

# Operations and Supply Chain Mini Simulator Development as a Teaching Aid to Enhance Student's Learning Experience

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## Abstract

This paper describes the approach for courseware simulation learning tool development that able to assist the students on learning and understanding their courses specifically on supply chain. A courseware simulation prototype called Operation and Supply Mini Simulator (OSMS) is being developed for deployment in interactive learning. A courseware development lifecycle is proposed with combination of empirical approach and prototyping model to allow iterative user's requirement gathering and to build optimal control application. The proposed OSMS offers an innovative learning tool that mimics the graphing calculator. The features in the tool enable students to compute and visualize graph data for multi-mode analysis in order to develop higher understanding on the supply chain course.

## Keywords

Computer-aided simulation, courseware development, supply chain management

## 1. Introduction

Advancement in multimedia capture, navigation, analysis and delivery system has transformed the conventional teaching and learning (T&L) techniques to a higher revolution. Recently, computer-aided simulation has become a popular T&L tools for active and independent learning for various areas of education. Many functionalities enhancement is being developed from time to time to improvised the capability of the computer-aided simulation software in order to facilitate T&L practical use. Therefore, the vast potentials of computer-aided simulation software are evidently beneficial for student learning experience especially for courses that involve mathematical calculation such as Logistics and Supply Chain Management (LSCM).

Lindstrom found that people can remember 20% of what they see and 40% of what they see and hear. However, people remember 75% of what they see, hear and do simultaneously (Lindstrom, 1994). Thus, T&L simulation tool must combine both modeling elements and instructional (or pedagogical) elements. Students can therefore acquire more understanding on the subjects by doing problem solving and analysis by following the instruction provided in the simulation tools. In the meantime, the software development lifecycle need to be used imperatively in such application development. It is important to design the product based on appropriate development lifecycle models. Good users'

satisfaction could be achieved when their requirements are implemented in the development process (Sommerville, 2015).

In this work, we propose a courseware simulation development that provides trainings and problem solving skills of various analysis and visualization for Supply Chain Management (SCM) by mimicking graphing calculator technology. The development of courseware simulation with graphing calculator technology could increase student motivation and academic performance particularly for mathematical formulation analysis (National Council of Teachers of Mathematics, 2000). Graphing calculator technology is recommended for the proposed simulation design since many SCM problems involve graph plotting, solving simultaneous equations and performing tasks with variables. The proposed courseware simulation is called the Operation and Supply Mini Simulator (OSMS).

## 2. Background

In the digital age, the use of technology has enhanced teaching and learning approaches. Wu and Katok (2006) highlighted that the use of computer-aided courseware has significantly helped students to learn and understand their courses much easier. It is evident that blended learning approach – hands-on and computer-aided courseware are vital in studying Supply Chain (SC) as it would be difficult for the student to experience both theoretical and practical techniques.

The Byte Corporation purchases a critical component from one of its key suppliers. The operations manager wants to determine the economic order quantity, along with when to reorder, to ensure the annual inventory cost is minimized. The following information was obtained from historical data.

- Annual requirements (R) = 200 units
- Setup cost (S) = \$100 per order
- Holding rate (k) = 20% per year
- Unit cost (C) = \$20 per unit
- Order lead time (LT) = 6 days
- Number of days per year = 360 days

Demonstrate:

1. The annual purchase cost
2. The annual holding cost
3. The annual order cost
4. The total annual inventory cost
5. The reorder point
6. The number of orders placed per year
7. The time between orders
8. The graph analysis for the Economic Order Quantity (EOQ) and Total Cost. Describe your analysis in detail.
9. The graph analysis for physical inventory with the EOQ model. Describe your analysis in detail.

Figure 1. Sample of questions related to Economic Order Quantity, one of subtopic in SCM.

Firstly, it is essential for the educators to identify the students' perception and capability towards their courses. A pilot study was conducted for a group of bachelor degree students in Computer Entrepreneurial Management program. The target group focused on students who had completed the SCM course. A set of questionnaire was being developed to be distributed to a total of 40 students. These questionnaires aim to identify the perception of students in their learning process towards understanding the course. It was being designed to evaluate the students' opinions about their current learning experience in SCM subject. From the survey, 19 out of 40 students were shown to encounter problem in doing analysis and evaluation (Hassan, 2016) involving several topics in SCM such as the ABC Inventory Analysis, Break-Even Analysis, Total Cost Analysis, Inventory Models Analysis and Material Requirement Planning (Wisner, Tan, & Leong, 2014). As a result, these students obtain lower marks for their academic assessment because of their lack of understanding and inability to solve SCM problems accurately. Figure 1 above shows an example of the problem sample that requires students to perform analysis for Economic Order Quantity (EOQ), a sub topic in SCM subject. Hence, our proposed OSMS which implements an automated graph analysis in the design aims to assist the students to perform visualized analysis and thus able to enhances their understanding in the SCM.

### 3. Literature Review

#### 3.1 Courseware Development Process

In general, the development process of any software product is known as Software Development Life Cycle (SDLC). Each SDLC models follows a specific life cycle (Sommerville, 2015). When frequent interaction is required between software/system and end user, prototype model is among the best development model to be used by the developers. As its name, this model emphasizes the software prototype development more than other phases. Thus, user involvement from the early stage is required to ensure the desired software/system could be realized. Any flaws, errors and misunderstandings should be minimized or avoided with the presence of user. Prototyping includes phases (Figure 2) which is repeated until the software/system prototype is done. The prototype (working model) gives the actual feel of using the software/system.

#### 3.2 Simulation Tools for Supply Chain Management

Simulation tool has significantly influenced in teaching and learning (T&L) environment. Lau (2015) highlighted that the use of simulation has improved T&L in logistic management as it enables the instructor to show the business case in real environment. Ellis, Goldsby, Baily and Oh (2014) argued supply chain simulator helps freight industry integrates business process and supply chain to improve decision making and to deliver better services. Othman and Mustaffa (2012) emphasized that “simulation is the best practice to evaluate the system performance closely to real situation” (p.161). However, relying on simulation only “is not enough to achieve optimal result” (p.161) in T&L, which the integration between theoretical and practical practices can optimize the outcomes (Othman and Mustaffa, 2012).

According to Merkurjev and Bikovska, (2012), computer-aided supporting tool is useful in solving operational issues as it enables supply chain expertise to communicate and improve policy implementation system. This enables the user to generate strategic model of supply chain. Hidayatno, Moeis and Raditya (2014) proposed cloud-based simulation can be used to create supply chain model to understand the operation processes in the organization. It is evident that cloud-based simulation is one of the best practices for T & L of supply chain courses (Hidayatno, Moeis & Raditya, 2014). Existing research demonstrates that the use of simulation tools has significantly impact on T & L, yet, limited research investigates the use of simulation tools in multiple supply chain topics. As, most of the simulation tools focus on a particular topic or issue. Thus, this project aims to fill this research gap.

#### 3.3 Graphing Calculator Technology

The graphing calculator is a program for creating graph. It recognizes all mathematical functions. This graphing calculator technology helps the teacher and student to calculate, analyze, and show the outcomes graphically. Horton, Storm and Leonard (2004) emphasized that this technology allows the student to compute, visualize the graph and create table much faster. Subsequently, it enables the student to understand the mathematical calculation and improve their mathematic-related skills (Tan, 2012). Tan, Tan, Razak, & Ling (2013) highlighted the use of handheld technology is beneficial in learning probability as it improves the student achievement. Existing research shows that the use of graphing calculator technology is useful in T&L. Thus, the study aims to imitate the features of graphing calculator that allows the user to install OSMS in multi-platform installation.

### 4. Methodology

Our strategy using SDLC begins with trial and error procedure or formally known as the *empirical approach*. The approach is paired with *prototyping*; a quick working physical model of OSMS. Using empirical approach, the OSMS is produced and the effectiveness is determined after the development. This approach may increase the amount of uncertainty involved while creating the tool. However with prototyping, user’s requirement could be gathered iteratively and quickly by allowing them to see and interact with the prototype. This model includes the following six different sequences of activities (Figure 2):

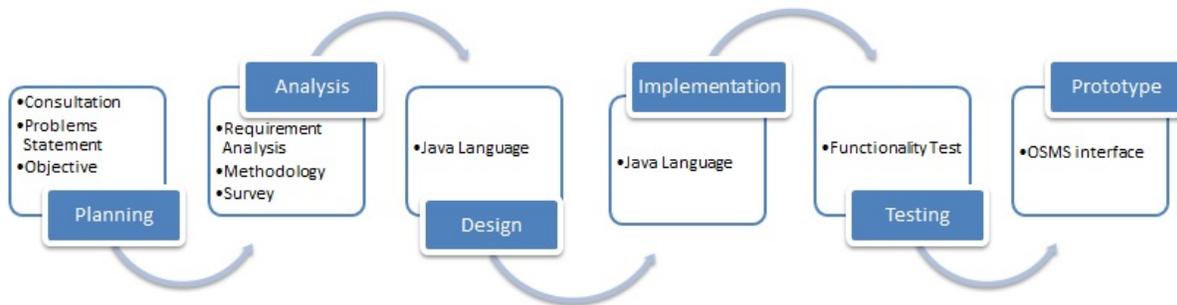


Figure 2. OSMS Development Model

- i. Planning – The project idea builds from consultation with team members and potential users. Ideas from team members and users were gathered and categorized. Within this phase, we also identify the problems in existing application to enhance for this new project. The similarities and differences with existing application as well as the requirement gathering were documented.
- ii. Analysis – The analysis is required to avoid time, budgeting, and developing problem. This is important to understand the flow of the project needs. We took 5 months to accomplish the prototype development with budget as planned. This duration was not including the study for their effectiveness in T&L.
- iii. Design – During this phase, the feasibility of developing the OSMS on desktop platform was determined. This tool will be released as free version for limited time. The Instructional Design (ID) model includes three main modules; Course Overview, Lesson & Practice and E-Book as depicted in Figure 3. In order to develop the constructive learning in self-directed learning environment, we provide six main sub-modules in Lesson & Practice. Three media elements such as text, image and 2-D graph were used. These elements are considered enough to support visual cognitive multimedia learning theories for processing information. Storyboard was created for the user interface (UI) interaction. Some of the UI design mimicking the graphing calculator especially at user data input and graph visualization. However, OSMS use desktop/laptop keyboard instead of device keypad (as in graphing calculator) for entering values.
- iv. Implementation - This phase involved the actual development of the system. The application built by the Java language, including interfaces and the functions. OSMS modules coding was done in parallel followed by modules integration. There were two coding phases:
  - a. Functional Requirement – Coding was implemented for the core functionalities.
  - b. User Interface – The Eclipse IDE (Eclipse Luna framework) is used to handle all OSMS modules in Java programming language.
- v. Testing – This phase is to verify correctness and completeness of this tool. The functional test was used to assess their correctness, consistency, and completeness. This method can identify the missing functionality, interface errors, data structure errors, behavior or performance errors, and termination errors. Throughout testing, we can determine the courseware function according to specifications.
- vi. Prototype – This is the end of the phase in prototype model in methodology. Before end of the system development, prototype must complete and sent to the users for their feedback. The necessary changes and updates were done after receiving users’ feedback. Using prototyping, activity iv-vi is repeated until the final prototype is ready.

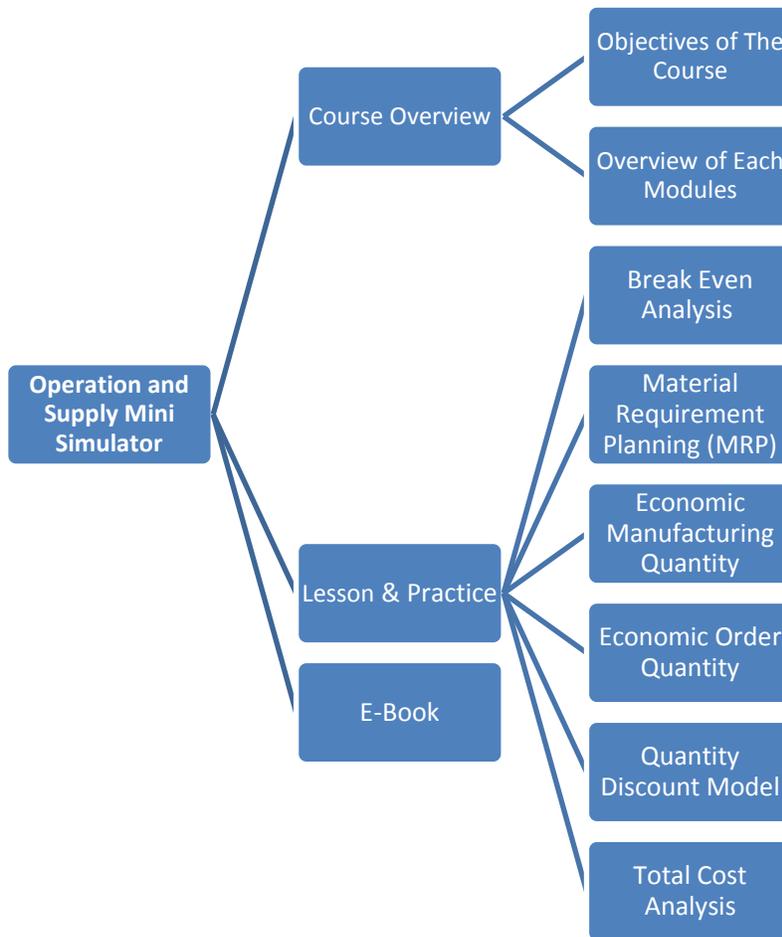


Figure 3. OSMS Modules

## 5. Discussions on the OSMS Development

### 5.1 Pedagogical Issues on OSMS Development

The OSMS was developed using empirical approach and prototyping model. The development process following such development life cycle helped us to plan and execute the OSMS in a more effective manner. OSMS facilitates T&L in Break Even Analysis, Total Cost of Ownership Analysis, Economic Order Quantity, Quantity Discount Model, Economic Manufacturing Quantity and Material Requisition Planning. Thus, two pedagogical objectives on OSMS implementation have been specified; to develop hands-on understanding and to develop analytical skills in topics presented in OSMS. The following instructional events (Gagné, Briggs and Wager, 1992) were focused in OSMS development:

- i. Ability to gain attention – OSMS would be used to attract learners’ attention to learn and participate in classroom activities. Thus, OSMS development would have to dependent on color, graphics and other technical aspects to sustain the learners’ attention and interest.
- ii. Clearly objectives-informed – Each module are provided with objectives before any instruction begins. This is important to help students understand what they are to learn during the course.
- iii. Stimulate recall of prior learning – Instructor would use the OSMS to conduct drill exercises in helping learners to retain their memories.

- iv. Content is presented – the content in each module is simple but comprehensive, appropriate with the learners’ interest and understanding level.
- v. Guided learning – OSMS guides learners to learn step-by-step from one phase of learning to another phase.
- vi. Elicit performance – OSMS would be able to be used for T&L to elicit learners’ performance through the provision of information.

Overall, there is ultimate aim of OSMS development; to create high quality T&L classroom environment especially for the SCM course that involves mathematical calculation and analysis. Being a simple portable Java platform simulator, OSMS provides material for instructor-led training and material for self-directed computer-aided training.

## 5.2 OSMS Advantages

*Simple functionalities:* OSMS is desktop application which restricted to desktop or laptop device. Thus, it is easy application and not requires the implementation of additional functionalities. Minimum requirements are only desktop or laptop with the Microsoft Operating Systems (Windows XP and above) and Java (version 7 and above).

*Fewer physical interfaces:* OSMS only need keyboard and mouse. Due to the keyboard size for both desktop and laptop, the OSMS can be designed more user friendly.

*Low memory usage:* Since OSMS is a desktop application, the idle processes running on a desktop/laptop would not consume a significant percentage of the available memory or battery.

## 5.3 OSMS Snapshot

Using OSMS, students are allowed to simulate six lessons (Figure 3). For brevity, we only demonstrate one of the lesson; the Economic Order Quantity (EOQ). EOQ is used for determining order quantity for independent demand inventory. The order decision is to determine the optimal order quantity (*EOQ*) that minimizes total annual inventory cost (*TAIC*). Figure 4 provides an illustration of calculating the EOQ. Using the OSMS – EOQ module, student could provide any hypothetical situation in which a firm needs to determine the EOQ and reorder time/point to ensure the *TAIC* is minimized. To find the EOQ and all relationships, this formula was programmed in the related module:

$$EOQ = \sqrt{\frac{2RS}{kC}} \quad (1)$$

$$TAIC = APC + AHC + AOC = (RC) + \left(\frac{Q}{2}\right)(kC) + \left(\frac{R}{Q}\right)S \quad (2)$$

Where,

*R* = annual requirement or demand

*C* = purchase cost per unit

*S* = cost of placing one order

*k* = holding rate

*Q* = order quantity

*APC* = annual purchase cost

*AHC* = annual holding cost

*AOC* = annual order cost

Based on the data entered in Figure 4(i), the 2-D graph in Figure 4(ii) shows the relationships between annual holding cost, annual order cost and total annual holding plus order cost after the “submit” button is pressed. At the EOQ (600 units), annual holding cost (\$1,200) equals annual order cost (\$1,200). The figure 4 (ii) also shows, if the order size is smaller than the EOQ, the annual holding cost is slightly lower, whereas the annual order cost is slightly higher. Similarly, if the order quantity is slightly greater than the EOQ, the annual holding cost is slightly higher, whereas the annual order cost is slightly lower. The net effect is a slightly higher annual total cost (*AOC* + *AHC*). Graph in Figure 5

depicts the movement of physical inventory and the relationships of EOQ, average inventory reorder point (ROP) and order cycle (order numbers). The inventory is consumed at 20 units per day. On the 24th day, the ROP of 120 is reached and the firm places its first order of 600 units (at EOQ). It arrives six days later (on the thirtieth day). The 120 units of inventory are will be totally consumed immediately prior to the arrival of the first order. The vertical line on the thirtieth day shows that all 600 units are received (instantaneous replenishment). A total of twelve orders will be placed during the year to satisfy the annual requirement of 7,200 units.

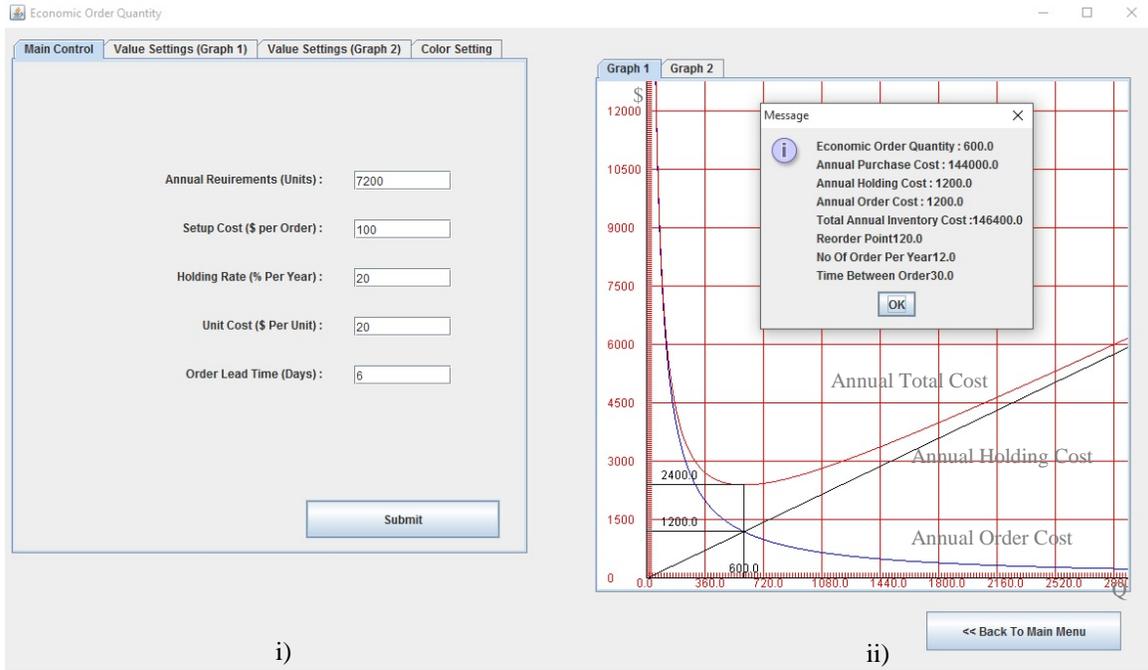


Figure 4. The EOQ Module; i) data fields ii) EOQ and total cost graph

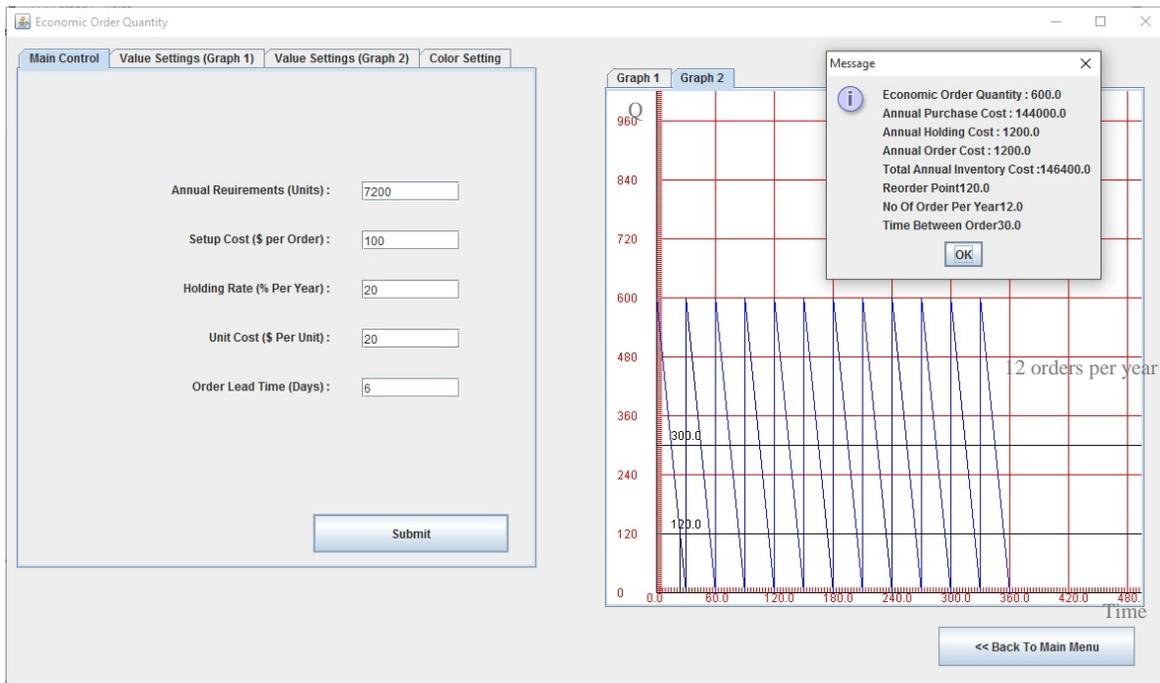


Figure 5. Physical inventory with the EOQ

## 5.4 Summary on the Evaluation Method

OSMS implementation has completed the evaluation phase (Level 1). This after development phase is important to determine and evaluate the final findings. Two types of survey evaluation are used to evaluate the effectiveness of OSMS in (Level 1) and to assess students' learning experience (Level 2). During Level 1 evaluation, questionnaire is provided to assess the effectiveness of the OSMS for improving students' skill in performing correct calculation and analysis. This courseware simulation is tested on students who are currently sitting their end year semester (semester 7 & 8) and enrolling in SCM course at Universiti Kuala Lumpur. They are a group of students who get conventional T&L process ( $X^7$  - control group) and a group of students who is aided with OSMS ( $X^8$  - experiment group). Based on Reeves and Harmon (1993) work, these are the evaluation procedures to ensure the effectiveness of the OSMS:

- i. Ease of use – concerns with students' ability to easily interact with the OSMS (easy - difficult).
- ii. Navigation – concerns with students' ability to move through the OSMS contents in an intentional manner (easy - difficult).
- iii. Cognitive load – concerns with students' ability to, recognize options, think about a choice and take some action to make the choice (manageable - unmanageable).
- iv. Visualization/Mapping – concern with OSMS ability to graphically represent to the students the path through the courseware (powerful - none).
- v. Knowledge space compatibility – concern with students' ability to receive information that fits into his/her current understanding of the topic (compatible - incompatible).
- vi. Information presentation – concern with students' understanding on the presented information (clear - dull)
- vii. Aesthetic – concern with students decision whether the OSMS has appealing value or not (pleasing - unpleasant )
- viii. Media integration - concern with how well the OSMS integrates all media form to produce effective presentation and performance (coordinated – clumsy)
- ix. Overall functionality – concern with OSMS perceived utility to meet the learning objectives for students' learning (highly functional - flawed)

Level 2 evaluation will measures students' learning experience regarding the ability of the OSMS to increase their understanding in subject. Result of these two evaluation studies will be reported in future works.

## 6. Conclusion

The OSMS development process has been proposed to bring out an empirical approach and prototyping model for simulation-based application development. Simulation-based software learning could be built following OSMS development for quick development process. The development life cycle includes the following phases; planning, analysis, design, implementation, testing and prototype. The OSMS has been thru the functionality testing and the quick development process indicates that the proposed development could help project managers and software developers to efficiently execute projects on time.

## Acknowledgements

We would like to thanks Universiti Kuala Lumpur, Universiti Teknologi MARA and all those involved in this study either directly or indirectly.

## References

- Ellis, S.C., Goldsby, T.J., Bailey, A.M., & Oh, J.Y. (2014). Teaching Lean Six Sigma within A Supply Chain Context: The Airplane Supply Chain Simulation. *Decision Sciences Journal of Innovative Education*, 12(4), 287-319.
- Gagné, R. M., Briggs, L. J., & Wager, W. W. (1992). Principles of instructional design (4th ed.). Forth Worth, TX: Harcourt Brace Jovanovich College Publishers.
- Hassan, M. M., (2016). *Courseware Teaching and Learning System for Supply Chain Management*. (Undergraduate Thesis), Universiti Kuala Lumpur, Malaysia.
- Hidayatno, A., Moeis, A. O., & Raditya, R. (2014). Development of Simulation Game for Teaching Strategic and Operational Aspect of Production System.

- Horton, R. M., Storm, J., & Leonard, W. H. (2004). The graphing calculator as an aid to teaching algebra. *Contemporary Issues in Technology and Teacher Education*, 4(2), 152-162.
- Lau, A.K. (2015). Teaching supply chain management using a modified beer game: an action learning approach. *International Journal of Logistics Research and Applications*, 18(1), 62-81.
- Lindstrom, R. . (1994). *The Business Week guide to multimedia presentations: create dynamic presentations that inspire*. . New York: McGraw-Hill.
- Merkuryev, Y., & Bikovska, J. (2012). *Business simulation game development for education and training in supply chain management*. Paper presented at the 2012 Sixth Asia Modelling Symposium (AMS).
- National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics (Vol. 1). *National Council of Teachers of Mathematics*.
- Othman, S. N., & Mustaffa, N. H. (2012). Supply chain simulation and optimization methods: an overview. In *Intelligent Systems, Modelling and Simulation (ISMS), 2012 Third International Conference on* (pp. 161-167). IEEE.
- Reeves, T. C., & Harmon, S. W. (1993). Systematic Evaluation Procedures for Interactive Multimedia for Education and. *Multimedia computing: Preparing for the 21st century*, 472.
- Sommerville, I. (2015). *Software Engineering*. International computer science series. ed: Addison Wesley. 10<sup>th</sup> Edition.
- Tan, C.K. (2012). Effects of the application of graphing calculator on students' probability achievement. *Computers & Education*, 58(4), 1117-1126.
- Tan, C.K., Tan, C.P., Razak, S.F.A., & Ling, L.S. (2013). Undergraduate Students' Perceptions toward the Graphing Calculator Instructional Approach. *Communications of the IBIMA*, 1.
- Wisner, J.D., Tan, K.C., & Leong, G.K. (2014). *Principles of supply chain management: a balanced approach*.: Cengage Learning.
- Wu, D. Y., & Katok, E. (2006). Learning, communication, and the bullwhip effect. *Journal of Operations Management*, 24(6), 839-850.

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