

DEVELOPMENT OF BASE SUPPLY CHAIN COLLABORATION GAME

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ABSTRACT

Many books describe Supply Chain Collaboration (SCC), an important idea in the business world. Numerous successful examples of SCC are described in these books. Basic contents of teaching SCC at a university are explanation of SCC's theory and successful case studies. Moreover, some teachers use SCC computer games in the lecture as educational assistance. Regarding development of a SCC computer game themselves, the more they want to teach SCC knowledge, the more the computer game becomes complicated. These circumstances are satisfied by teachers, but students might feel embarrassment. Students, except some very good students, assume that managing SCC theory and many parameters for operating SCC computer game are extremely difficult, such that they can not be used. To resolve these misunderstandings, the authors developed simple SCC analogue games. As described in this report, the basic idea of BASE SCC games and the educational effectiveness of applying SCC games to the lecture of SIIT Thammasat University are introduced.

INTRODUCTION

In this era of globalization, competition in the manufacturing sector is becoming increasingly severe. Since the manufacturing process and number of parts have become more complex, it has become rare to treat every process at a single company. Recently, companies are incorporated into a chain that includes raw material suppliers, manufacturers, wholesalers, and distributors to the customer. They are independent companies, but share useful information related to quantity, quality, manufacturing progress, lead time, and delivery. Forming supply chains brings those companies great benefits. They must repeat price competition continuously and lose corporate power gradually if they do not collaborate at all. These ideas, originally called Supply Chain Management (SCM), have been argued from the late 1990s. Lambert et al. (1997) and Copacino (1997) are regarded as the originators of the concept. SCM respects collaboration, whether internal or external. Stank et al. (2001) specifically examined the importance of collaboration designated as "Supply Chain Collaboration (SCC)." Ireland & Crum (2005) proposed practical methods for how

to install SCC throughout consideration of Collaborative Planning, Forecasting and Replenishment (CPFR) guidelines. Ireland and Crum pointed out four important essential elements of SCC: Agree, Execute, Educate, and Share. Recently, the authors have identified many papers using SCC ideas used with SCM.

The authors have been developed many business games since 2007 (Hamada et al., 2013). In 2011, new business games of Supply Chain were developed based on the demands of the Supply Chain Management course, School of Management Technology, Siridhorn Institute of Technology (SIIT), Thammasat University. The use of business games in higher education has a long history and experience. According to Faria et al. (2009), the origin of simulation games for educational purposes can be tracked more than 5,000 years (Wolfe, 1993). Faria (1998) found that 97.5% of AACSB member schools were using business games. Business games have become widely used in higher education. In terms of manufacturing game development, Reed (1974) has already pointed out manufacturing-related games have been developed since the 1960s and confirmed their use in 1963. Following growth of the manufacturing industry, manufacture business games have also been improved.

Badurdeen et al. (2010) counted such games and found 40 similar games; 75 percent of them include real processes of manufacturing, from raw materials to products. In terms of SCM-related business games, SCM has already been recognized as a big issue at the ISAGA Annual Conference in 2001 (Spindler and Leigh, 2002). Zhou et al. (2008) examined the Beer Game and developed a four-step internet based Supply Chain Simulation Game. Kiekintveld et al. (2004) created the Supply Chain Management Game to attend an event called the Trade Agent Competition (TAC). However, those works are highly theoretical. Few descriptions exist in terms of education of students. Leger et al. (2010) proposed the Enterprise Resource Planning (ERP) Simulation Game. Medical Services related SCM have been realized as games by Po and Deng (2010) and by Ma and Po (2011). However, few experiences exist related to exploration of SCM ideas in engineering education. Therefore, the authors infer that SCC games in engineering education without using computers are a rare case for trial.

BASE SUPPLY CHAIN COLLABORATION GAMES

Students study diligently and acquire much knowledge of Supply Chain Collaboration and Inventory Control through university lectures. This knowledge has high specialty and difficulty. It is taught by teachers as a traditional lecture style in general. The authors assume that it is possible for students to understand Supply Chain Collaboration and Inventory Control as knowledge, but it is difficult to understand them as experimental. To provide opportunities to learn them as experimental, the author created BASE business games of two types: “Supply Chain Collaboration Game (SCC game)” and “Supply Chain Collaboration 2 Game (SCC2 game).” These games are a simple model of smartphone manufacture. They have only two layers of industry type, e.g. one assembler and part suppliers, and only part suppliers of two types, e.g. a Motherboard and Display. They are the simplest model of SCC. These business games require that players form teams and operate a mock-up company. They can understand and manage cash accounts, fixed costs, operations, inventory control, strategy, risks, and finally, supply chain collaboration as an extended concept of Supply Chain Management experimentally through the SCC games. The authors also know that understanding of multiple supply chains is necessary in the real business world, but only a few businesspersons are engaged in operation of multiple supply chain collaboration. However, almost all businesspersons need to know the concepts of supply chain collaboration. Therefore, the authors assume that SCC games are sufficient for application to the university’s lectures.

Figure 1 presents an SCC game outline. Players operate Smartphone Manufacturers and create smartphones comprising a motherboard and a display. Then they sell them in the market.

Figure 2 presents the SCC game flow. The period of the game is one year, which is divided into 12 months. One

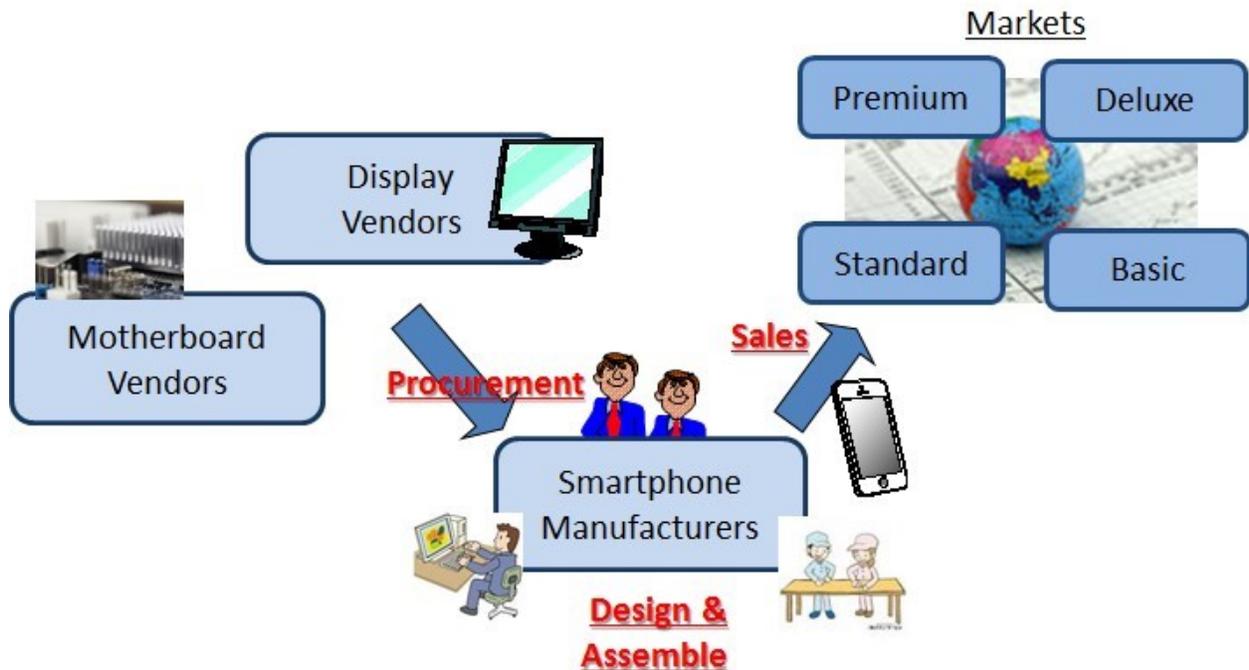
month is the minimum time scale. Players who want to sell a smartphone must decide many actions in order “Sell a Smartphone,” “Assemble,” “Procurement,” and “Payment.” They must spend three months from procurement to sales. This procedure teaches players to allow lead time for making product and prevents players from mistakes such as operating with “Procurement,” “Assemble,” and “Sell” of the same parts in the same month.

In the procurement process, each company purchases Motherboards and Displays every month in accordance with the condition of procurement in Table 1. Each Motherboard and Display has six levels of quality stars. The price of each Motherboard and Display is fixed according to the level of quality stars. Before purchasing a Motherboard and Display, a facilitator rolls the dice, e.g. blue dice for the Motherboard and red dice for the Display, and decides condition of procurement. In a case where the blue dice spot 6 is appeared, every company can purchase only six quality stars’ Motherboard within three lots. However, dice spot 1 means an opportunity loss. In case a red dice spot 1 appears, no company can purchase a Display in this month. Of course, dice spots are controlled in accordance with market circumstances by the facilitator. Furthermore, two special rules exist in this process, e.g., a “Three month rule” and a “Discount rule.”

Three month rule: The part loses one quality star if players cannot use their own parts within three months. This special rule teaches players that the quality of parts degrades with the progress of time once they are purchased.

Discount rule: Price/lot are discounted 10/lot from the price if a company buys same quality parts in a row. This special rule teaches players the important merit that they continue purchasing the same parts from the same suppliers.

FIG.1 OUTLINE OF THE SCC GAME



Therefore, players must devote careful consideration to which combination represents the best choice for the market situation and other companies' strategies. After the procurement, players make records of their inventories in Figure 3.

Figure 4 presents examples of assembly processes. In case one six quality stars' motherboard and one four quality stars' display are assembled with design and assembly cost, which is calculated as total quality stars times 15, players get one smartphone, which is represented by one dodecahedron dice and put it on their company sheet in Figure 5.

In the selling process, players can sell smartphones every month. Four different markets exist: Premium, Deluxe, Standard, and Basic. Figure 6 shows that each market is defined as "Acceptable Quality," "Price Cap," and "Market Volume." These conditions change annually. Players must choose the market in comparison between their smartphone's quality and market's acceptable quality.

When total sales volume does not exceed market volume, players get maximum sales revenue, which is the same as the market price cap. However, when total sales volumes exceed market volume, open bidding is opened. Open bidding is face-to-face bidding. Players come out to the market board, by which they wanted to sell smartphones, and put them on the market. After they are ready, they show the price to other

companies with a calculator by the signal of the facilitator. If a player wins the bidding, then they get sales revenue of their sales price. For a loser of the bidding, one special rule exists, the "Lose quality rule." Smartphones of the loser of the bidding lose two quality stars. This special rule teaches players that the value falls once the product becomes widely known to the market. Figure 7 shows a snapshot of the open bidding.

During the payment process, players calculate total revenue and total expense; then they check their cash amount every month, as shown in Figure 8. At the end of the game year, they produce a basic Income Statement and Balance Sheet as shown in Figure 9. In SCC games, all sheets are purely hand-scored. Players must manage inventory, cash, and finances with pencils and a calculator. The authors do not intend to make players expend meaningless effort. This task is a rare chance to recognize that humans often make simple calculation mistakes and that they understand a role and value of accurate accounting through experiences of this kind.

Figure 10 presents an SCC2 game outline. It is more complex than the SCC game. In the SCC2 game, players separate and form three companies: Motherboard Vendors, Display Vendors, and Smartphone Manufacturers. Each company assembles motherboards, displays, and smartphones, as in the SCC game. A salient difference between the SCC2 game and

FIG.2 GAME FLOW OF SCC GAME

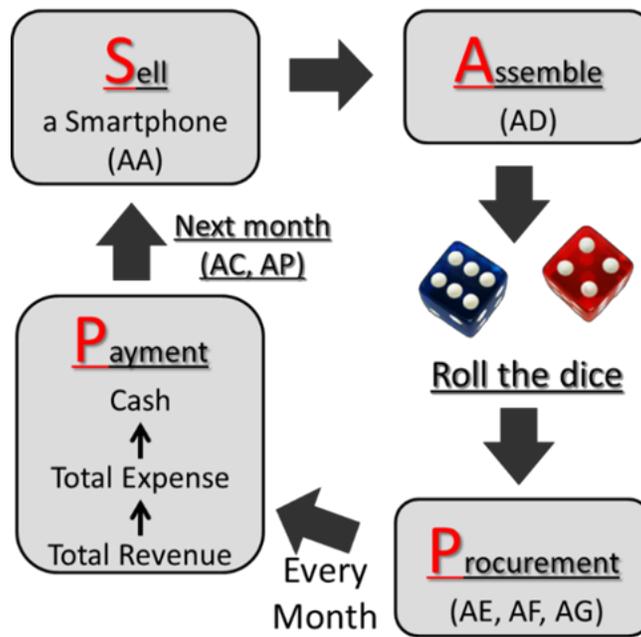


TABLE 1 CONDITIONS OF MOTHERBOARD AND DISPLAY PROCUREMENT

Spot	Quality	Max. lots	Price/lot
6	☆6	3	60
5	☆5	3	50
4	☆4	3	40
3	☆3	3	30
2	☆2	3	20



FIG.3 INVENTORY CONTROL SHEET

Year 1	Company Color: <u>Red</u>		Student ID & Name:										Table B
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Motherboard	5 x 1	5 x 0	- x	- x	- x	- x	- x	- x	3 x 1	3 x 0	- x	- x	
	- x	3 x 1	3 x 0	- x	- x	- x	- x	- x	- x	5 x 1	5 x 0	- x	
	- x	- x	5 x 1	5 x 0	- x	- x	- x	- x	- x	- x	- x	- x	
	- x	- x	- x	5 x 1	5 x 0	- x	- x	- x	- x	- x	- x	- x	
	- x	- x	- x	- x	4 x 1	4 x 0	- x	- x	- x	- x	- x	- x	
	- x	- x	- x	- x	5 x 1	5 x 1	5 x 0	- x	- x	- x	- x	- x	
Display	3 x 1	3 x 0	- x	- x	- x	- x	- x	- x	3 x 1	3 x 0	- x	- x	
	4 x 1	4 x 1	4 x 0	- x	- x	- x	- x	- x	- x	5 x 1	5 x 0	- x	
	- x	- x	6 x 1	6 x 0	- x	- x	- x	- x	- x	- x	- x	- x	
	- x	- x	3 x 1	3 x 1	3 x 1	3 x 0	- x	- x	- x	- x	- x	- x	
	- x	- x	- x	5 x 1	5 x 0	5 x 0	- x	- x	- x	- x	- x	- x	
	- x	- x	- x	- x	5 x 2	5 x 2	5 x 1	5 x 0	- x	- x	- x	- x	
Smartphone	7 x 0	9 x 0	- x	- x	- x	- x	10 x 1	10 x 1	8 x 1	8 x 1	6 x 1	6 x 0	
	- x	8 x 1	8 x 0	- x	- x	- x	- x	10 x 1	10 x 1	10 x 0	- x	- x	
	- x	- x	7 x 1	7 x 0	- x	- x	- x	- x	7 x 1	7 x 0	- x	- x	
	- x	- x	- x	11 x 1	11 x 0	- x	- x	- x	- x	6 x 1	6 x 0	- x	
	- x	- x	- x	- x	10 x 1	10 x 1	10 x 1	10 x 0	- x	- x	10 x 1	10 x 0	
	- x	- x	- x	- x	- x	7 x 1	7 x 1	7 x 0	- x	- x	- x	- x	

FIG.4 ASSEMBLE PROCESS

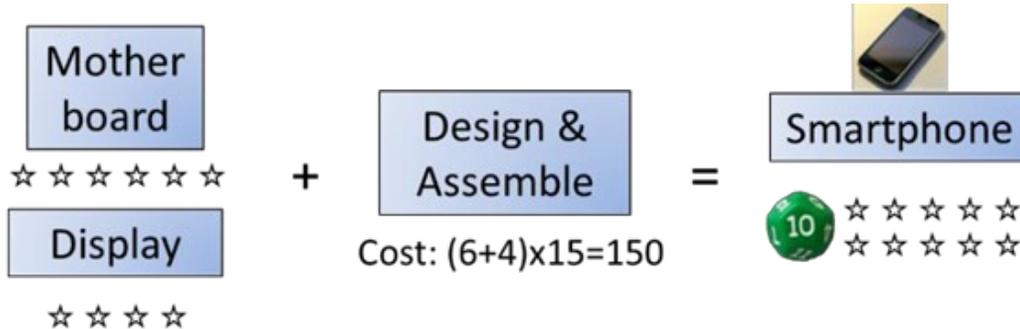


FIG.5 COMPANY SHEET

Company Name

Company Color

Student ID & Nickname
Board members

Smartphones

the SCC game is that Motherboard Vendors and Display Vendors are subcontractors of the Smartphone Manufacturers. Thereby, Smartphone Manufacturers must negotiate with Motherboard Vendors and Display Vendors on prices and many motherboards and displays. All companies must negotiate with awareness of their own company's cash flow. Moreover, players play a role as companies of three types throughout SCC2 game. Therefore, they get a viewpoint from prime contractor and subcontractor. These are outstanding features of the SCC2 game.

SUPPLY CHAIN COLLABORATION GAMES AT SIIT LECTURE

The authors collaborated with SIIT from August 2010 to ascertain the global and general efficiency of BASE business games. SIIT provides students of the "Management Technology" with lectures related to basic accounting, finance, human

resource management, supply chain management, etc. Although students study diligently, their knowledge is not meaningfully connected. SIIT strives for students to unite their knowledge horizontally and to seek tools for meeting SIIT's object. Therefore, BASE business games have been adopted as a conclusion of their education.

From 2013, the authors conducted a lecture: "Entrepreneurship for IT Business Development." All were senior students of the undergraduate Management Technology Course and Engineering Management Course. They already understood supply chain management to a certain degree. However, they had no ideas related to supply chain collaboration. The SCC game and SCC2 game were used in most lectures. At the beginning of the lecture, they were concerned about the adjunct Japanese Associate Professor and the lecture contents. However, as they came to understand the game rules, they were able to enjoy lectures more. Figure 11 presents photographs of this lecture.

FIG.6 MARKET SHEET

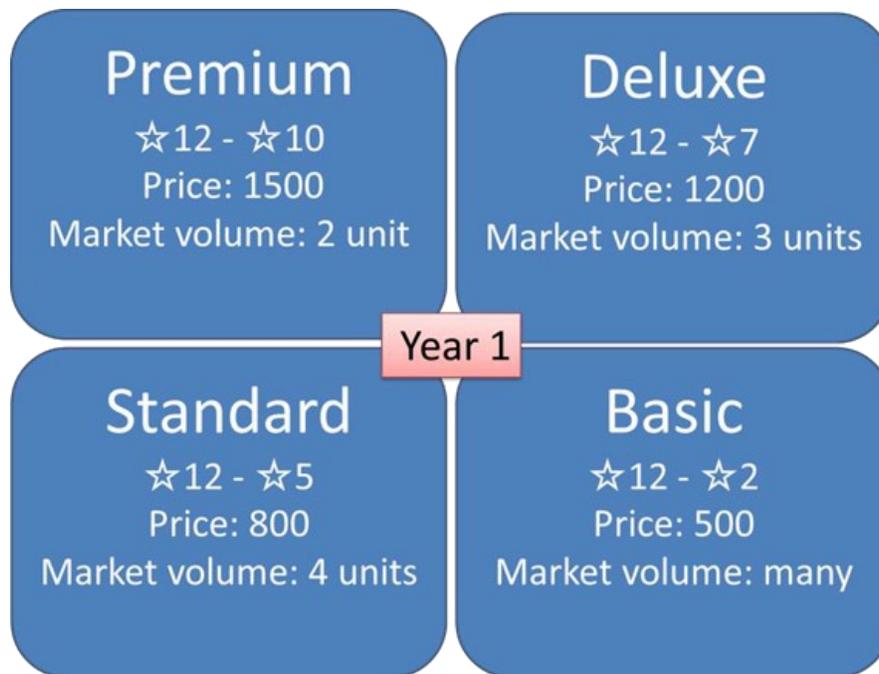


FIG.7 SNAPSHOT OF OPEN BIDDING



To verify the game's effectiveness, the authors conducted questionnaire research as self-evaluation using a Likert Scale: an ordinal scale. The average of responses to each question can be compared because the respondents were the same students. Before and after the lecture, students replied to the same ques-

tionnaire as shown in Figure 2 assessing the understanding of management knowledge of the students. The comparison enabled the authors to evaluate the game impact. The response options were represented as a five-point scale for these questions.

FIG.8 CASH FLOW SHEET

⊕ = 835 $\bar{A}15 = 365$ 43%
 ⊖ = 1020 $\bar{A}15 = 480$ 47%

Year 1	Company Color: Red	Student ID & Name: 552280021E Ball												Table A
Business Action	Initiation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sales	⊕	⊕	⊕	⊕	⊕	⊕	—	—	⊕	⊕	⊕	⊕	⊕	⊕
Assemble	—	A8	A7	A11	A10	A9	A10	A10	A7	A6	A10	—	—	—
Procurement	—	M5, D3, D4	M3	M9, D6, D3	M9, D5	M9, D5, M4, M5	—	M3, M5	D2	M3, D3	M5, M5	—	—	—
1. Revenue														
1.1 Operating Revenue														
(AA1) Sales	(Units)	(1)	(1)	(1)	(1)	(1)	(-)	(-)	(2)	(-)	(2)	(1)	(2)	(-)
(AA1) Sales	(Price)	1200	1200	1200	1200	1200	—	—	2100	—	2150	800	1600	12650
1.2 Finance Revenue														
(AA2) Share Capital		2,000												
(AA3) Debt		1,000												
Total Revenue		3,000	1200	1200	1200	1200	—	—	2100	—	2150	800	1600	15650
2. Expense														
(AB1) Assemble Cost	Total #x15	—	120	105	165	150	105	150	150	105	90	150	—	1290
(AE1) Procurement	(Units)	(1)	(1)	(1)	(1)	(2)	(-)	(2)	(-)	(1)	(1)	(-)	(-)	(-)
(AE1) Procurement	(Price)	350	310	225	380	715	—	880	—	225	360	—	—	3245
(AF1) Procurement	(Units)	(2)	(-)	(2)	(1)	(2)	(-)	(-)	(1)	(1)	(-)	(-)	(-)	(-)
(AF1) Procurement	(Price)	260	—	620	400	750	—	—	200	390	360	—	—	2800
(AG1) Equipment Cost	Assemble Line: 1000/line	1,000												1000
(AH1) Line Cost	Maintenance: 20/line-month	20	20	20	20	20	20	20	20	20	20	20	20	240
(AI1) Labor Cost	Employee: 20/employee-month	20	20	20	20	20	20	20	20	20	20	20	20	240
(AJ1) Selling Expense	President: 40/month	40	40	40	40	40	40	40	40	40	40	40	40	480
(AK1) Administrative Cost	(Number of Employees + President) x 10/month	20	20	20	20	20	20	20	20	20	20	20	20	240
(AL1) Office Expense	(Number of Lines) x 10/month	10	10	10	10	10	10	10	10	10	10	10	10	120
(AM1) Interest Expense	Debt x 0.1/month	10	10	10	10	10	10	10	10	10	10	10	10	120
(AN1) Refund Debt														
Total Expense		1,000	720	550	1070	1065	1735	225	950	470	660	930	270	9735
Cash		2,000	2470	3120	3250	3385	2890	2625	1675	3305	2645	3865	4095	5895

FIG.9 ACCOUNTING SHEET (INCOME STATEMENT AND BALANCE SHEET)

Year 1	Company Color: Red	Student ID & Name:	
Table D Income Statement (P/L)			
1. Sales Revenue	(AA1)	12650	
2. Cost of Goods Sold			
2.1 Product Cost #1	(CR1)	7335	
2.2 Line Cost	(AH1)	240	
2.3 Labor Expense	(AJ1)	240	
2.4 Depreciation Expense	(ES1)	100	
2.5 Selling Expenses	(AK1)	480	
2.6 Administrative Expenses	(AL1)	240	
2.7 Office Expenses	(AM1)	120	
Income from Operation		3875	
4. Other Expense and Loss			
4.1 Interest Expense	(AN1)	120	
Income before Income Tax		3795	
5. Tax			
5.1 Income Tax Expense	(DQ1)	1510	
(Income before Income Tax x 0.4)			
Net Income for this year (DU1)		2265	
Table E Balance Sheet (B/S)			
Asset		Liability	
1. Current Assets		1. Current Liabilities	
1.1 Cash	(AZ1)	5875	
1.2 Inventory #2			
Smartphone	(ED1)	0	0
Motherboard	(EE1)	0	0
Display	(EF1)	0	0
2. Non Current Assets		2. Non Current Liabilities	
2.1 Equipment		2.1 Long-term Debt	
Beginning of Balance		Beginning Balance of Debt	
Purchase Lines	(AG1)	1000	1000
Depreciation Expense	(ES1)	100	(New Debt)
		100/Line-year	Net Debt for this year
Balance	(ET1)	900	(AC1)
			(AP1)
			(EV1)
			Total Liabilities
			2510
		Equity	
		1. Share Capital	
		(AB1)	
		2. Retained Earnings	
		2.1 Beginning Balance of Retained Earnings	
		2.2 Net Income for this year	
		2.3 Ending Balance of Retained Earnings	
		Total Equity	
		4265	
Total Assets		Total Liabilities and Equity	
	6775		6775
#1 Calculation of Product Cost			
Product Cost			
= Assemble cost + Motherboard + Display - Inventories			
= AD1 + AE1 + AF1 - ED1 - EE1 - EF1			
= 1290 + 3245 + 2900 - 0 - 0 - 0			
#2 Calculation of Inventory Value			
Total Stars			
Smartphone: 0 x 25 = 0 (ED1)			
Motherboard: 0 x 10 = 0 (EE1)			
Display: 0 x 10 = 0 (EF1)			

1. Strongly do not understand
2. Do not understand
3. Neutral
4. Understand
5. Strongly understand

Figure 12 presents results of 2014 and 2015. Overall results show that results of both years exhibit a similar tendency and understanding of management knowledge was generally improved. The SCC games are designed to teach the importance of continuous collaboration with suppliers and inventory control as an experience. The authors confirm that SCC games

satisfy lecture course requirements.

One outstanding improvement can be found for Questionnaire Number 8. The authors analyze details related to Questionnaire Number 8. Table 3 presents changes before and after results for each student on Questionnaire Number 8 in 2014 and 2015. A large number of results in 2014 are “2+2=4,” which represent “result before the lecture + differences = result after the lecture,” for 10 students and “3+1=4” for 10 students. However, the large number of results in 2015 is “3+1=4” of 13 students. Results show that the students who were unable to understand the issue before the lecture became able to understand it.

FIG.10 OUTLINE OF THE SCC2 GAME

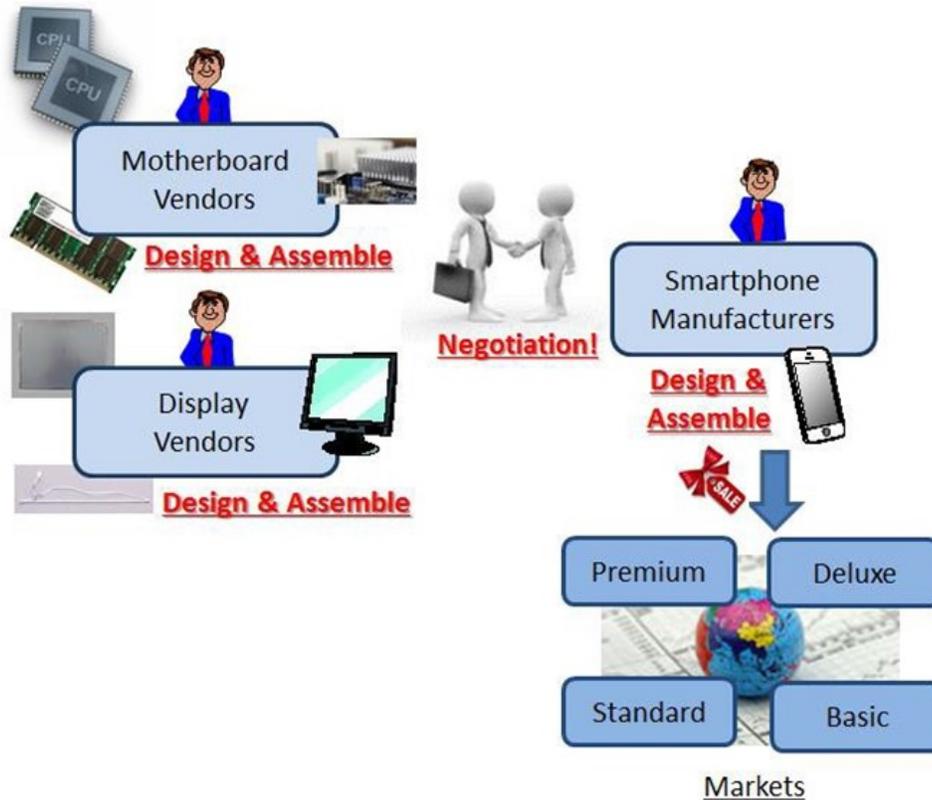


FIG.11 PHOTOGRAPHS OF THE LECTURE



CONCLUSIONS

This paper presented details of the SCC game and the SCC2 game and applied SCC games to the lectures of SIIT in 2014 and 2015. Furthermore, the SCC game effectiveness was investigated using responses to questionnaires by students.

1. The SCC game and SCC2 games, which are designed to teach supply chain collaboration, are designed. They are useful tools for the teaching and learning of SCC.
2. Overall results of Questionnaires show that the understanding of management knowledge was generally improved. Through game play, students learned the importance of supply chain collaboration and acquired a holistic view of

TABLE 2 QUESTIONNAIRES OF THE GAMES ON THE UNDERSTANDING OF MANAGEMENT KNOWLEDGE

1.	What would a company do when cash becomes short?
2.	Why does a good company sometimes become bankrupt suddenly?
3.	Why do most companies borrow money from a bank?
4.	How does a company reduce manufacturing costs?
5.	What would happen to a company when they produce too many goods?
6.	Why is risk management important?
7.	How is break-even point calculated?
8.	What factors does supply chain collaboration include other than price?
9.	Why is a continuous relationship with suppliers important to sustain the company?
10.	Why do companies establish a business strategy?
11.	Concept of inventory control
12.	Concept of production planning
13.	Concept of human resource development

FIG.12 COMPARISON BETWEEN BEFORE AND AFTER RESULTS IN 2014 AND 2015

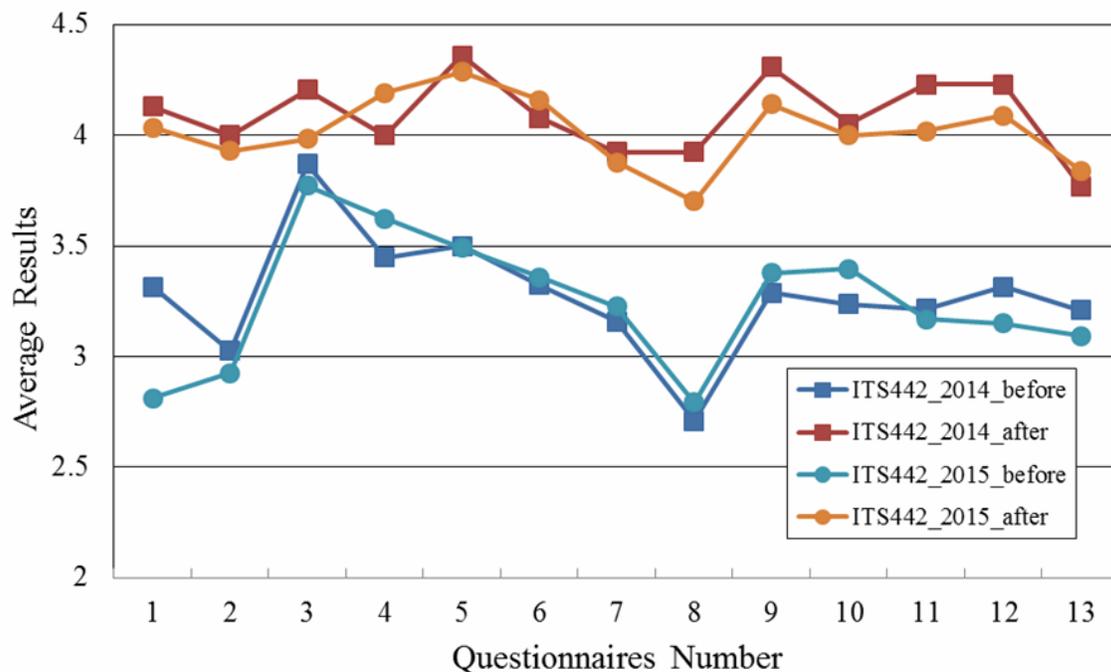


TABLE 3 DETAIL ANALYSIS OF STUDENT ANSWER ON QUESTION 8 IN 2014 AND 2015

2014		After				
		1	2	3	4	5
Before	1	0	0	0	0	0
	2	0	0	1	10	2
	3	0	0	6	10	2
	4	0	0	1	2	1
	5	0	0	0	0	0

2015		After				
		1	2	3	4	5
Before	1	0	0	4	2	1
	2	0	3	4	3	0
	3	0	0	6	13	2
	4	0	0	3	3	3
	5	0	0	0	0	1

management.

- Detailed analyses of Questionnaire Number 8 indicate that this teaching method can facilitate the comprehension of students: they were unable to understand it before the lecture, but became able to understand it.

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