ASSESSING THE EFFECTIVENESS OF TEACHING OF SUPPLY CHAIN MANAGEMENT COURSES USING THE SIMULATION: A CASE STUDY

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ABSTRACT

This paper aims at investigation the effect of using simulation strategy in teaching supply chain management (SCM) course on students’ academic success. A sample included 60 students who studied at one public university in Australia, in the School of Engineering participated in this research. The students divided into two groups (30 control, 30 experimental). Each of these groups consists of females. The groups are subjected to pre-and post-tests in the SCM lecture. Qualitative and quantitative approaches are used in research design to assess the student scores in these tests. Statistical analyses conducted on the tests indicated that students of experimental group who were taught using simulation strategy were more efficient in comparison with students of the control group who were taught SCM by the traditional strategy of lecturing. The results further revealed that simulation-based SCM teaching affects satisfaction of students of experimental group.

Keywords: Teaching, Simulation, Supply Chain Management, Case Study

I. INTRODUCTION

Using of advanced instructional strategies enables students actively engage in teaching and encourages civic involvement. The simulation is one of these strategies that has great potential impact in improving science learning [1]. In this context, the use of simulation activities engages students in system thinking and empowers their understanding of the system and the concepts of the discipline area [2]. This is because simulations that promote learning allow the students “hands-on”, not mere listeners or observers. Currently, the use of simulation within higher education have been applied to include variety of disciplines including engineering, medical, law and business. Simulation addresses the relevant uncertainty aspects of the system, which cannot be represented using a deterministic mathematical model. Both in industry as well as in academia, supply chain management (SCM) is still gaining high importance. Uncertainties in supply and demand are well known that affect manufacturing functions. Most of Supply chain management system models are basically deterministic and lack to consider uncertainty aspects. Regarding academic area, the universities and management schools offer most SCM courses as text-based [3]. Inherent complexity and operational dynamic behavior of SCM networks can be illustrated using the simulation. As an alternative educational tool, the simulation allows student to see impacts of individual decisions on the system's performance. Although many business schools and management engineering programs in the UK offer SCM courses, still limited opportunities available to learn and experience hand-on SCM simulation.

Actually, the literature includes a huge of research focused on using the simulation as teaching strategy for the basic components of supply chain management; fundamentals, design, planning, and execution. Regarding this research [4-6] provided an extensive work about that. Despite its popularity, the authors realized that assessing the effectiveness of using simulation as learning or training strategy for SCM is still unclear. Based on that, the aim of this paper is to assess the effectiveness of teaching of SCM courses using simulation. The remainder of this paper is structured as follows. Section 2 briefly discusses Teaching and practicing strategies of SCM. Section 3 introduces details of the undertaken case study including research sample, procedures, and variables. Next, in section 4, results and statistical analyses are outlined. Section 5 presents conclusion and recommendation for future research.
II. TEACHING AND PRACTICING STRATEGIES OF SCM

It’s clear over the past decade or so years, SCM was considered as one of key significant courses that should be offered within logistic engineering and business. It comprises a wide variety of knowledge and focuses on strong practicality. Actually, this discipline is a combination of other disciplines such as the management, operations research, manufacturing processes, marketing and logistics engineering [7]. No doubt then, such comprehensive knowledge is abstract and is dead easy for students to understand. As a result, teaching of SCM courses in business and engineering curricula is subjected to considerable controversy over the appropriate strategy which offers practical insights for customers (i.e., students and the companies that hire them) on the role of logistics processes improvement in maximum use of available resources for production practice and logistical control.

Accordingly, to improve teaching effectiveness and enable students fully engaging in an active learning process, several strategies have been introduced for teaching and practicing SCM with various and many work experience and educational backgrounds [8]. These strategies include integration of information technology (IT), case studies analysis, the use of SCM software packages or visiting companies for project - based purpose. However, relying on well written and up to date text book which includes a wide range of supporting materials, is still the dominant strategy for the instructors. Using of simulation software packages in teaching of SCM design and process is an instructional strategy which is based on some reality and is designed to provide the student with experience without the risk, cost, or complexity of real application[9]. In the forthcoming section of this paper a focus on teaching and practicing strategies specifically used in SCM courses.

2.1 Mathematical Models

The model represents abstract of a system. In different disciplines of knowledge, its used to explain and predict the behavior of the system or of real objects. In most curricula of SCM, the common models of the system introduced are formed in a prescriptive variety way [10]. These models are subjected sets of mathematical assumptions which bring the model closer to reality. Actually, this is differed in what follow in other scientific disciplines such as biology, chemistry and physic where the models are descriptive [11]. Due to the sources of randomness in manufacturing systems such as processing or assembly times at each workstation and skill levels of workers who perform these tasks, most of these systems are stochastic rather than deterministic[12]. Among specialists, it is widely accepted that using mathematical modelling techniques is not sufficient to describe a system with random behaviour[13]. This is because mathematical models do not consider the stochastic nature of the system and are based on many simplifying assumptions providing a limited number of system performance measures [14]. Consequently, accuracy often becomes a major problem for system optimisation when using mathematical models[12].

2.2 A SCM Experiment: The Beer Game

The beer game is designed by the Massachusetts Institute of Technology (MIT) - Sloan School of Management- for helping students understanding dynamic behaviour systems [15]. Since early 1960s, this simulation game used to demonstrate of key factors of SCM. Often in heated competition, this game at least needs four people each one assumes role of a company (a factory, distributor, wholesaler, and retailer) which considers is the supplier or customer of other company [16]. The objective design of assumed SCM is to minimise the total cost for all players “companies” in the system by marinating low level inventory but managing to deliver all orders. However, several weaknesses can be indicated in the beer game; inflexibility in changing the structure of SCM specially the input parameters which motivate students natural desire to play around the developed model, non-real assumptions, lack of constraints related to the capacity [17]. Now, the game is becoming a component of most software packages used as an executive program to design SCM system; i.e., the reader can find the simulation model of beer game distribution in free download copy of AnyLogic™, ARENA™, ProModel™. It is found the students prefer the simulation model to the beer game because it is enable them to handle and visualization of the system entities flows as well as helps better understanding of the underlying causes.

2.3 Simulation Models

Taking into account the limitations of the two teaching and practicing strategies of SCM that described above, simulation modelling, in particular discrete event simulation is introduced as an appropriate strategy for analysing real life case problems and also to shed light on the dependencies in the SCM context[18]. Hence, the simulation has gained high importance as learning environment of SCM. Simulation modelling has emerged as a powerful tool for optimising of complex manufacturing systems that are characterised by stochastic operating
environments[19]. Currently, simulation modelling is considered the most commonly used technique behind optimization [20].

The components of a simulation model try to represent with varying degrees of accuracy the actual operations of the real components of the system. Within simulation, the flow of entities through the system is controlled by logic rules that derive from the operating rules, which are associated with underlying assumptions. Like other manufacturing systems, the simulation model for manual assembly systems is used to obtain performance measure values for different combination scenarios of design variables. There are two main aspects in using the simulation as learning environment in SCM:

2.3.1 Example Simulation Models

All SCM simulation software packages are included example models. The student can easily access to visualize, slightly change and analyze the impact of improvement ideas on those already implemented models[21]. What – if scenarios are the standard technique to analyze cause and effect with a simulation model by modify a few parameters.

2.3.2 Replicated Simulation Models

Using simulation in teaching represents the application of concept “learn by doing” [22]. Building new models of SCM from scratch needs to look at what available tools and processes to use and what people “resources” were going to be in the organisation. This allows to students gaining broader experiences through developing SCM models. Building new model of SCM involves comprehensiveness regarding to the decomposition of the system as well as the interrelations of the linked subsystems which considered the key components here[4]. The certain aspects of SCM modelling; designing, building, testing and analysing the run of the model is rather demanding for students without previous experiences in this area. Verification and validation are considered from the challenge tasks in developing simulation models[23]. This is related to the concerns with whether a developed model and its outcomes are accurate and credible, in other words, the model performs as intended and represents the system under investigation with high accuracy. Verification and validation are addressed these concerns that raise up throughout the development of the simulation model. Building successful simulation model includes several steps: a clear description of problem formulation, collecting the data and set of acceptable assumptions, discussion with subject-matter experts and decision makers, determine important model factors through sensitivity analysis, and comparison of model run results with real application system outputs. In simulation learning environment, the main problem is finding a real system structure and operation procedures [24]. Also, because the educational purposes, it is typically unpractical to develop a model which closely resembles a complicated real application situation. Moreover, descriptions of Reference books are mostly oversimplified and do not reflect the dynamics of SCM[25]. Therefore, there is no much efforts dedicate to replicate the results of simulation models existed in the literature.

III. THE CASE STUDY

Through conducted case study, the paper illustrates how the simulation can help students learn SCM concepts actively and effectively. The paper describes the important aspects of the simulation and explains how introducing this teaching method may effectively affect students understanding.

3.1 Research Sample

The research sample consists of all students enrolled in course of operations research at University of South Australia, School of Engineering. (60) students from both genders. The researcher divided them into two random groups: control and experimental. The control group is composed of 9 students and 21 students studied in the traditional way (analytic models) while 12 students and 18 students who studied using (simulation modelling).

3.2 Research Procedures

The researchers conducted the following procedures:

- The undergraduate students in the second semester of the year 2015/2016 who enrolled in course of operations research; 60 Students were randomly divided into two groups: control and experimental groups
- Giving the learning material (the lecture of SCM design) to be researched from the subjects offered by the curriculum operations research. The control group was given lectures using the traditional way in
teaching; i.e. ppt slides, numerical analysis, and class tutorial. While experimental group had lectures using a simulation software package (AnyLogic) to create SCM models. Both groups were subjected to pre & post test ‘success test’ in the subject of SCM tackled by the lecture.

- A ‘success test’ includes multiple choice questions has been conducted on the two student groups. It includes 25 questions which classified into three types of questions (background, acquiring and understanding, and higher thinking abilities).

- The validity of the success test was confirmed by approving it from the specialists in statistic who confirmed that it was stable, based on Kuder–Richardson Formula 20 (KR-20). It was found that the coefficient of stability = 0.88.

- The statistical analysis: SPSS; statistics software package, is used to analyze the data statistically. Two-way ANOVA is conducted at two stages: pre-test scores stage and post-test scores stage. ANOVA is used to find out the extent of the differences between the averages of the understanding of the research sample groups due to the strategy of teaching, the gender of the students, and the interaction between the teaching strategy and the gender of the students.

3.3 Research Decision Variables
The research includes the following decision variables:

- The independent variable: the teaching strategy: analytic or simulation,

- The Moderator variable: the student gender, and

- The dependent variable: the marks of the students to their answers of the multiple-choice test

IV. RESULTS AND DISCUSSION

4.1 Pre-test Success Scores
Analysis of variance (ANOVA) is utilized to research the impacts of the variables (independent & moderate) and their interactions on performance in terms of level of information the students had about the SCM design. Table 1 shown the effects of these variables. P-value (or significant probabilities) from ANOVA elements is used as an informal measure about their significant effects. If the value of “P” less than 0.05 this statistically indicates that the parameter is significant. The data obtained from the pre-test scores indicated no statistically meaningful differences between the two groups, as can be shown in ANOVA results presented in Table 1 (p > 0.005). This proves the equivalence of the both groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sum of squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F Value</th>
<th>P-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Strategy</td>
<td>8.87</td>
<td>1</td>
<td>8.87</td>
<td>0.75</td>
<td>0.47</td>
<td>—</td>
</tr>
<tr>
<td>The Gender</td>
<td>1.22</td>
<td>1</td>
<td>1.22</td>
<td>0.08</td>
<td>0.75</td>
<td>—</td>
</tr>
<tr>
<td>Teaching Strategy * The Gender</td>
<td>7.85</td>
<td>1</td>
<td>7.85</td>
<td>0.62</td>
<td>0.33</td>
<td>—</td>
</tr>
</tbody>
</table>

4.2 Post-test Success Scores
To indicate the effect of simulation strategy in teaching SCM on students’ level of information they had about the subject, Table 2 presents results of post-test administrated by the authors and was given to the students from both groups (control and experimental). Based on research variables (the teaching strategy and the student gender), the table shows the averages and standard deviations of the performance of the control and experimental control groups on the test.

<table>
<thead>
<tr>
<th>The Gender</th>
<th>Statistics</th>
<th>Teaching Strategy</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control Group</td>
<td>Experimental Group</td>
<td></td>
</tr>
</tbody>
</table>

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Table 2 shows that the average overall performance of students in the control group is 18.70 and with a standard deviation equal to (2.22) less than the average overall performance of the experimental group students (20.98) and by standard deviation (2.27). For the both genders of the students, it was found out the average overall performance in the experimental group was higher than in the control group; the scores were (21.35) and (20.64). While in the control group, for males and females, they were (18.46) and (18.90) respectively. The results indicated that regarding teaching strategy there was impact the performance experimental group. Table 3 shows that the average score students’ post-test for males of the control group (18.46) is approximately similar to that of the females of control group (18.90), and that the average score of the males experimental group (21.35) is also similar to that of the females experimental group (20.64), so there are no significant differences in tested groups for student gender.

Table 3: ANOVA table for effect of independent and moderate variables on post-test scores of the students

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sum of squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F Value</th>
<th>P-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Strategy</td>
<td>58.33</td>
<td>1</td>
<td>58.33</td>
<td>10.51</td>
<td>0.0021</td>
<td>*</td>
</tr>
<tr>
<td>The Gender</td>
<td>0.530</td>
<td>1</td>
<td>0.530</td>
<td>0.085</td>
<td>0.897</td>
<td>-</td>
</tr>
<tr>
<td>Teaching Strategy x The Gender</td>
<td>0.925</td>
<td>1</td>
<td>0.925</td>
<td>0.234</td>
<td>0.763</td>
<td>-</td>
</tr>
</tbody>
</table>

From Table 3, teaching strategy has significant effect on the on-post-test scores of the students as their P-values are below 0.05. This result can be attributed to the effectiveness of simulation-based teaching, taking into account the individual differences of students, their abilities and speed of learning, the availability of computers in the department and their accessibility to use in the learning environment. Actually, the use of simulation-based teaching enhances students understanding to the content of the learning components, increase their motivation to learn especially as using the computer drives boredom away and increases the eagerness of students to learn more. In addition, the student can repeat the simulation process repeatedly and based to his need to learn. Also, in table 4, student gender has an insignificant effect on post-test scores. This indicates the gender parity (male and female) in their willingness to learn, the educational circumstances experienced by both genders were the same, and the learning components given to both genders is one.

The interaction between the two variables teaching strategy and the gender is insignificant with respect to average score students’ post-test. This relates to the to the interest shown by the students from both genders. It noted that the use of simulation strategy complies with male and female students’ desires.

V. CONCLUSION AND FUTURE RESEARCH RECOMMENDATIONS

Supply chain management (SCM) is one of the courses in business schools or engineering management departments that students have difficulty in understanding. With the results presented in this paper, it can be claim that by using simulation strategy in teaching, students’ performance in terms of feelings, thoughts, and interests toward SCM course can be changed in a positive way. Using software packages in modelling real case supply chain systems improves student’s learning by providing relevant experiential exposure to real applications and decision support tools. Based upon the outcomes acquired from the results of research work conducted in this paper, it is better to support the results presented here by extending the duration of the time period to be the whole semester instead of three weeks (as limited here) as well as engaging a large number of students.

REFERENCES