Operations and Supply Chain Simulator: Imitating Graphing Calculator for Courseware Development to Enhance Students' Learning Experience

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Abstract: Courseware simulation can help student to understand technical courses using an innovative approach. In this paper, we proposed the design of computer based courseware simulation to teach students on the concepts underlying supply chain topics as well as to enhance their problem-solving skills. A prototype called Operation and Supply Mini Simulator (OSMS) covers specific supply chain topics such as inventory models, purchasing and material requirement planning. OSMS mimicking the graphing calculator, enabling students to compute and visualize graph data for multi-mode analysis.

Keywords: Computer-aided simulation, courseware, design and development, operations and supply chain management.

1. Introduction

Recent advances in multimedia capture, navigation and delivery system had begun to dominate traditional methods of teaching and learning (TandL). In information technology (IT) education, the use of mobile devices, simulation and multimedia courseware have been greatly facilitated both educator and students. Computer-aided simulation software for TandL is continuously invented to provide an additional aided TandL tools for practical use. These days, computer-aided simulation has become popular TandL tools for active and independent learning in various types of education. Courses involving mathematical calculation such as Supply Chain Management (SCM) take full advantage of this technology.

In his previous research, Lindstrom (1994) found that people can only remember 20% of what they see and 40% of what they see and hear. However, the percentage of remembering things could be increased up to 75% when they see and hear and do, simultaneously. These 3 features exist in simulation tools that also combine modeling and pedagogical elements. Students can learn rigorously with relevant instructions provided in the simulation tools. Educators would also like to have cost effective products that are also

reusable as aids for the students to use when they are performing their lessons (Ng Smith and Killinger, 2005). In TandL, the development of courseware simulation with graphing calculator features could increase student performance (National Council of Teachers of Mathematics, 2000). Graphing calculator features have been considered for the courseware development since it deals with graph plotting, solving simultaneous equations and performing tasks with variables.

By mimicking the graphing calculator, we proposed a design and development of courseware simulation for providing training and problem solving skills in various analysis and visualization related to Operations and Supply Chain Management (OSCM) topics. The propose simulator is called the OSMS – Operation and Supply Mini Simulator.

2. Literature Review

A. Research Context

It is important for educators to know more about their students as learners. A learner refers to any person who engages in the processes of acquiring new knowledge and/or developing new skill (Oduro and MacBeath, 2016). Thus, educators must know how students perceive their current learning courses. To answer this question, a pilot study was conducted for a group of bachelor degree students who enrolled in Computer Entrepreneurial Management program. The target group was students who have completed the SCM course. A set of questionnaires were distributed to 40 students. These questionnaires help researchers to know the perception of students in their learning process towards understanding the course. It is designed to evaluate their opinions about their current learning experience in SCM subject. From the survey, 19 out of 40 students were identified as having problem in doing analysis and evaluation (Hassan, 2016) involving some topics in SCM such as the Break-Even Analysis, ABC Inventory Analysis, Total Cost Analysis, Inventory Models Analysis and Material Requirement Planning (MRP) (Wisner *et al*., 2014). As the result, many students either get less mark or not able to solve the questions related to these topics during test and final exam. Hence, an automated graph analysis that is provided in the proposed mini simulator is believed could improve students' ability to perform visualized analysis as well as to enhance understanding of the subject. Figure 1 shows the sample of problem that needs students to perform analysis for Economic Order Quantity (EOQ), a sub topic in SCM subject.

In this modern era, students need to have fundamental knowledge in IT and business in order to empower knowledge and practices in SCM. Learning the concepts and developing competencies in Supply Chain (SC) would be challenging without experience in both areas. Fortunately, students in these days are very computer literate. They can quickly learn theories and core concepts in any subjects with hands-on learning using computer-aided simulation training tools. With the training tools, students could learn in a meaningful way and individual's knowledge could also be improved (Wu and Katok, 2006).

Figure 1. Sample of questions related to subtopic in SCM

Question 1: Make or buy materials or components is a strategic decision that can impact an organization's competitive position. Consider the following hypothetical situation in which a firm has to make or buy a part. Its annual requirement is varies every year. Currently, a supplier is able to supply the part at RM20 per unit. The firm estimates that it costs RM3800 to prepare the contract with the supplier. To make the part, the firm must invest RM50000 in equipment and the firm estimates that it costs RM10 per unit to make the part.

Table 1: Make-Buy Option Data

Compute the break-even quantity.
Compute the total cost of the break-even point.
If the requirement is 8500 units, is it more cost-effective for the firm to buy or to make the components?
What is the cost savings for choosing the cheaper option?
If the requirement is 3500 units, is it more cost-effective for the firm to buy or to make the components?
What is the cost savings for choosing the cheaper option?
Draw the break-even analysis cost curve to demonstrate answers for question 1a to 1f. Describe your analysis in detail.

B. Related work

The Simulation tool has been used in educational settings since 1960s (Forrester, 1961). Recently, Lau (2015) presented the modified business simulation game to facilitate TandL in logistic management. The simulation game was redesigned from the famous Beer Game that was previously developed in the 1960s at the Massachusetts Institute of Technology's (MIT) Sloan School of Management (Senge, 1990; Sterman, 1989). The game has been proven as a powerful tool to demonstrate the bullwhip effect and clarifies the advantages of taking an integrated approach to SCM (H. L. Lee, V. Padmanabhan, and S. Whang, 1997; Lee *et al*, 1997; Merkuryev and Bikovska, 2012). Another SC simulator called Airplane Supply Chain Simulation (ASCS) simulates how lean six sigma concepts may be leveraged to improve SC performance (Ellis *et al*, 2014). ASCS simulates a four-tier SC, consisting of suppliers (two tiers), a manufacturer, and a customer, that produces three models of paper airplanes to meet randomly distributed customer demand.

In related to operational issue, computer-aided supporting tool for ECLIPS was developed with aim to create awareness of modern inventory management policies in SC. ECLIPS demonstrate efficiency of collaboration between supply chain partners (Merkuryev and Bikovska, 2012). TandL tools and simulators that we describe above only focus on single SC topic. Our proposed simulator includes graph analysis that covers various SC topics. In order to model strategic and operational aspects of production system, a cloud-based simulation named as FORIO is proposed as part of TandL tools in SC (Hidayatno *et al*, 2014). Different from FORIO, our simulator focusses on operational and supply issues in SC. The Enterprise Resource Planning (ERP) systems simulation to teach the ERP concepts and competencies is proposed by the HEC Montréal to teach students on the value of integrated system (Leger et al., 2014). Our proposed

simulator takes part of the ERP elements to emphasize on the Materials Requirement Planning (MRP) computation.

C. Graphing calculator technology

Graphing calculator has been widely used in the mathematics classroom for TandL. The technology is recommended by national standards in mathematics (National Council of Teachers of Mathematics, 2000). In previous study, the graphing calculator helps teachers and students for rapid TandL, leap hurdles, making analysis and relationship, permitting realism through the use of authentic data, improving manipulative skills and indeed, improved attitudes and increase motivation (Horton *et al*, 2004; Tan, 2012; Tan *et al*, 2013). Generally, graphing calculators serves the following purposes:

1. Speed: Students should master the mathematic-related skills and able to use the graphing calculators to compute, visualize the graph, and creating a table of values quickly.
2. Leaping hurdles: Students can study mathematics in deep and performing skills that they are unable to do themselves.
3. Connections: Students can make connections among different representations (tabular, graphical, and algebraic) of mathematical models.
4. Realism: Modern data analysis can be integrated within the traditional curriculum.

OSMS is mimicking some features of graphing calculators. While graphing calculator itself is a handheld device, OSMS is designed as application software to enable multi-platform installation.

3. Methodology

We use prototyping; a working physical model of a system as OSMS needs to have plenty interaction with the end user. With prototyping, we are able to gather user's requirement iteratively by allowing them to see and interact with the prototype. Prototyping is especially good tool for iterative user requirements engineering and human-computer interface design (Sadabadi, 2009). This model consists of 6 phases, starting from planning, analysis, design, implementation, testing, and prototype (Hassan, 2016). For designing the OSMS, we first develop a conceptual framework that consists of activities, modules and outcomes (Figure 2).

Figure 2. Conceptual framework of OSMS

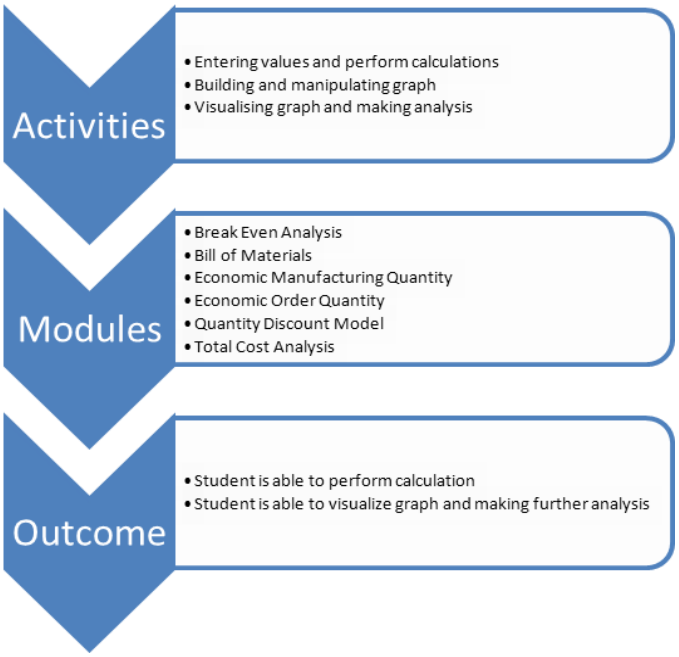
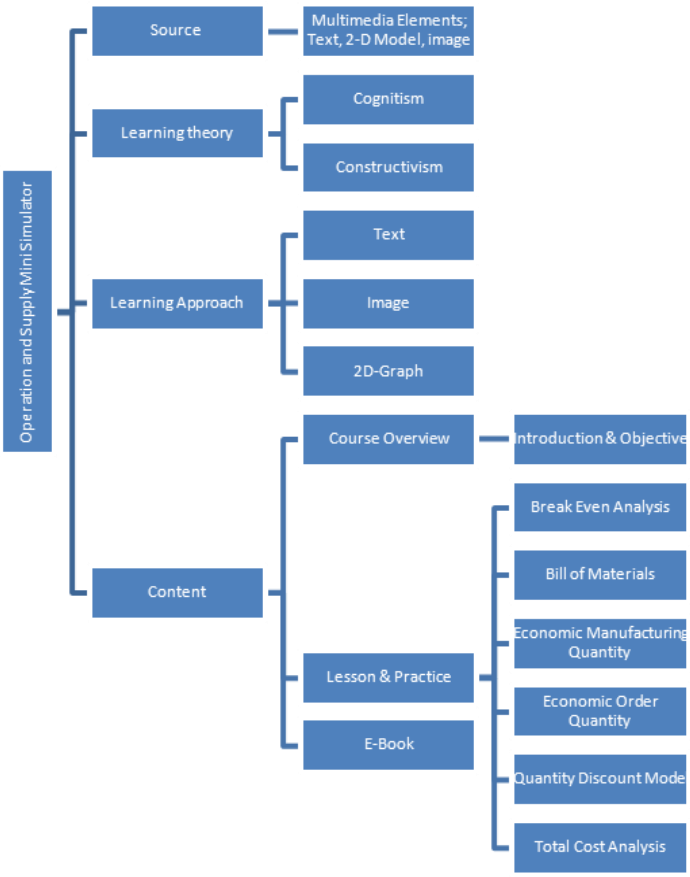
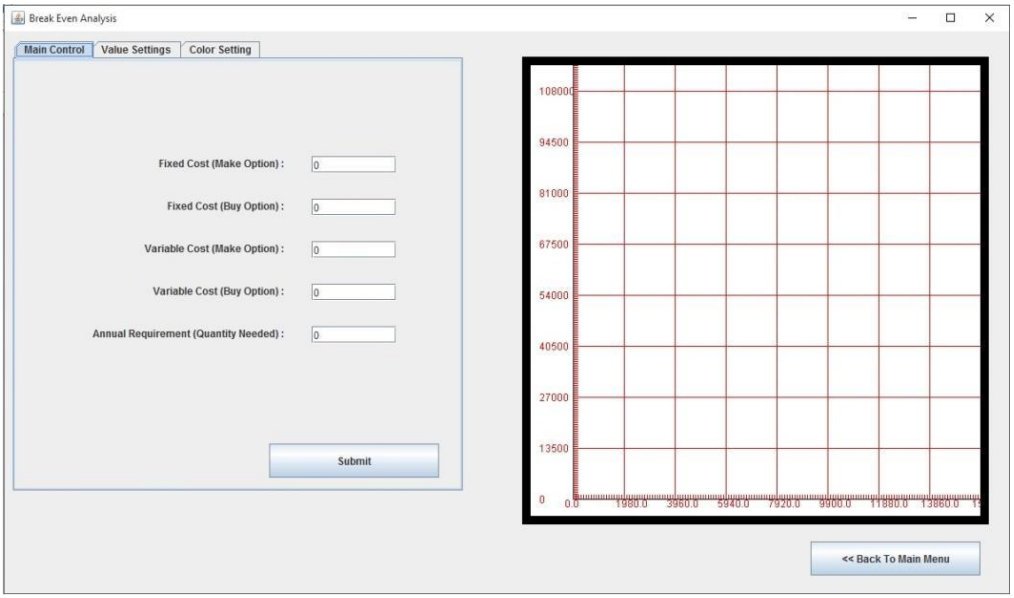


Figure 3. The OSMS ID model



The Instructional Design (ID) Model for OSMS contains three media elements, namely, text, image and 2-D graph model. For creating the related modules, these three elements are considered enough to support visual cognitive multimedia learning theories for processing information. There are three main sections; Course Overview, Lesson and Practice and E-Book. Lesson and Practice section is the main section of OSMS to develop constructive learning in self-directed learning environment. Figure 3 depicts the ID Model for OSMS. For user interface (UI) and programming design, Eclipse Luna framework is used. We use the Eclipse IDE to handle all OSMS modules in Java programming language. Storyboarding is sketched to guide interface design. While graphing calculator use the device keypad, OSMS make use keyboard for entering values. Graphing calculator features that exist in OSMS is graph visualizing and using variables to perform specific tasks. For brevity, Figure 4 depicts UI design for Make or Buy Decision sub-module.

Figure 4. Make or buy decision sub-module design



4. Discussion on the OSMS

A. Overview

The OSMS is designed with the purpose of transforming the way SCM concepts involving calculation and analysis is taught in the classroom. OSMS is a simple simulator that is built on a standard technology, JAVA platform and it is also a portable simulator in computer. The simulator includes material for instructor-led training and material for self-directed computer-aided training.

The OSMS is designed to facilitate learning in the topics; (i) Break Even Analysis; (ii) Total Cost of Ownership Analysis; (iii) Economic Order Quantity; (iv) Quantity Discount Model; (v) Economic Manufacturing Quantity; and (vi) MRP calculation. The pedagogical objectives of this simulator are twofold: (i) to develop hands-on understanding of the concepts underlying inventory models, MRP and purchasing; and (ii) to develop analytical skills related to the above topics.

OSMS is designed to offer the followings unique attributes:

1) The content is designed to fit into the learning outcomes.
2) The content depends on what goals for learning outcomes.
3) The content such as e-book is referring for learning outcomes.

B. Requirements

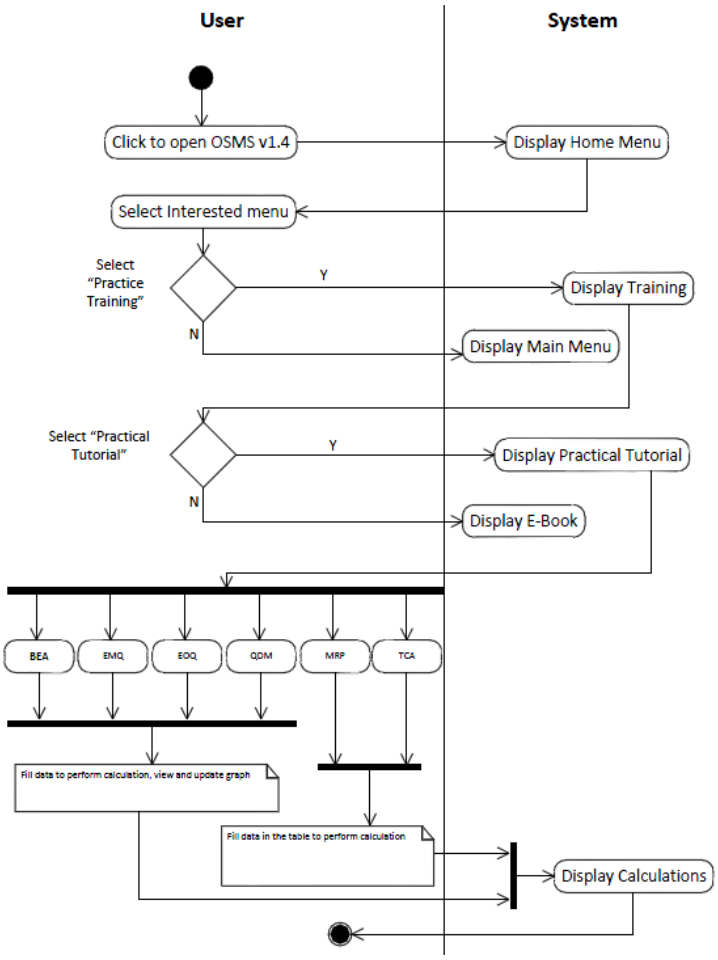
Target audience: OSMS is designed to let students use it at their own pace until they complete the training. It is perfectly suited for individual or group use in undergraduate courses such as Supply Chain Management, Operation management and Logistic Management.

Software: OSMS is able to operate on PC or laptop with the Microsoft Operating Systems Windows XP and above. The simulator supports Java version 7 and above.

Installation: In order to use the simulator, users need to install the simulator into their computer. All the zipped files must be changed to .jar to be usable for computer.

Navigation: The simulator has been designed to be simple enough to use, providing quick and easy access to the contents (Figure 3). The activity diagram in Figure 5 shows the workflow in OSMS.

Figure 5. The OSMS activity diagram



C. OSMS snapshot

In the proposed simulation software, students are allowed to simulate six lessons (Figure 3). One of the lessons is to simulate the "Make or Buy Break-Even Analysis". By using break-even analysis, students are able to simulate the cost-effectiveness of sourcing decisions when cost is the most important criterion. For this, student must provide any hypothetical situation in which a firm has the option to make or buy a product. OSMS will calculate the break-even point quantity BEQ and simulate the break-even analysis by

showing the 2D graph. To find the break-even point quantity and its total cost for make and buy, these parameters are programmed in the related module:

$$BEQ = (FCmake - FCbuy) / (VCmake - VCbuy) \quad (1)$$

(2)

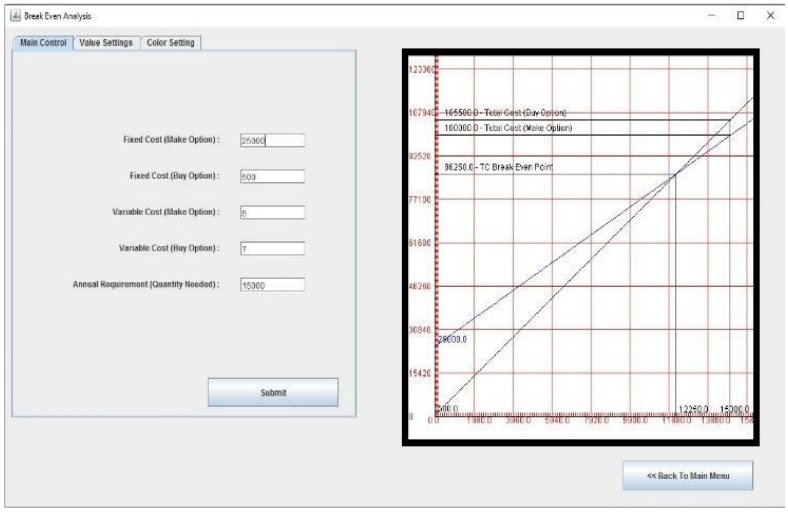
$$TCBEQ = FCmake + (VCmake \times BE) \quad (3)$$

$$TCBEQ = FCmake + (VCmake \times BE)$$

$$or \quad TCBEQ = FCbuy + (VCbuy \times BE)$$

Figure 6 shows the example of break-even analysis simulation after all the required fields are filled in. After button 'submit' is clicked, OSMS will shows the BEQ (unit) and the total cost (RM) at the break-even point. Using the graph, student can make further analysis. If the requirement is less than 12,250 units, it is cheaper to buy the parts. Otherwise, it is cheaper to make the parts if the firm needs more than 12,250 units. With small purchase requirements which less than 12,250 units, the low fixed cost of the buy option makes it attractive. With higher purchase requirements which greater than 12,250 units, the low variable cost of the make option makes this option more attractive. Since the requirement entered in the field is 15000, the analysis shows that the firm should make the item since the quantity is large enough to warrant the capital investment.

Figure 6. Simulation of break-even analysis



D. The proposed evaluation method

The design and development of OSMS has reached the final stage. This courseware simulation is being tested on students who are currently sitting their final semester. Two types of survey (Likert scale-based questionnaire) evaluation are considered to assess students' learning experience and to evaluate the effectiveness of OSMS. Using survey, we measure students' learning experience regarding the ability of the courseware simulation to increase their understanding in subject. Then, a field study with experimental

approach will be carried out on randomly. Respondents will be the selected students from a group who is exposed to conventional learning and another group who is aided with OSMS.

5. Conclusion

In this paper, we proposed a design of courseware simulation for training and problem solving skills in SCM courses by creating OSMS. For the proof of the concept we have proposed the coursework simulation that has significantly helped students to understand the SCM courses. It is also enabled the students to improve their problem solving skills and effectively helped them to learn the courses.

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