comprehension index distribution before and after the educational intervention

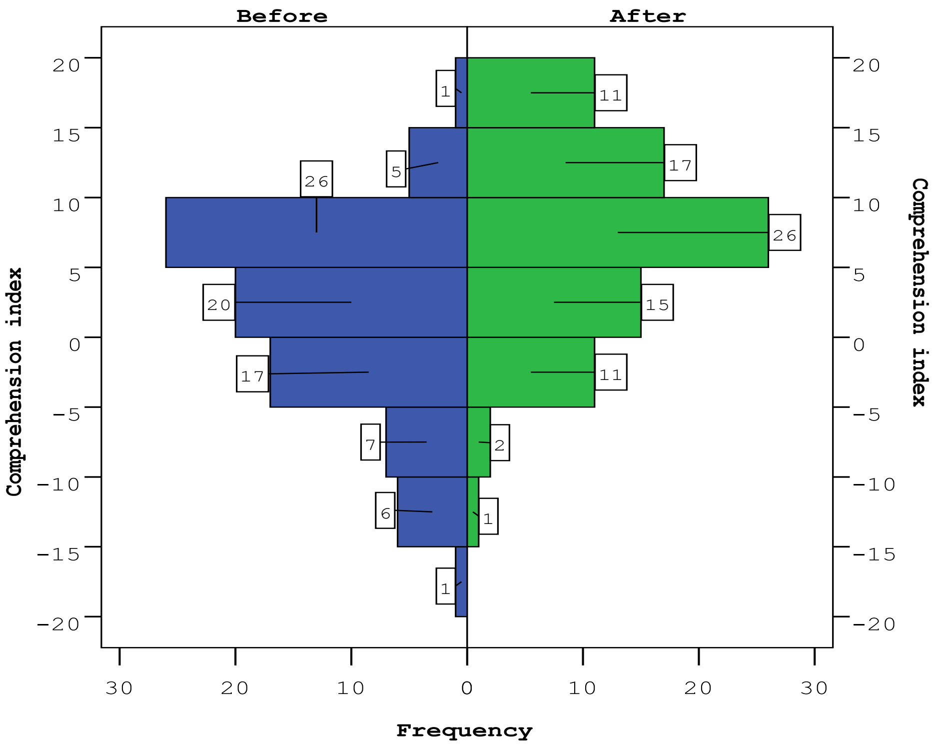
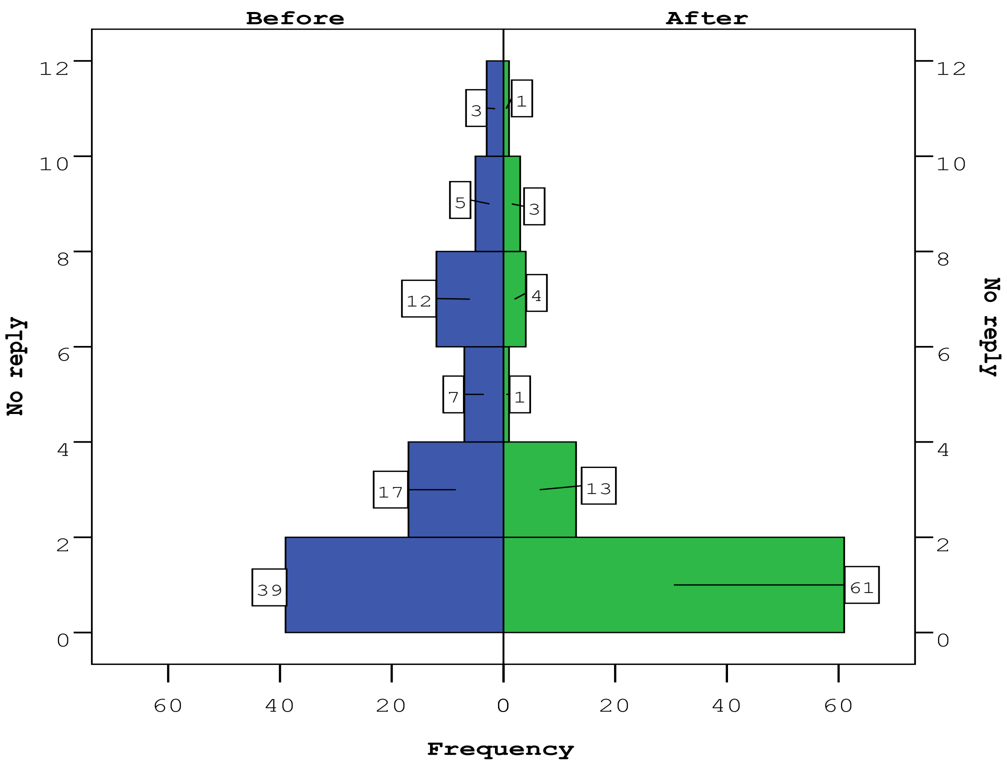


Figure 2: Confidence index distribution before and after the educational intervention



4.2 Results

Before the intervention the mean difference of correct minus the incorrect answers was 1.6 (SD = 6.9), and the mean number of non-replied questions was 2.9 (SD = 3.1). After the intervention the comprehension index was 6.7 (SD = 6.9) while the mean number of non-replied questions was 1.4 (SD = 2.4) (Table 4).

Table 4: Comprehension and self-confidence before and after the intervention (Mean, SD*)*

	Before	After	Spearman's ρ
Comprehension Index(1)	1.6 (6.9)	6.7 (6.9)	.648
Correct answers	13.3 (3.4)	15.9 (3.4)	
Incorrect answers	11.7 (3.4)	9.1 (3.4)	
Self-confidence Index(2)	2.9 (3.1)	1.4 (2.4)	.397

(1): Difference of correct minus incorrect answers
(2): Number of non replied questions

Repeated analysis of variance (Repeated ANOVA) was conducted to explore whether gender, age, work experience and type of vocational school had an effect on the students comprehension. The linear model consisted of the main effects of gender, age, work experience and type of vocational school as main effects, as well as all possible two way interactions between them and the time factor. It was found that there was a significant effect of time on the comprehension index ($F(1,78) = 53.685$, $p < .001$, $\eta^2_p = .408$) (Table 5). Concerning student confidence in answering the supplied questions, a Wilcoxon signed rank test indicated that the number of empty questions after the intervention was statistically significant lower than before the intervention ($Z = 4.909$, $p < .001$).
The above results suggest that the educational intervention really did have a positive effect on students understanding on the subject of Logistics and SCM.

Table 5: Tests of Within-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	p	η^2_p
time	849.565	1	849.565	53.685	.000	.408
time * gender	17.973	1	17.973	1.136	.290	.014
time * age3	11.672	1	11.672	.738	.393	.009
time * experience	4.528	1	4.528	.286	.594	.004
time * epal	31.518	1	31.518	1.992	.162	.025
Error(time)	1234.351	78	15.825			

5. Discussion of findings / Conclusions

Lesson planning is a tough task of teaching. Teachers utilize educational techniques for the students to meet goals and objectives that enable learning and meet their different learning styles. In particular, the use of information technology lends more value to the teaching and offers a lot of opportunities to raise educational experiences. In addition, over the past five years, Secondary Technical and Vocational Schools in Greece have introduced supply chain management courses in their curricula. In these courses students learn to use SCM practices and tools, such as Just-In-Time, Vendor Managed Inventory and Demand Forecasting, in many business sectors' problems. The implementation and use of educational-professional simulation software in the teaching of such courses renders the teaching more effective, efficient, interesting, less boring, more engaging and certainly more focused, rich and substantial. However, despite the fact that simulation is one of the multitude of learning techniques that have been deemed suitable for educational purposes, teaching in the Secondary Technical and Vocational Schools in Greece is, on the one hand, dominated by lectures and, on the other hand, simulation software are employed in the literature to support executive decision making and not as educational tools.

In this paper, we demonstrated a comprehensive paradigm of teaching key supply chain concepts through simulation software and presented the findings of its application in four Secondary Technical and Vocational Schools in Greece. Specifically, we: (a) designed a lesson plan that employs simulation as its major teaching method for teaching three fundamental supply chain management concepts, (b) designed an exercise based on a free to use web-based simulation application, (c) implemented the lesson in four Secondary Technical and Vocational Schools in Greece, and (d) investigated and presented the findings of our case study.

The contribution of this paper lies in the demonstration of a comprehensive lesson plan teaching crucial concepts for the understanding of SCM by employing a freely available for use simulation software and utilizing it as an educational tool. By means of clear and structured guidelines and instructions, we directed students to become involved in an organized simulation 'game', which introduced them to the taught concepts in a pleasant and entertaining way. Moreover, our work achieved to accentuate the utility, importance and necessity of simulation software applications in the teaching process, thus demonstrating that learning can be substantial and meticulous, while at the same time being entertaining and pleasant. During the educational game, students worked on the activity while cooperating with their peers, with the continual interchange of skills, mutual guidance related to computers and the role of students as tutors (Groff and Mouza, 2008), thus attaining its cognitive, emotional and psychomotor goals.

Findings proved that the education process of supply chain management oriented courses is more valuable when simulation technology is involved in alignment with the researches by Feng and Ma (2008) as well as Vanany and Syamil (2016). Specifically, in this study the results indicate that the educational intervention had a significant positive effect on students' comprehension on the subject of Logistics and SCM as well as on students' confidence in answering the supplied questions independently of their age, gender, type of school and previous working experience.

Through our work, we also verified empirically that simulation application technology transforms the role of the educator from a simple knowledge transmitter to a collaborator and learning organizer, since it supports the transmission of knowledge in a clear, practical, effective and acceptable way. However, in order to achieve more effective integration of simulation software applications in teaching practice, there is also a need for better coordination of the various training activities, review of curricula, creation of appropriate educational software with parallel development and teaching material. As Dimitrakopoulou (2002) argue such an integrated approach requires coordinated actions that are part of an educational planning with clear and explicit objectives and are accompanied by specific support measures that facilitate and activate teachers. In particular, concerning teachers' ability to support computer assisted educational activities, previous training is a crucial factor towards the success or failure of the learning activity in a computer-mediated learning environment (Hampel & Hauck, 2006).

Additional findings and suggestions that emerge from this research focus on the effectiveness of the use of the simulation softwares for a supply chain course, capturing those features that software must meet to be a modern teaching tool. For example, in general, the software must be user-friendly (that does not require technical background of the user) with flexible and functional interface, should have the ability to measure the performance of the students and provide the analysis of their errors and omissions. Furthermore, it must provide the specific and dynamic nature of the targeted business environment, monitor and record the various logistics events and prepare the students for the real life business arena.

Regarding limitations, it should be noted that the educational intervention could have been more successful if implemented by the students' teachers, since learners met us for the first time and there was no time to build the optimum classroom environment and a relationship of trust between us. Finally, regarding future research, we intend to develop more lesson plans that focus on SCM concepts and practices and employ simulation applications as educational tools.

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