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Active Learning in Supply Chain Management Course

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Abstract

This paper presents an active learning approach implemented in the Supply Chain Management (SCM) course. In this course, the fundamentals of supply chain and logistics, drivers of supply chain performance and analytical tools necessary to develop solutions for a variety of supply chain design problems are covered through class lectures and case study discussions. In the past few years, due to the growth in the needs of organizations for "Lean" principles, the course was modified to satisfy this requirement more efficiently. For this purpose a hands on experience workshop, TimeWise simulation game, was utilized where the students could physically simulate the implementation of lean principles in a supply chain network. Through this simulation, students explored the impact of various lean tools such as Kanban, pull and just-in-time production systems, and flow management in a dynamic supply chain. In addition, this game empowers the learners with a better understanding of the fundamental concepts of a collaborative supply chain such as demand management, inventory management, role of information system and coordination, transportation, finance and accounting. The implemented simulation game could enhance material retention and foster critical thinking among the students by increasing visibility and illustrating the concerns of any supply chain. Moreover, several directed presentations by speakers invited from diverse industries and ISM (Institute of Supply Chain Management) were arranged to expose the students to some real case studies. To assess the effectiveness of the course modules and applied pedagogical methods, and measure learning satisfaction, a survey is conducted to evaluate the effectiveness of each instructional tool, students' perception of knowledge and satisfaction in this course and the results are analyzed.

I. Introduction

Supply Chain Management (SCM) as a graduate level course was offered by the Industrial and Manufacturing Engineering Department as well as the School of Business at Wichita State University. Both courses covered almost the same concepts from different perspectives and detail levels. Based on the catalog description, understanding the elements of business logistics,

logistics applications in supply, demand and value chain management, quantitative and qualitative techniques in design and management of the supply chain, inventory management techniques, risk pooling as well as general concepts of the integrated decision support systems in a supply chain constitute the main learning objectives of this course.

The goal of this paper is to share the findings and lessons learned from the practices applied in the SCM course taught in the department of Industrial and Manufacturing Engineering as well as the School of Business. Previously, classroom PowerPoint presentations, covering the text book material, were the main instructional tool in both SCM classes, and the significance of lean thinking in supply chain was not included in the course lectures. After course restructure in both departments, the proposed framework is mainly composed of the class lectures, case study analyses, talks presented by the invited guest speakers from industry as well as some introduction to SAP software. To enhance the learning process, TimeWise simulation game is also integrated in the course to explore the application of lean concepts in supply chain networks. In this study, two questionnaires are designed to assess the effectiveness of each instructional method per topic based on the learners' attitudes. In addition, in this study we are interested to investigate if the students' background in each semester is influencing their attitude in evaluation and ranking the educational modes. At the end, some recommendations are given to improve the quality of the course.

In the past few years, the benefits of lean principles in reducing waste and increasing system's performance and throughput are gaining more importance. These facts along with potential dollar savings in competitive markets make inclusion of lean concepts into the supply chain management course a necessity. Moreover, the ability to implement lean tools in industries and organizations is turning to be as one of the key enablers and required skills in the job market for the graduates. Review of the posted syllabus contents for supply chain management courses from different schools indicate that in large number of the supply chain management courses, the role of lean techniques in supply chain courses is either ignored or not well emphasized.

The Lean Enterprise Institute founded by Womack[1] (1997) is aiming at developing educational methods and workshops to promote training about lean tools. Nontraditional instructional methods such as learning-by-doing methods, active and collaborative learning techniques are getting more popular in the past few years. This trend is mostly reflected by introducing various physical simulation or computer games (gamification) and is growing rapidly due to their positive impact on learning process [1, 2]. The literature study illustrates a large pool of educational simulation games targeting different lean concepts and principles such as pull production, one piece flow, Jidoka, 5S, Poka Yoke and waste elimination. TimeWise simulation, Veebots Simulation, Hands on Lego Model Base Simulation, 5S Simulation, Box Game Simulation, Lean Enterprise Value Simulation, Lean Lego Simulation, Lean Leap Logistics Game, Paper Airplane Simulation are some of the examples of the lean educational tools in the literature [3-10].

Hands-on-experience learning is considered as one of the most effective educational methods [11]. This fact is very important, especially since various students have diverse schemas, learning styles, and background knowledge. In order to address learners' diversity and ensure the retention of material in the SCM course, the authors chose the TimeWise simulation game, developed by the Manufacturing Extension Partnership, Management Service Inc. (2001). Using this game, students have the opportunity to physically implement and analyze the impact of diverse lean tools such as pull production systems, Just in Time system, Kanban, flow creation and leveling methods in the supply chain. The logic of selecting this simulation game among the other available packages is that this game not only addresses major lean principles, but also illustrates the domino effect of the associated decisions from a network perspective, and demonstrates a clear picture of the interactions among supply chain components, which makes it more suitable for a supply chain management course.

In addition to the TimeWise game, the instructor administered several directed talks presented by the invited guest speaker from industry with the help of the Institute of Supply Chain (ISM) on relevant topics in order to expose students to real-life challenges that supply chain managers and coordinators are dealing with. These practices were implemented along with class lectures and

[1] http://www.lean.org/

case studies analyses. Also, the application and logic behind SAP software application was explained to the students as part of the course syllabus, however, not a significant class time could be devoted to cover the details in depth due to lack of time. This was not considered as a significant issue from the instructors' opinions as the course was offered at the graduate level and students represent higher degree of maturity and responsibility. Students were provided with all the sufficient SAP software manual as well as one example problem that was assigned as a term project.

For Grading purposes, SAP Project constitute 10% of the overall grade, and on average case study analysis, exam(s), quizzes, class discussion and homework include 20%, 40%, 10%, 10% and 10% of the term grade, respectively.

II. Simulation game

The goal of the instructors in this study was to integrate lean concepts into the supply chain management course and facilitate better understanding of the course material for the students. As described earlier, evaluating literature and analyzing the benefits of the other existing games, TimeWise Simulation was selected as the supplementary pedagogical tool. This round-based physical simulation was implemented as an accelerated 8-hour learning workshop; however, it can be divided into smaller sessions per round.

The simulation runs with a minimum of 18 students and the number of participants can increase up to 28. A large classroom at the approximate size of 30x50 feet, equipped with a projector, laptop, big tables and chairs is required to implement the game. once all the equipment are set up, two faculty or trained assistants are required to run the game and answer possible questions as the game develops.

In this role-playing simulation, students work in groups and each student can play different roles in each of supply, manufacturing or support domains in a clock assembly company. The game initially starts with a "business as usual" scenario in the first round where the supply chain is suffering from long lead time and high levels of inventory. The simulation runs in total of three predefined rounds of 15-minute and in the last two rounds, students utilize several given lean tools to improve the initial scenario as summarized below:

- Round 1: This round is a push supply chain where all the companies in the supply chain manufactures with respect to a forecast in large batches. The supply chain is not synchronized and optimized. As a result, there are several inefficiencies which result in huge inventories, and late delivery of products to customers. This round provides a baseline in terms of the performance measures

- Round2: In round2, Just in Time (JIT) and KANBAN concepts are introduced to most of the supply chain. As a result, the supply chain becomes a pull system, which reacts to demand in real time while making production decisions. The expectation is lowered inventory levels, higher inventory turnover ratio and timely delivery of orders.

- Round 3 implements the pull system throughout the supply chain, and utilizes less than truck load logistics operations to optimize minimal sized batched JIT production. In addition, production scheduling at the manufacturing plant is made intelligently to react to the demand in a timely manner. These improvements have significant impact on all performance measures.

At the beginning of each round, job descriptions are provided for each role to the students and goals are explained by the instructor. The rounds and improvement tools are predetermined and fixed. Once the students utilized lean tools in the last two runs and collected information, they will be able to compare the recorded performance metrics data such as number of delayed orders, inventory level, lead time, cash flow, and throughput. The collected data empowers the learners to observe partial improvements throughout the network and recognize the impact of each lean principle in the supply chain. At the end of each round, students discuss the lessons learned and propose recommendations for system improvements in a debriefing session. The improved scenarios indicate the status of on time delivery, reduced variation and operational expenses, lower inventory levels, improved product quality, and increased productivity, revenue, and available capacity [12].

The designed network in this game considers a low-volume high-mix product supply chain and includes four different customers, six suppliers and a manufacturing facility, which in turn includes production planning and accounting departments, warehouse and factory area. The customers, manufacturing company and suppliers are connected via two different truck line systems. The flow of information such as customer and supplier orders, invoices and payments is managed by an information network. The students can take any of these roles and switch between rounds.

III. Simulation requirements

One of the challenges in implementing this simulation learning tool is the long setup time of the stations and equipment. If there is a possibility to keep the setting in a room for a few days/weeks, then the simulation can be implemented in several sessions or be repeated to allow the students take various roles in the supply chain and enhance the learning process. The other downside of this game is the relative large number of participants which makes it difficult for implementation in courses with small enrolments. Besides the pedagogical benefits of this game, one-time initial cost can be named as the other advantage, such that once the game is purchased, it can be used unlimited times with no restrictions o extra costs for the students or school.

IV. Simulation game learning effectiveness and challenges

The implemented TimeWise simulation game is a combinatory non-traditional teaching practice and combines most of the benefits of the new instructional approaches simultaneously. The TimeWise simulation game is:

- A collaborative learning method that students are working in groups with common objective of demand satisfaction [13]
- A role-playing learning method that students are playing various roles such as supplier, manufacturer, transporter, customer, information carrier, accountant, production controller, etc in the supply chain network
- An active learning strategy that students are engaged in each round and game is executed by the learners

This game increased the visibility of a dynamic supply chain and students could directly observe and practice the impact of pull systems, leveling, one-piece-flow, JIT and Kanban systems on supply chain productivity and profitability and market status, and examine the results of lean tools on material, cash and information flow in a collaborative supply chain network. The learning outcomes of each round can be summarized as follows:

- First round which is a make-to-plan (push) scenario illustrates the impact of push system on inventory, service level and operational expenses.
- In the second round, students practice a replenish-to-order supply chain, where the pull system is established to reduce lead time and operational costs. As a result of this scenario students recognize overproduction, extra inventory, cost of poor service and unnecessary transportation as types of wastes which need to be removed via an optimized flow of information, material and cash.
- During the third round, students practice leveling and postponement method with flow and pull systems aiming at increasing the pace of value stream and flexibility (agile production system) in a build-to-demand setting.
- At the end of the simulation, all the recorded information from each round are combined and presented via score board to flourish the students' understanding about the impact of improvement techniques on various metrics (finished good inventory, WIP, revenue, late deliveries, financial ratios, …).
- The learners could experience the inherent frustrations involved in any supply chain and explore the complexities involved in each component of the supply chain.

Besides the technical aspects, this practice provides an opportunity to improve teamwork skills, where the students play different roles in a supply chain network to design, produce and deliver a product to the final customers.

Timewise Simulation is more appropriate for the class sizes of 18 to 28 students. It can be a challenge for the instructors, especially for smaller size classes. If there are less than 18 students enrolled in the class, the instructors might need to seek the help of their teaching assistants or other students to fill the vacant roles in the supply chain network. In case of exceeding the size of

28, several students can take a given role simultaneously, which might lead to a confusion among the learners. The other challenge implementing this simulation is the relative long setup time and the learning curve for the instructors in the first few attempts of implementing the game. Therefore, creative game modifications by the instructors are not recommended during the first simulation runs. Before running the game, it is very critical that the instructors clarify the learning objectives of the game to help the students understand and contribute to the simulation.

V. Data analysis

To assess the students' perception of knowledge acquired during the supply chain course and evaluate the effectiveness of the simulation game on relevant topics, two questionnaires were developed. The first questionnaire (pre-assessment) was given to the students before the simulation game and the second questionnaire (post- assessment) was distributed after the game implementation. In addition, students were asked to evaluate the effectiveness of the other instructional modules (class lecture, guest speaker presentations, class note, SAP, case study, text book material) for each of the covered topics. IRB approval from Wichita State University was obtained before the questionnaires were distributed. The presented analyses in this study reflect the collected data from Spring 2010 (industrial engineering major), Spring 2012 (industrial engineering major), Fall 2012 (business major) and Spring 2014 (industrial engineering major) semesters.

In the pre-assessment questionnaire (see Appendix 1) which was distributed early in the semester, students were asked to evaluate their knowledge level of 22 fundamental concepts in the supply chain. In the post-assessment questionnaire, they re-evaluated their developed knowledge level on those concepts. As the data was collected from business and engineering classes, initially to remove a probable bias from the analysis, students' background knowledge was studied. For this purpose, the average percentage of the students in each class who believed their initial knowledge on the above 22 concepts is scored 4 and above (to fairly large extent and more) was calculated for each of the semesters (see Table 1-Second column). To compare four proportions, a chi-square test of hypothesis was conducted at 95% confidence level to test H_0: the average percentage of the students in each term who believed their initial knowledge on 22 fundamental SCM concepts is scored 4 or more, vs. H_1: at least one percentage is different. The test results show no significant difference between students' background on the above concepts in different terms (p-value: 0.28> α= 0.05), based on students' self-assessment. In other words, at 95% confidence level, there is no statistically significant difference between engineering and business major students' background knowledge. The examination of the post-assessment (See Table 2, third column) data to test H_0: the average percentage of the students in each term who believed their developed knowledge, as a result of simulation, on 22 fundamental SCM concepts is scored 4 or more, vs. H_1: at least one percentage is different, gives p-value: 0.054 which is slightly greater than α= 0.05, where Marascuilo procedure shows a small difference between Spring 2010 and Spring 2014 (|Spring 2010- Spring 2014|= 0.45> critical value=0.41). As a result, it seems reasonable to conclude that the average percentage of business and engineering major students, who believed simulation helped them develop their knowledge on the 22 illustrated topics to a fairly large extent or more, is identical for all the semesters. In other words, the participants with different majors represent the same opinion about their developed level of knowledge using the simulation game.

Table 1. students' perception of initial knowledge at the beginning (pre-knowledge) and developed knowledge based on simulation only (post-knowledge)

	sample size	Pre-knowledge level>=4	Post-knowledge level>=4
Spring 2010	30	7%	37%
Spring 2012	22	23%	41%
Fall 2012	25	16%	56%
Spring 14	11	27%	82%

In spring 2014, 11 out of 18 students completed both the pre and post assessment questionnaires, and as part of the analysis they assessed the impact level of each course module from their own perspective based on a 7-point evaluation scale, ranging from zero for not being helpful at all to 6 referring to be helpful to a great extent. Students were also asked to rank these modules from 1 as the most helpful and 7 as the least helpful educational method. The results of the analyses of the collected data consistently indicate that students found the simulation game, guest speakers, case study analysis, class lectures by instructor and text book supplementary material as the most effective modules in the given order. The results of this analysis are summarized in Table 2 and Figure 1.

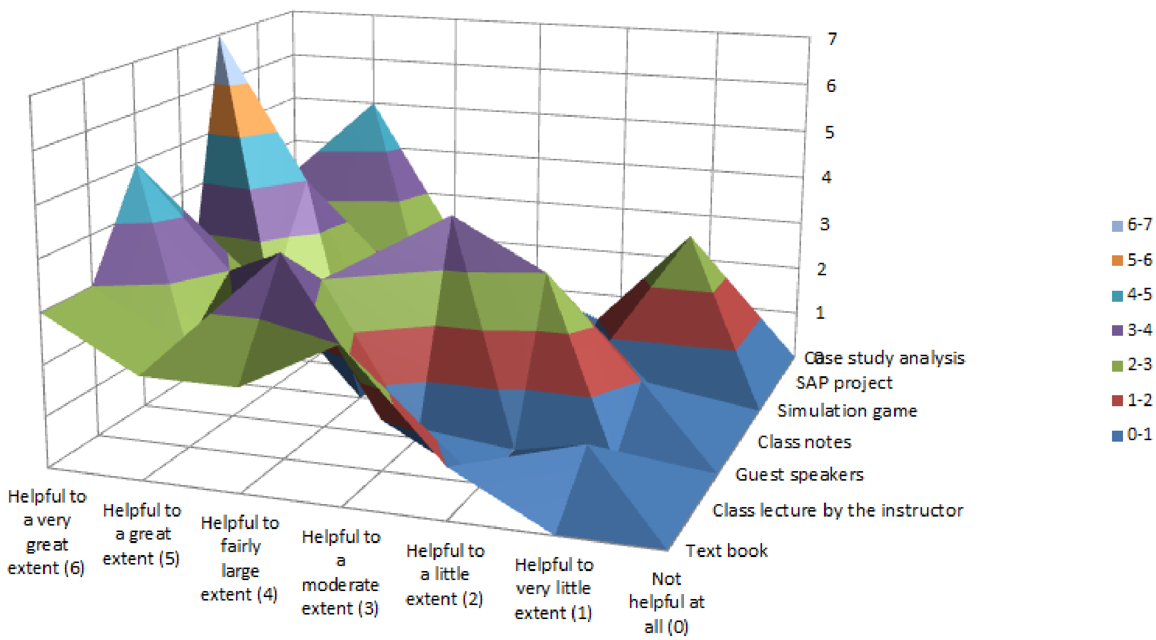

Figure 1. Course modules impact levels

Table 2. Course module ranking statistics

Course module	Helpfulness index >=4	Rank summation
Case study analysis	91%	42
SAP project	55%	64
Simulation game	100%	31
Class notes	27%	62
Guest speakers	100%	33
Class lecture by the instructor	82%	50
Text book	64%	54

To investigate the effectiveness of the simulation game on knowledge development from the students' perspective, a paired t-test is conducted to test the hypothesis H_0: the simulation game did not improve the knowledge level on 22 fundamental SCM concepts. The P-value=0.02< α=0.05 leads to the rejection of the H_0, and concludes that simulation game has been significantly effective.

For further analysis, in Spring 2014, students were asked to determine the effectiveness of each module on 20 of the SCM concepts, as shown in A2 of the Appendix. The results of this analysis are summarized in Figure 2, which shows how effective each module is per topic. The vertical axis demonstrates the average score provided by the students. According to the students' feedback, the simulation game is the most helpful tool in understanding the relation between supply chain players, supply chain strategies, overall supply chain design, and supply chain integration towards suppliers and customers. Meanwhile, case study analysis is the most dominant effective tool for teaching planning and quality control concepts. In addition, case study analysis (scored 9) and simulation (scored 8) are top two educational methods in presenting JIT concepts.

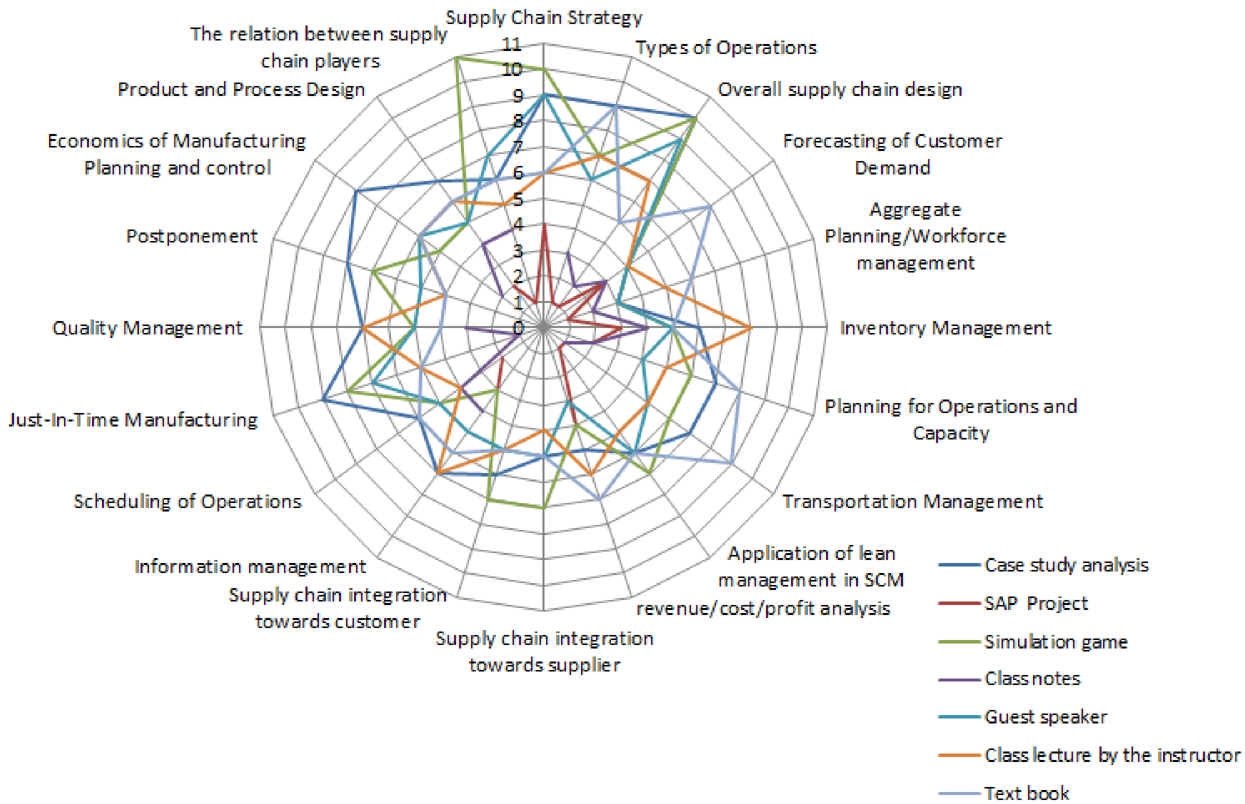

Figure 2. Significance of each course module per supply chain concept

The students' feedback about the effectiveness of the simulation game from education stand point is collected via Table A3 of the Appendix, and the results are presented via Figure 3.

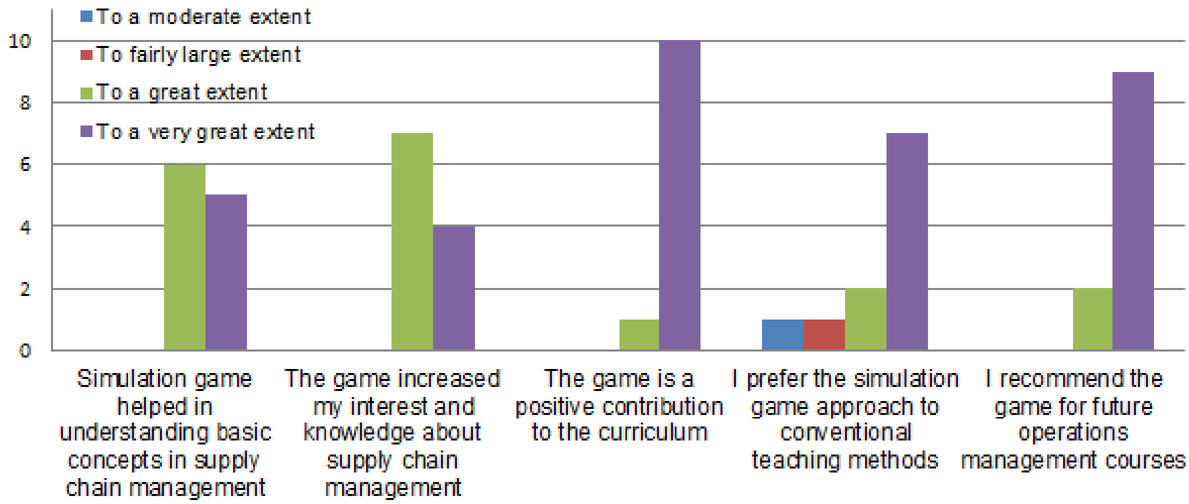

Figure 3. Students' attitudes about the effectiveness of the simulation game from education perspective

Based on these data, on average 96% of the students demonstrate a great to a very great extend positive response to the simulation game as an educational tool and would recommend it to be implemented in the future courses.

VI. Concluding remarks

This study reviews the perceived effectiveness of various course modules integrated into a graduate level supply chain management course and measures learning satisfaction, based on the surveys collected from students. The analysis shows that the simulation game and presentations by guest speakers are considered to be the most helpful pedagogical tools from students' standpoint. As a result of the simulation game, students acquired deep insights about fundamental concepts of the "Lean Supply Chain Network" which is mostly difficult to obtain through traditional instructional methods. It also increases the visibility of a supply chain design which leads to a more critical thinking among the students. The analysis reveals that students show the least interest in the SAP project implementation. On the other hand, they present a very positive feedback to the game as an instructional method and find it the most helpful tool in understanding the relation between supply chain players, supply chain strategies, overall supply chain design, and supply chain integration towards suppliers and customers. Therefore, the authors highly recommend utilization of this game for the supply chain and/or operations management classes.

As part of the course improvement action plans, especially for the engineering major students, we are interested to investigate the possibility of using a SAP simulation game in the course to prepare the students with the requirements of the job market. In addition, modifying the syllabus and inclusion of some of the entrepreneurial concepts into the SCM course is the other direction of the improvement which assists in flourishing the entrepreneurial mindset among the engineering students. The possibility of a flipped classroom is under investigation for this course, to allow the students take advantage of course lectures out of the classroom, and devote more of the class time to case study discussions and hands-on experience practices.

Bibliographic Information

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Appendix

Table A1. Pre-assessment questionnaire on fundamental SCM concepts

To what extent do you have knowledge on (mark only one cell)	Not at all (0)	To very little extent (1)	To a little extent (2)	To a moderate extent (3)	To fairly large extent (4)	To a great extent (5)	To a very great extent (6)
problems associated with SC operations							
principles and theory of SC management							
Supply Chain Strategy							
Types of Operations							
Overall supply chain design							
Forecasting Customer Demand							
Aggregate Planning/Workforce management							
Inventory Management							
Planning for Operations and Capacity							
Transportation Management							
Application of lean management in SCM							
revenue/cost/profit analysis							
Supply chain integration towards supplier							
Supply chain integration towards customer							
Information management							
Scheduling of Operations							
Just-In-Time Manufacturing							
Quality Management							
Postponement							
Economics of Manufacturing Planning and Control							
Product and Process Design							
The relation between supply chain players							

Table A2. Post-assessment questionnaire to evaluate module effectiveness and concept interaction

Which of the instructional methods could enhance your knowledge on the following topics? (you may need to mark more than one cell for each topic)	Case study analysis	SAP Project	Simulation game	Class notes	Guest speaker	Class lecture by the .	Text book
Supply Chain Strategy							
Types of Operations							
Overall supply chain design							
Forecasting of Customer Demand							
Aggregate Planning/Workforce management							
Inventory Management							
Planning for Operations and Capacity							
Transportation Management							
Application of lean management in SCM							
revenue/cost/profit analysis							
Supply chain integration towards supplier							
Supply chain integration towards customer							
Information management							
Scheduling of Operations							
Just-In-Time Manufacturing							
Quality Management							
Postponement							
Economics of Manufacturing Planning and control							
Product and Process Design							
The relation between supply chain players							

Table A3. Post-assessment questionnaire to evaluate module effectiveness and concept interaction

Please indicate to what extent the statement is true for you:	Not at all	To very little extent	To a little extent	To a moderate extent	To fairly large extent	To a great extent	To a very great extent
Simulation game helped in understanding basic concepts in supply chain management							
The game increased my interest and knowledge about supply chain management							
The game is a positive contribution to the curriculum							
I prefer the simulation game approach to conventional teaching methods							
I recommend the game for future operations management courses							