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An Application of a Manufacturing Activity Simulation Board for Teaching Product Costing*

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This paper presents a feasibility study of using a manufacturing activity simulation board as a teaching tool for product costing. The manufacturing activity simulation board has been developed for teaching product costing in a virtual manufacturing setting. This setting and goal of the board has been designed to appeal to engineering students based on the basic principles of cost accounting. Hands-on manufacturing activities are incorporated in order to enable the user to be familiar with cost accounting between manufacturing activities and their costs. In this research, we tested the feasibility of introducing the use of the simulation board in the regular cost engineering course. Preliminary evaluations indicated that the board could be successful in achieving these objectives.

Keywords: simulation board; manufacturing activity; manufacturing cost; cost accounting; learning activities; engineering education

1. Introduction

There is an increasing emphasis in engineering education of the importance of product costing since it provides cost information about products that is useful to managers for planning, controlling, making continuous improvements, and decision making [1]. For this purpose, many engineering schools have developed a cost engineering course to help engineering students become familiar with product costing. Teaching costing accounting to engineering students, however, has been challenging because most learners' background is engineering or related field.

The customary approach used to teaching product costing to engineering students has been through the use of lectures and practice set questions. The content of the cost engineering course is suitable for management majors who require understanding and application of financial concepts. Therefore, the current cost engineering course to introduce product costing does not attract engineering students' interest and engage them in the learning process effectively. For engineering majors, the content needs to be designed to more focus on an understanding of basic costing concepts and practical ways of applying costs in a manufacturing environment.

Students generally learn material better when they engage actively with the subject matter and if their interest is stimulated [2]. This can be especially useful in helping engineering students gain an intuitive understanding of many costing concepts. Therefore, effective teaching tools that may help to achieve the necessary learning outcomes appear to be a natural choice for instructors and students. The only use of lectures and practice set questions is not enough to provide clear explanation to engineering students and often fails to generate students' active participation.

Simulation games provide a place where learning arises as a result of conducting the tasks provided by the content of the game [3, 4]. Educational games are specifically designed to teach students about a certain subject or assist them in learning a skill through developing a degree of user engagement which could be usefully harnessed in an educational context. As they play the game, knowledge and skills are developed through the content of the game [5]. Therefore an effective teaching method for cost accounting is to integrate the use of the simulation game into a formal learning setting [6–9].

In order to accomplish this goal, it was felt that there was a need for developing a simulation tool used as a teaching aid to engage the interest of students and help them aid gain a qualitative understanding of costing concepts as efficient a manner as possible. Because of the necessity to determine costs on goods produced, it was felt that relationship of manufacturing and cost accounting needed to envision easily. With this in mind, the manufacturing activity simulation board was designed for teaching product costing with hands-on production activities in a virtual manufacturing setting. This setting and cost accounting were carefully designed to appeal to engineering students. The manufacturing activity simulation board presented in this article is a hands-on tool for conducting both production activities and cost accounting at the production level. It currently comprises a manufacturing task board, a cost allocation board, and bookkeeping books.

To explain each component of the manufacturing activity simulation board, the remainder of this research paper is organized as follows. First, a

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survey of teaching aids related to this research area is presented. Second, a design basis for cost accounting that targets engineering education will be described. Third, it is shown how the design basis is implemented into designing a manufacturing activity simulation board and that its implementation is outlined. Thereafter, results from pilot tests of the board and overall benefits are reported. This paper ends with the limitation of using the simulation board and some conclusions.

2. Accounting games for experiential learning activities

A simulation board game is a game played with counters or pieces that are placed on, removed from, or moved across a board with a specifically marked surface [10–13]. Frequent subject matters for the board games are teaching fundamental aspects of personal finance, investing and accounting to children [14–15]. In particular, accounting games in the education can be found in various forms. Uncommon Courtesy [16] and Bingo Card Creator [17] make accounting principles bingo cards, which includes bingo cards with accounting terms on them. The game requires players to figure out the answers to questions to choose the correct bingo square to play. The Balancing Acct offers a board game that teaches how the accounting equation works, and familiarizes players with accounting terminology and typical business transactions [18]. SmartPros offers a more sophisticated version of Accounting Monopoly that a basic Monopoly ™ game board and pieces are turned into [19, 20]. The properties in Monopoly are bought and sold by players, and transactions, along with cash holdings, are recorded day to day in a classroom setting, to teach basic accounting and bookkeeping principles to students. Similarly Koo [21] offers an accounting game which applies accounting theory which includes sale and operating of the gas station. The accounting simulation enables students to gain real-world experience in running a business using accounting principles by putting the student in the role of a business owner where he/she can directly experience the impact and importance of accounting in a business.

There is virtually unanimous agreement by simulation game developers that simulations have a high potential to integrate concepts of the same discipline or from different disciplines [22, 23]. 71% of the user respondents reported that one reason for adopting the simulation was to give the course an integrative multi disciplinary element and that 76% of the user respondents reported that their expectations on this objective were achieved or exceeded [24]. Chang et al. [25] analyzed the effectiveness of a management simulation game for 93 students and acquired that the game was very useful tool for studying. Barry and Hodgman [26] designed a tactical simulation board game and indicated that the game complemented traditional quantitative learning tools from preliminary play testing with undergraduate students. They realized that learners were actively and intensely involved in learning process by strong interaction between teachers and learners throughout playing the game. Thus, adopting a simulation game in class can be an effective way of facilitating the learning process of complex and theoretical theories. However, none of the accounting games introduced in this survey has directly dealt with cost accounting for engineering students.

3. Manufacturing activity simulation board

3.1 Design basis

This research targeted development of a manufacturing activity simulation board as a teaching aid for a regular cost engineering course. Therefore, design basis for the manufacturing activity simulation board are required. A design basis for the manufacturing activity simulation board that targets engineering education will be described.

Engineering students usually needs to understand the basic costing concepts and practical ways of applying costs in a manufacturing environment. Therefore the first issue in developing the manufacturing activity simulation board is to choose the basic costing concept out of cost accounting most engineering students need to learn about. The cost accounting concepts used in the simulation board are determined to be suitable for teaching students in the engineering domain. The basic concepts of cost accounting starts with three basic steps: 1) accumulate costs within a production or nonproduction department, 2) allocate nonproduction department costs to production departments, and 3) allocate the resulting production department costs to various products [27]. Cost accounting allocates costs based on single-volume measures such as direct-labor hours, direct-labor costs, or machine hours. While using a single volume measure as an overall cost driver seldom meets the cause-and effect criterion desired in cost allocation, it provides a relatively cheap and convenient means of complying with financial reporting requirements [28, 29]. In addition, most manufacturing companies have still used such cost accounting to estimate product costs [30]. The cost accounting applied in the board adheres on above typical cost accounting concepts.

The second issue in developing the manufacturing activity simulation board is to take advantages of the method of role-taking and game playing,

which enables students gain a quick appreciation of the concepts and principles of related subjects [31–33]. Therefore, hands-on manufacturing activities are required to learn the relationship between manufacturing activities and cost accounting. For role-taking and game playing, three persons are assigned as a team in the game. Each person assigns one out of three roles: an accountant, a production manager, and an assembler. The outlined design basis may be disputed as a teaching aid to improve the learning process. The feasibility of applying this board to engineering education will, however, be discussed later after the pilot test on student groups.

3.2 Manufacturing activity simulation board

The manufacturing activity simulation board is composed of three primary modules: (1) a manufacturing task board with business forms and cost cards for collecting cost elements and assembling two types of products, (2) a cost allocation board for visually showing three steps of product costing, and (3) bookkeeping books for recording entire cost transactions.

3.2.1 Design of manufacturing task board with business forms and cost cards

The manufacturing activity simulation board starts with the manufacturing task board with specifically designed activities flows between well known manufacturing departments as shown in Fig. 1. The manufacturing task board is designed with the eight departments for a participant to conduct manufacturing activities, including production control, design, quality control, production, supply, purchasing, human resources, and accounting department. A part supplier is located in the outside of the board to show logistics between the purchasing department and the part supplier. The production area is where the game participant assemblies parts in the parts warehouse and stores final products in the finished products warehouse. The game participant follows the arrows pointing at the next department on the board and conducts a task on each department.

On the manufacturing task board, there are locations for simplified business forms or cost cards. The business forms play an educational role in presenting a game participant with a normal task of each department and require him/her to fill out the form in order to keep transaction records. For example, the production plan form in the production control department is used to record the monthly volume of each product for production (in most cases, the volume is given for simplicity). The production order form is used to deliver a daily

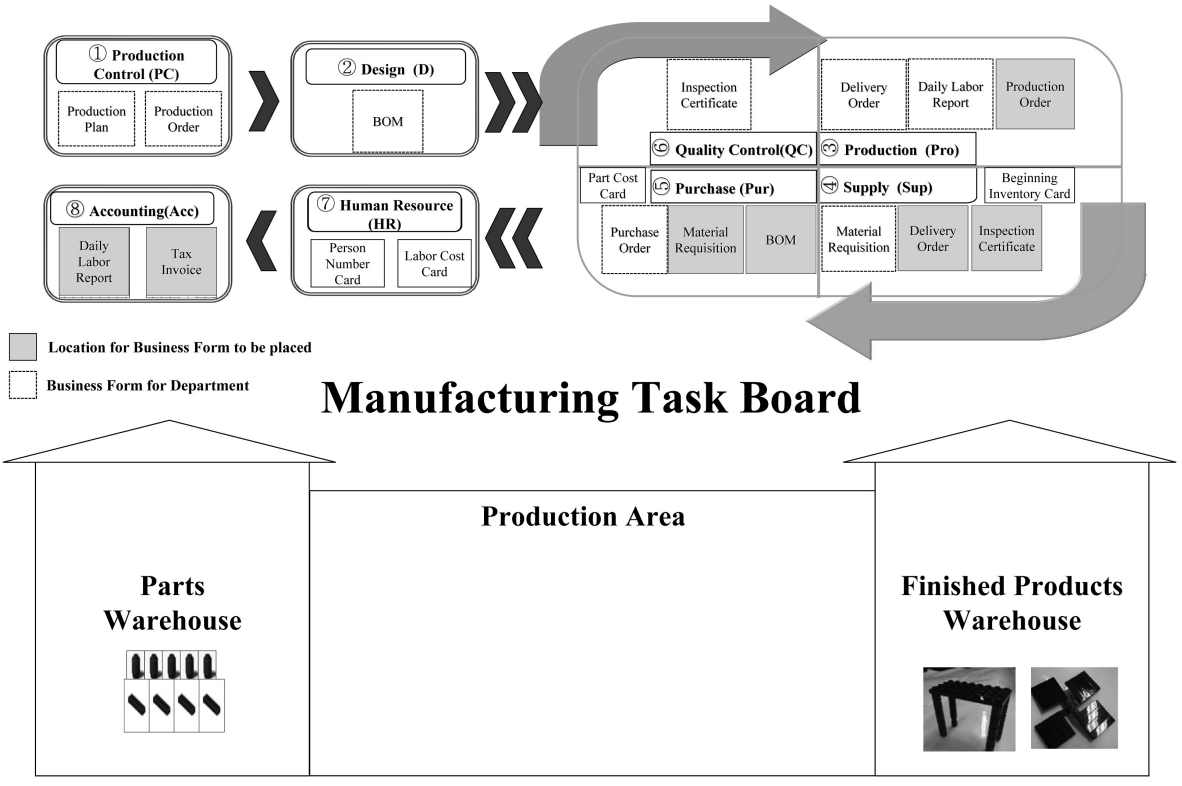

Fig. 1. Manufacturing task board for the manufacturing activity simulation.

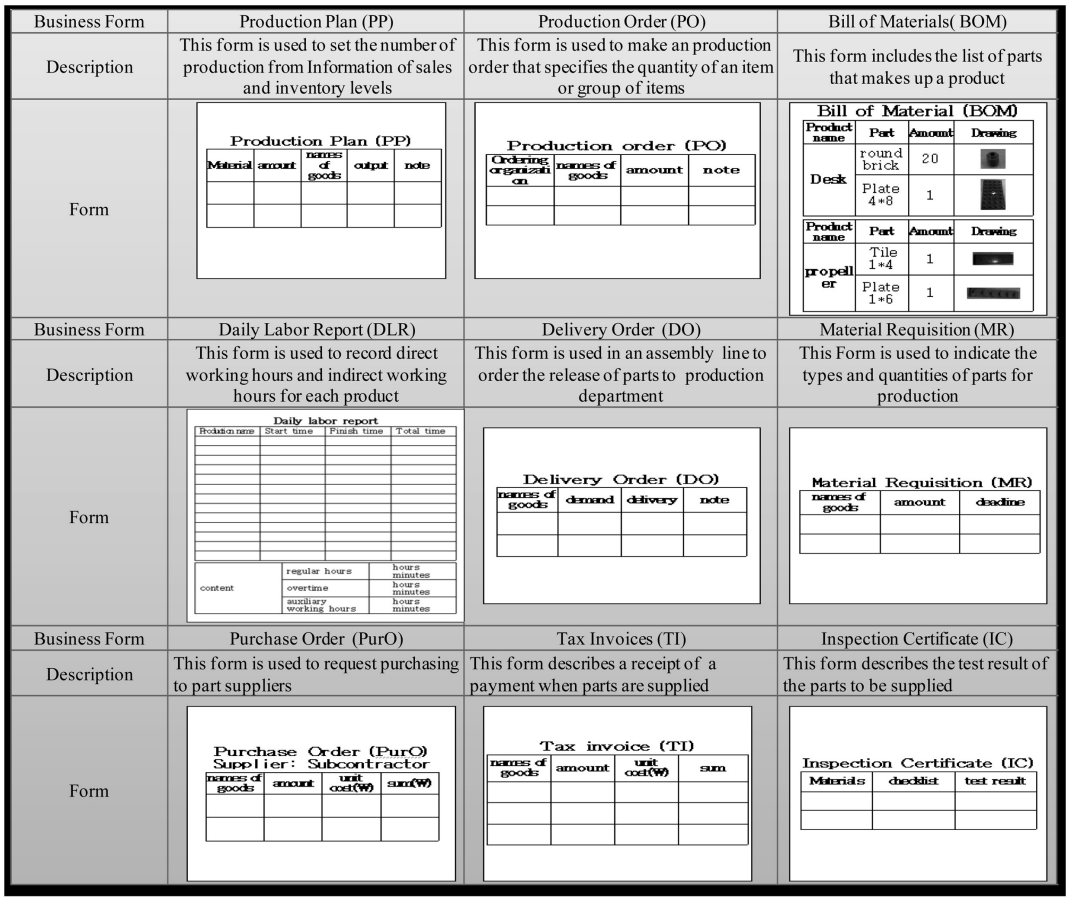

Fig. 2. Business forms for the manufacturing activity simulation.

production plan to the production department. In the case, a game participant writes a calculated daily production volume in the form and passes it to the production department. Those tasks in the board are conducted by one participant called a board manager. While conducting manager's tasks, the board manager assigns the tasks making finished products to another participant which is called an assembler. After finishing all the tasks, the last person collects cost cards and plays an accountant in the board. Tasks associated with making finished products are conducted by another participant called an assembler. A parts supplier are located outside the board providing parts with a tax invoice form and a cost card. In particular, the daily labor report form and the tax invoice form should be precisely recorded since they mostly affect accuracy of product costs. Fig. 2 illustrates business forms used in the manufacturing task simulation

After performing manufacturing tasks assigned on each department, the board manager picks up cost cards in a cost card container which stores cost data related to each department. For example, a base-stock card has information of the beginning inventory of parts, and a cost card is used to determine the cost of parts to be purchased from a parts supplier. Fig. 3 illustrates cost cards used in the game. Those forms and cards are circulating around on the board according to the simulation flowchart as illustrated in Fig. 7. By conducting manufacturing tasks, participants get to know where cost information incurs.

3.2.2 Design of the cost allocation board

The cost allocation board is designed to visually determine cost distribution rules of the manufacturing department and allocate costs into individual products. According to the cost accounting principles [28, 29], a cost center is a business unit that is only responsible for the costs that it incurs. The costs incurred by a cost center may be aggregated into a cost center (cost pool) and allocated to other business units depending on causal relationship. Those cost centers can be classified into an engineering center, a direct and an indirect service center, and a manufacturing center. Each department in the board belongs to one of the cost centers as shown in the top of Fig. 5. The costs collected in the manufacturing task board are aggregated in the top of this board and are allocated to the individual product costs in the bottom of the board.

The cost calculating flow diagram has three steps

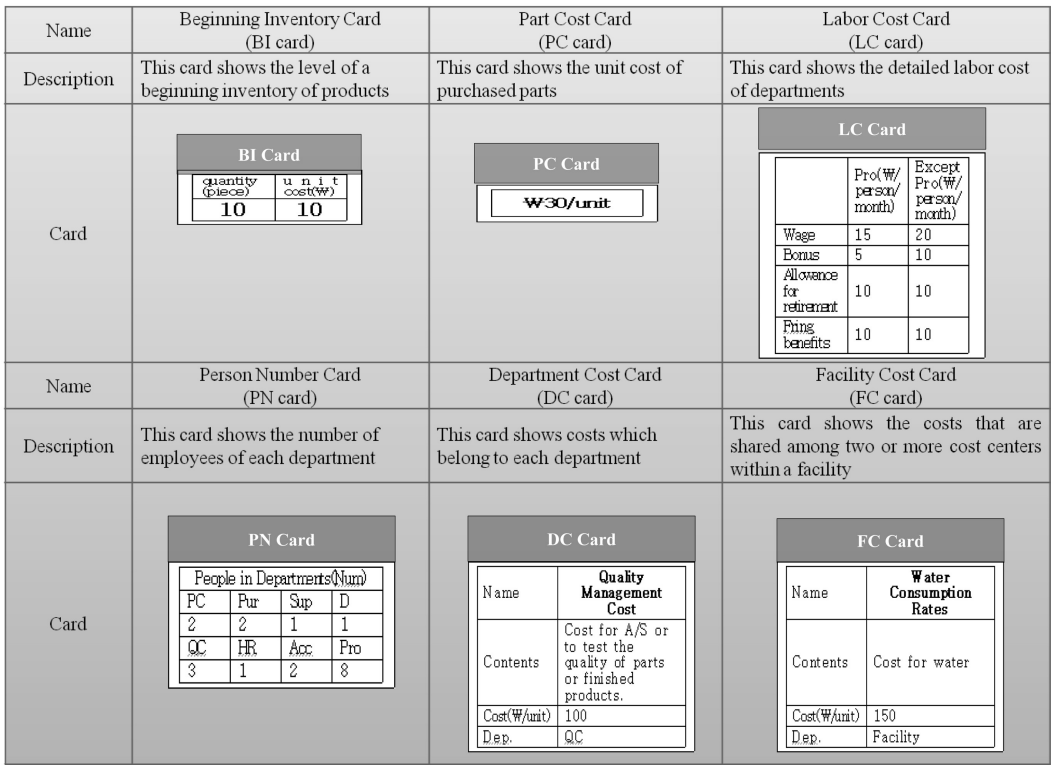

Fig. 3. Cost cards for the manufacturing activity simulation.

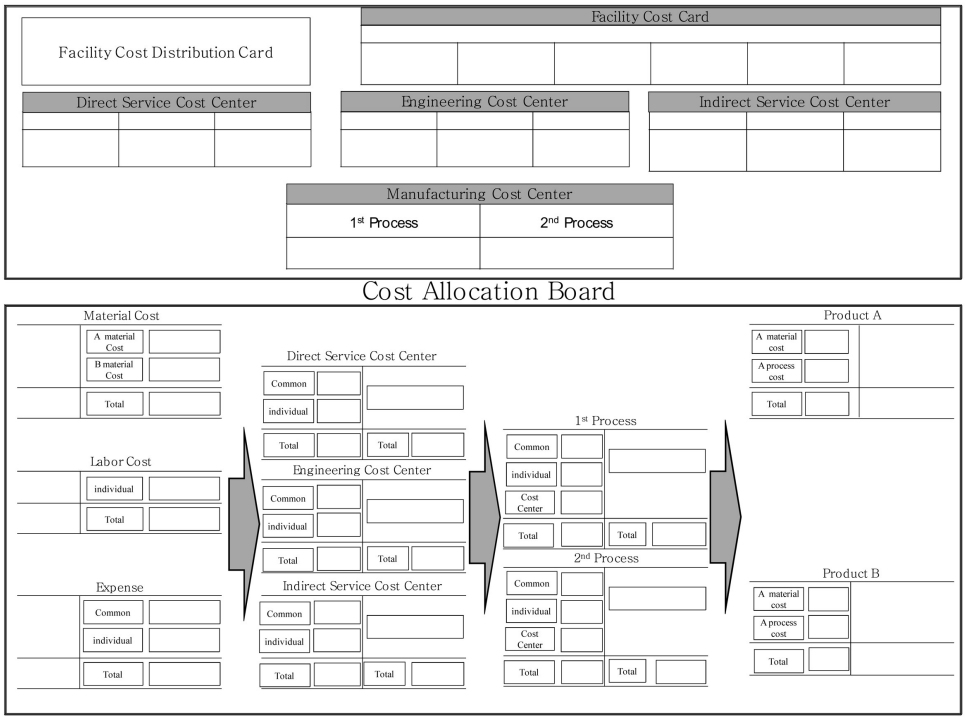

Fig. 4. Cost allocation board for cost allocation to each product.

for participants to be easy to follow cost allocation processes as shown in the bottom of Fig. 4. The cost distribution rules are selected among cost distribution cards in the cost container.

3.2.3 Design of bookkeeping books

The bookkeeping books as seen in Fig. 5 are designed as a supplement tool to record every cost transaction during playing manufacturing activity

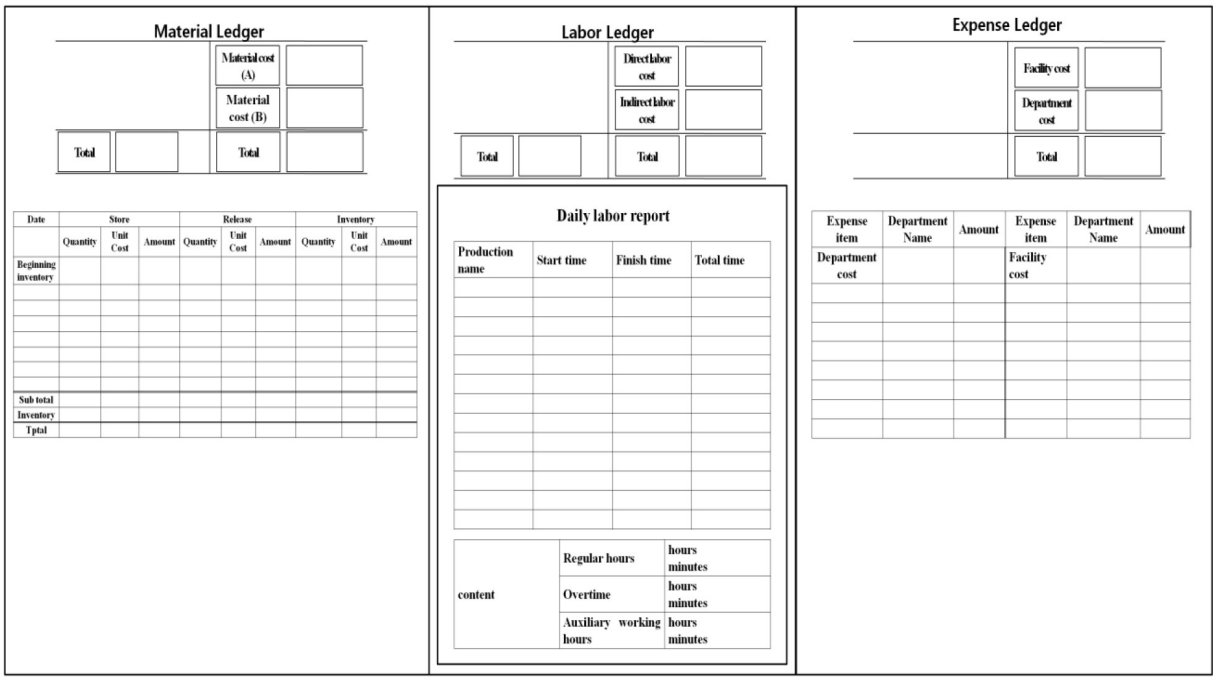

Fig. 5 Bookkeeping books to record cost transaction.

simulation. In the bookkeeping book, the material ledger plays a basic role in recording the parts cost of carrying in from the supplier and release to the production department. The labor ledger is used to calculate direct and indirect labor costs with the labor cards selected by a participant. The expense ledger is used with a subsidiary ledger to record the department expenses and facility overhead costs. In addition, each page in the book has an example case for an illustrative purpose. The books help participants to experience and apprehend entire costing flow in a practical way.

3.3 Simulation implementation

The manufacturing activity simulation board needs three persons as a team to run the entire boards. The first person is a production manger (A) in charge of running the manufacturing task board by filling out business forms and picking up cost cards. The second person (B), as an assembler, makes parts to finished products and records the time of assembling parts in a given form. Another role of (B) requests parts by sending a corresponding form to (A) and receive them from the part supplier (D). The last person's role is to place cost cards on the cost allocation board and record entire transactions in the bookkeeping book as an accountant (C). Several teams can conduct the manufacturing activity simulation at the same time. In the case, only one part supplier (D) is required due to providing parts to several teams. Normally, a teaching assistant (TA) plays such a supplier's role since he/she can confirm what a team is playing right or wrong by observing the flow of parts. Two products are assembled by each team for product costing.

The entire role playing flowchart is shown in Fig. 6. The production manger (A) conducts the tasks given in the departments on the board. The manager starts with writing a production plan (PP) and a production order (PO) in a row and sends them to the supply and the manufacturing department (1&2), respectively. And then, the manger moves to the design department, checks the BOM for assembly, and sends it to the purchasing department (4). When the manager receive an delivery order (DO) from the production department (10), the manager fills up a material requisition (MR) and send it to the purchasing department (11). In the purchasing department, the manager fills up a purchase order (PurO) based on a material requisition (MR) and send it to the parts supplier (12). The supplier provides parts, selecting a part cost card (PC) and a tax invoice (TI) (13&19). The unit cost of a part is determined by a part cost card (PC).

The purchased parts are sent to the quality control department in which a quality test is conducted and an inspection certificate (IC) is issued (14). The certified parts go through the supply department to the production department (15&16). Those manufacturing activities are repeatedly conducted until the quantity of products is matched with a production plan (PP).

The last step of manufacturing tasks is to go to the human resource department where the number of

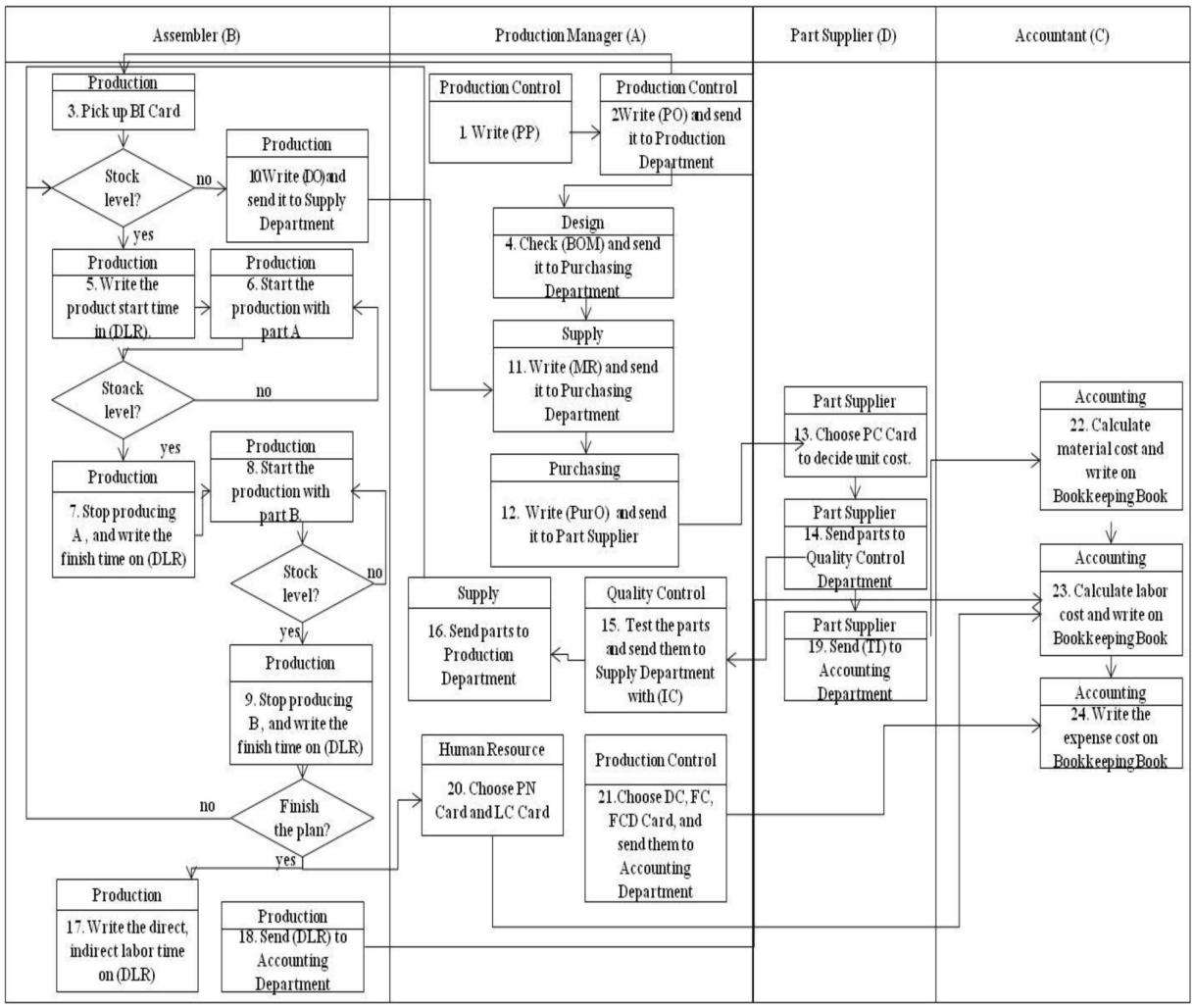

Fig. 6. Role playing flowchart for cost simulation.

person and labor cost are selected among person number cards (PN) and labor cost cards (LC) (20). Before moving to the cost allocation board, the manager chooses a department cost (DC), a facility cost (FC), and facility cost distribution (FCD) card (21). Those cards are placed on the cost allocation board to see related costs visually. Those tasks allow participants to understand manufacturing activities from setting up a production plan to acquiring parts from the supplier.

While the manager is conducting manufacturing tasks, the assembler (B) records his/her assembly starting and finishing time of each product in the daily labor report (DLR) (17) while assembling parts to finished products (5–9). In this task, direct and indirect labor hours are measured with a time watch and sent to the accounting department (18). The base stocks are in the warehouse whose amount is selected from the beginning inventory (BI) card (3). When the parts in the warehouse decreases to a definite number, then the assembler stops assembling and sends a delivery order (DO) to the production manager (10).

The accountant (C) places cost cards on the cost allocation board and records entire transactions in the bookkeeping book while tasks are conducted by the production manager (A) and the assembler (B). A tax invoice card (TI), which is received from the supplier (D), informs material cost (22). Labor cost is calculated with the daily labor report (DLR), the person number (PN) card and the labor cost (LC) card (23). Expenses are calculated with DC, FC, and FCD cards (24).

4. Preliminary evaluation

Preliminary evaluation of the manufacturing activity simulation board has been conducted to determine whether it can be used as a teaching aid to engage the interest of students and help them gain a qualitative understanding of cost accounting. Towards this end, the participating students were

chosen based upon their performance of the final exam. The final exams were made up of two Sections A & B: Section A for questioning basic terminologies of accounting concepts and Section B for questioning industry cases. The questions of Section B were designed to do hand calculation to find final answers. A comparative profile of the two groups was developed using test scores as their main performance indicator in section B.

The participating students were selected among those who achieved lower performance in Section B. The primary reason we chose the participating students only from the test result of Section B is that we assumed that differences in the educational environment has only a negligible effect in the course performance of Section A . The only students who understand costing concepts can find the right answers to the questions of Section B.

From the result, the participating students were divided into two groups A and B. In Group A, approximately 15 students whose test score are below 50% were selected out of some 50 enrolled in the cost engineering course, and 10 students agreed to participate in the evaluation. Group B was those who accepted this test among 10 students whose test score are above 80%. Table 1 shows the number of students and their average test score of Section B.

The experiment was conducted just after the final exam. The treatment group, as Group A, was taught for two days in a row using only the manufacturing activity simulation board as the dominant delivery method. Only the game manual was given for the test period, and a teaching assistant checked whether or not they recorded transactions and calculated cost elements correctly as the example illustrated in the bookkeeping. The control group, as Group B, simply took the exam since we assumed that they were already familiar with the cost accounting.

Both groups were given a standard exam selected from part 3 of the CMA (Certified Management accountant) for assessing the effectiveness of manufacturing activity simulation board. The test questions selected from CMA were industry case problems including hand calculation, and their scores were quantified as a main performance indicator. The results of the preliminary testing are shown in Table 2.

Test score placed Groups A and B at 55 and 75, respectively. Before using the game, the average test score for Group A was 40 while that for Group B was 91. The difference of final exam for Groups A and B is 51. After the experiment, the difference of CMA for Group A and B is reduced to 20. The scores shown are that average test score of Group A are improved from 44% to 73.3% based on 100% of Group B, which raises 29.3% up. This preliminary testing result suggested that the use of simulation game resulted in observed learning outcomes that are significantly different to that of a traditional teaching method.

The most significant observation was made towards the end of the test. We provided the treatment group with different accounting cases that require different ways to calculate in order to help them learn more costing skills. In the simulation, they had to handle different accounting methods with only a written sample case without explanation. They put in extra hours to figure out what was different and how to account it through interactive group discussion which did seldom happen in class. It is to support the evidence to suggest that the use of this simulation board can reinforce self learning that leads to significantly different testing results to that of traditional one-way teaching methods such as lectures and practice set questions.

To test the feasibility of applying the manufacturing activity simulation board with a larger sample size, we conducted the second test on all the students taking the same lecture in the fall semester (2011).

Table 1. Final testing results in the fall semester (2010)

	Total	Group A	Group B	Difference
Number of students	50	15	10	5
The number of Participants	16	10	6	4
Average Test score	61	40	91	51
Converted Average Test score	–	44%	100%	–

Table 2. Preliminary testing results of the CMA in the fall semester (2010)

	Group A	Group B	Difference
Number of students	15	10	5
The number of Participants	10	6	4
Average Test score	55	75	20
Converted Average Test score	73.3%	100%	–

Table 3. Testing comparison between two consecutive semesters

	The first test (2010)	The second test (2011)	Difference
Number of students	50	63	13
Average Test score of Section B	61	75	14

The difference of the second test with the first test is that all the students conducted the simulation right after a new costing subject was learned. They had conducted the simulation repeatedly with different costing concepts. In the second test, we provided the students with the simulation right after giving them different costing lectures. The simulation board was indeed used as a teaching tool at this time. The final exam given to the students consisted of the same questions as before. We compared the final exam of the second test with that of the first pilot test. The final comparison is given in Table 3. As seen in Table 3, we had the consistent result that the use of the simulation board resulted in observed learning outcomes that were significantly different to teaching costing without it.

We analyzed the learning effectiveness of the cost simulation board using unstructured interviews. The qualitative observation by interview confirmed that those participants were actively involved in learning process because manufacturing activities entailed cost consequences, such as making products faster, choosing lower cost elements, etc. In addition, the majority of students claimed to help them better understand cost accounting with the cost allocation board that visually illustrates the relationship between manufacturing activities and their cost transaction.

Some responses to the interview are given as follows:

- I better know a manufacturing task flow and its corresponding cost information.
- I better know the role of business forms required for manufacturing tasks.
- I better understand relationship between costs and manufacturing tasks by purchasing and assembling parts in person.
- I better understand product costing by hands-on bookkeeping and comprehend different costing cases.
- I better know the concept of cost centers by changing distribution rules.

5. Conclusion

This paper presents a feasibility study of using a manufacturing activity simulation board as a teaching tool for product costing. This setting and goal of the board is designed to appeal to engineering students based on the basic principles of cost accounting. However, there are some limitations of this study. The proposed cost simulation board does not include every aspect of cost accounting which requires a much more complex manufacturing tasks, making the board conceptually too difficult for most students. Traditional cost accounting adopted in this simulation board for collecting and accumulating costs does not convert these costs into useful managerial information. Activity-Based Costing (ABC) is a better way of costing because it focuses on the work activities associated with the business operations. However, most companies still use the traditional cost system to estimate product cost because it provides a relatively cheap and convenient means of complying with financial reporting requirements

Since the main purpose of this simulation board is to provide engineering majors with the basics of cost accounting, the board is focused on providing hands-on experience and practice of estimating product costs based on the fundamental principles of the traditional cost accounting that students should have keep in mind. It requires students to do hands-on bookkeeping during conducting the simulation board. Once the fundamentals are understood, it is much easier for an instructor to then provide students with additional costing examples by using the simulated business as a context

During evaluating learning effectiveness of the cost simulation board, we found that students recognized the simulation board as making a positive contribution to their learning behavior. Such a positive feedback is a powerful tool that encourages a willingness to learn and creates a sense of excitement around the learning process. It leads the majority of student to be willing to put in extra hours to think about how it works. Indeed, it is to support the evidence to suggest that the use of this simulation board can reinforce self learning. Therefore we concluded that interactive learning using the board is the more efficient way to engage students in the learning process and the self studying.

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