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An Application of Educational Tool for Implementing Procurement and Inventory Planning in Furniture Company

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Abstract

Research on Supply Chain Management (SCM) in the furniture industry have been carried out in Indonesia lately. These researches have resulted in various models that are useful to solve the problems experienced by the furniture company in Indonesia, such as the high cost of furniture production, scarcity of raw materials, etc. However, the results of these researches are difficult to be implemented by small and medium-scale furniture company. This is due to lack of human resources and lack of understanding of the application of SCM. The purpose of this paper is to develop an interactive application as an educational tool to provide insight into one of the SCM technology implementations, especially in procurement planning and inventory control of raw materials. This research was developed from mathematical models in previous research, then the mathematical models are arranged into Ms. Excel based applications, verified by tested by the user and then refined, making it an application of educational tool that is easy, smart, and effective. The results of this paper can be used to improve the understanding of one of the SCM applications in the furniture industry.

Keyword: educational tool, furniture industry, interactive application, mathematical model, supply chain management

1. INTRODUCTION

City of Surakarta is one of the centers of the furniture industry in Indonesia. During its development, the furniture industries face many problems. These problems are the limited supply of raw materials, production inefficiency, requirement of export destination countries and foreign buyers to comply with several policies, i.e. environmentally issues and labor rights protection (Hisjam, et al, 2010a); Hisjam, et al, 2011; Hisjam, et al, 2012).

In this study, observations were done at three small and medium scale teak furniture companies. The main problems that are faced by these companies are the high price of raw materials and the scarcity of raw materials that trigger an increase in cost production of furniture (Sutopo, et al, 2012). These problems can actually be solved by using Supply Chain Management (SCM) technology. However, the lack of understanding and application of SCM, causing these companies can not solve the problems (Sutopo et al., 2010). Therefore, in previous research we developed a mathematical model to determine the optimal amount of the procurement and inventory of raw materials in order to obtain minimum production cost of furniture.

In fact the implementation of mathematical model obtained by previous research sustains many obstacles. A mathematical model was developed by using programming language of optimization software, Lingo, so it is difficult to be understood by employees of the furniture company. To overcome this problem, it is necessary to make an educational tool to help employees understand the objective and the use the mathematical model for furniture companies (Sutopo, et al, 2010; Hisjam, et al, 2010b; Wiyono et al, 2010; Felder and Brent, 2003; Chu et al, 1999). The educational tool is similar to a decision support system (DSS), a system to utilize models with internal and external databases, emphasize flexibility, effectiveness, and adaptability (Markas, 2003; Efraim, et al, 2005; Chu, et al, 1999).

Educational tool or learning tool is a tool to deliver the message of learning (Boove and Thill, 2008). The use of educational tools has been carried out in various fields, but no one has studied on educational tool for furniture companies.

This paper aims to design an interactive application as an educational tool to implement the SCM technology in the furniture industryies. The application was developed from a mathematical model that was built in the previous research (Sutopo, et al, 2012). The aapplication interface was created by using Ms. Excel. This software was chosen because it does not require a certain specification, so it can be implemented in the furniture industry which use Ms. Office-based computer. Then, the application was tested to capture user requirements of the application. Next, the application was repaired to meet the user application requirements of the application. The results of this study are an application of implementation SCM technology that can assist companies in determining the amount and type of the procurement and inventory of raw materials at the right time, the right amount and the right type.

2. METHODOLOGY

Figure 1 shows the methodology of this research. An interactive application was designed to help users gain a better understanding of the mathematical models. The interface of the applications was built by using Ms. Excel, while the mathematical models and the solutions obtained were processed by using Lingo optimization software (Anonym, 2003).

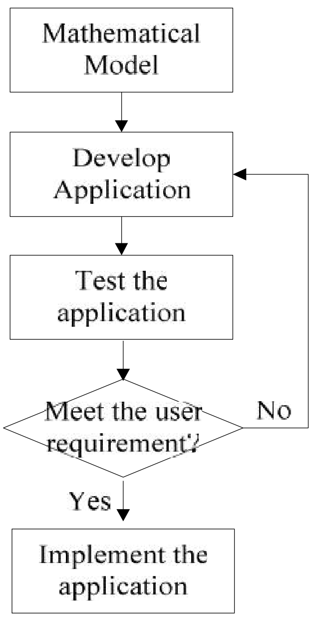


Figure 1. Methodology of the research

The methodology of this paper was started from the development of mathematical models to be an interactive application as an educational tool for the furniture industry. Mathematical model refers to our previous work in (Sutopo, et al, 2012). A mathematical model was created to determine the optimal number and types of purchases and inventory of raw material, so it could minimize the production cost of furniture. The application was developed by integrating the Lingo-based mathematical model with Ms. Excel- based interface. The Ms. Excel-based interface can help the user to input the production planning and get the optimal solution easily.

The next step is verifying the application by testing the application to furniture companies. This step was conducted to determine customer requirements of the application. After testing the application, the next step is to analyze whether the application meets the requirements of the furniture companies. If the application has not met the requirements of the furniture company yet, then the next step is making improvements to the application. If the application meets the requirements of the furniture company, then the next step is implementing the application to the furniture companies.

3. DEVELOPING THE APPLICATION

The application was developed from our previous research (Efraim, 2005). It was built by using four stages as follow: building mathematical models, developing the application, verify the application, and implementing the application.

3.1 Building mathematical models

Mathematical model that was used in developing this application was obtained from previous research (Sutopo, et al, 2012). Decision variables which can be determined by the mathematical model are optimal number and types of purchase and inventory of raw material. Meanwhile, the objective function of the mathematical model is to minimize the production cost of furniture. The equations of mathematical model are as follows:

$$TCM = \sum_{t=1}^{12} \sum_{j=1}^{2} \sum_{i=1}^{2} p_{jt}\, Q_{ijt} \qquad (1)$$

$$TCI = \sum_{t=1}^{12} \sum_{i=1}^{2} ch_{it}^{IL} Q_{it}^{IL} + \sum_{t=1}^{12} \sum_{i=1}^{2} ch_{it}^{IS} Q_{it}^{IS} \qquad (2)$$

$$TCP = \sum_{t=1}^{12} \sum_{i=1}^{2} cr^{S}\, qr_{it}^{S} + \sum_{t=1}^{12} \sum_{i=1}^{2} co^{S}\, qo_{it}^{S} \qquad (3)$$

The constraint equations of the mathematical model are as follows:

$$\sum_{t=1}^{12} \sum_{j=1}^{2} q_{ijt} \geq \sum_{t=1}^{12} d_{it} \quad (\forall\, i) \qquad (4)$$

$$Q_{ijt} - k_{ij} q_{ijt} \geq 0 \quad (\forall i, \forall j, \forall t) \qquad (5)$$

$$Q_{ijt} - k_{i,j} q_{i,j,t} \geq 0 \quad (\forall t = 8, 9, \dots, 12) \qquad (6)$$

$$\sum_{i=1}^{2} [Q_{it}^{IL} + Q_{it}^{IS}] \leq v \quad (\forall t) \tag{7}$$

$$Q_{i\,(t-1)}^{IL} + \sum_{j=1}^{2} Q_{i,j} - Q_{i,t}^{IL} - a q_{i,t}^{s} = 0 \quad (\forall i, \forall t) \tag{8}$$

$$Q_{i\,(t-1)}^{IS} + q_{it}^{S} - Q_{it}^{IS} = \beta_i d_{it} \quad (\forall i, \forall t) \tag{9}$$

$$\sum_{i=1}^{2} qr_{i,t}^{S} \leq r^{max} \quad (\forall t) \tag{10}$$

$$\sum_{i=1}^{2} qo_{i,t}^{S} \leq o^{max} \quad (\forall t) \tag{11}$$

$$qr_{i,t}^{S} + qo_{i,t}^{S} - q_{i,t}^{S} = 0 \quad (\forall t, \forall i) \tag{12}$$

where,

Q_{ijt} : Volume of purchasing *log* class *j* type product *i* in period *t*

Q_{it}^{IL} : Volume of inventory of *log* product *i* in period *t*

Q_{it}^{IS} : Volume of inventory of board product i in period *t*

i : Index of type product (1 = GF, 2 = INDOOR)

j : Index of teak class (1= type AII, 2= type AIII)

t : Index of period (*t* = 1, … , 12)

p_{jt} : Price of log class *j* in period *t* (Rp/m^3)

d_{it} : Number of demand of product *i* in period *t* (m^3)

q_{ijt} : Volume of product *i* produced from log class *j* in period t (m^3)

$ch_{i,t}^{IL}$: Holding cost of log of product *i* in period *t* (Rp/m^3 tahun)

$ch_{i,t}^{IS}$: Holding cost of board of product *i* in period *t* (Rp/m^3 tahun)

cr^{S} : Reguler cost of producing board (Rp/m^3)

co^{S} : Overhead cost of producing board (Rp/m^3)

q_{it}^{S} : number of producing board product *i* in period *t* (m^3)

$qr_{i,t}^{S}$: Number of reguler production board for product *i* in period *t* (m^3)

$qo_{i,t}^{S}$: Number of overhead production board for product *i* in period *t* (m^3)

$k_{i,j}$: Convertion value of product *i* to log class *j*

v : Maximum inventory capacity of raw material (m^3)

r^{max} : Maximum capacity of producing board in period t (m^3/bulan)

o^{max} : Maximum capacity of overhead producing board in period t (m^3/bulan)

α : Convertion value of board to log

β_i : Convertion value of product *i* to board

TCM : Total procurement cost of raw material

TCI : Total holding cost of raw material

TCP : Total labour cost of producing board

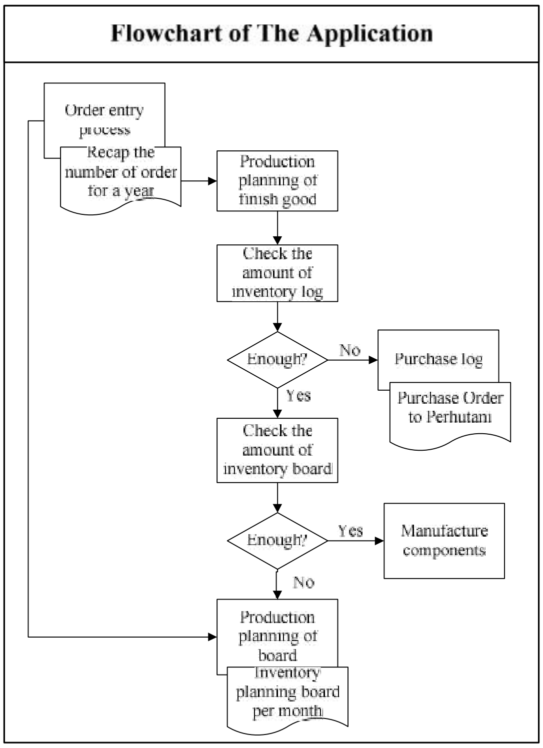
3.2 Developing the application

The application was extended from a mathematical model from the previous research. It was built by using Ms. Excel. Through this application, user can input the production planning of furniture for a year in the Ms. Excel workspace. Then, the application determines the optimum amount of the procurement and inventory of raw material. In this case, the raw material that be used by furniture company are teak log and teak board. Figure 2 shows the flowchart of application mechanism.

The mechanism of the application starts from the input the production planning based on the amount of furniture demand by consumers. Then the application will check the stock levels of teak log, if the number of teak log inventory is still sufficient to meet production needs, it is not necessary to purchase log. However, if the number of log inventory are not sufficient to meet the needs of production, then the application will give the output of the optimal number of log procurement.

Furthermore, the application will check the amount of inventory boards. If the board inventory are not sufficient to meet the needs of production, then the application will output the optimal number of boards that should be produced. However, if the amount of stock board is still able to meet the needs of production, the production of components can be done without purchasing boards

Figure 3 shows the main page of this application. On this main page, there are four menus, which are “Order per Bulan”, “Input Biaya”, “Proses Lingo”, and “Optimal Solution”. The “Order per Bulan” menu is used to input production planning, while “Input Biaya” is used to input the cost required to produce furniture. The application interface to input data can be seen in Figure 4.



. Figure 2. Methodology of the research

Fig. 3 Main page of the application

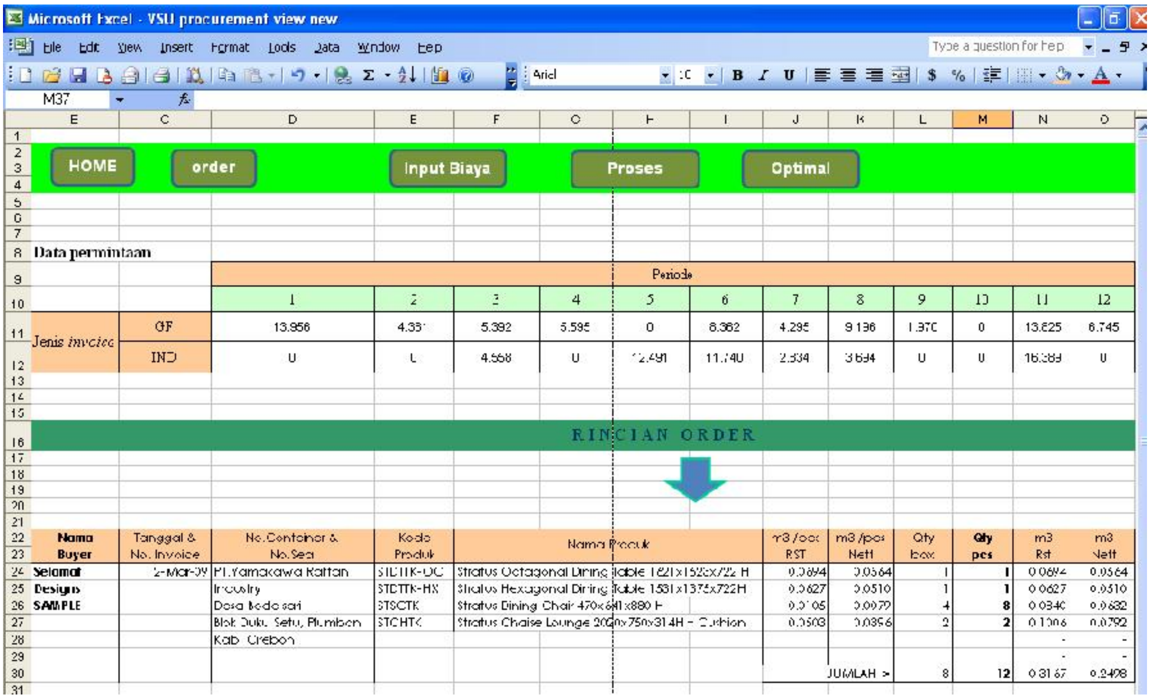


Figure 4. The page to input data

Figure 5 shows the "Proses Lingo" menu. This option is used to process the production plan that has been entered to be the optimal procurement and inventory planning of logs and boards. The result of this optimal solution finding can be seen in the Ms. Excel worksheet through the "Optimal Solution" menu.

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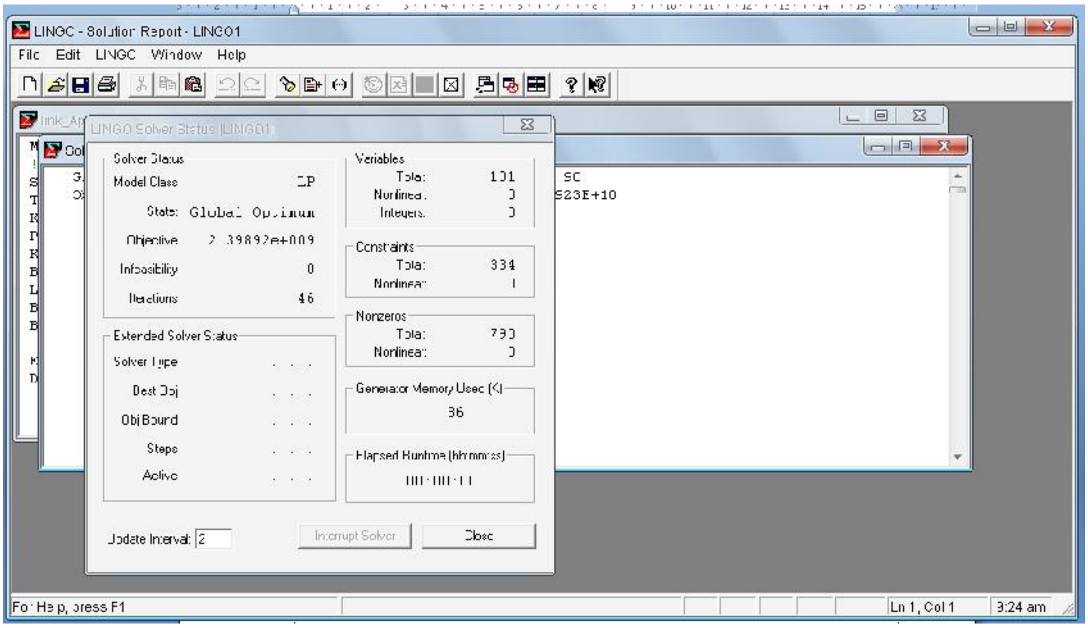

Figure 5. The process of finding the optimal solution by using Lingo

3.3 Verifying the application

Verification is conducted by testing the use of the application on the furniture companies. After testing the application, the furniture company employees filled out a questionnaire assessing the application. The purpose of this verification process is to capture user requirements of applications. The verification process obtained the list of user requirements of applications that can be used to improve the application.

3.4 Implementing the application

Aside from being an educational tool for the furniture company, this application can be implemented as a tool to determine the amount of the procurement and inventory of log and board on the teak furniture company. This application can be used effectively after the improvement based on user requirements for applications. The use of this application in furniture industry will provide convenience for the employees of the purchasing and production in determining the optimal amount of the purchase and inventory log and board, so the production cost of furniture can be minimized.

4. ANALYSIS

The application was tested by using it to solve inefficiency total cost of procurement and manufacture of raw material that experienced by CV.VSU. In order to illustrate the capabilities of the application, a numerical example has been studied by inputting parameters based on historical data into the application. These input data obtained from VSU and Perhutani by referring to the data in 2009. Table 1, Table 2, and Table 3 show the stock, demand, and all relevant data required (Sutopo *et al.*, 2012).

Table 1. The Demand and Price of Log

Period	Demand		Price of log	
	GF (m^3)	**IND (m^3)**	**AII (IDR/m^3)**	**AIII (IDR/ m^3)**
Jan.	13.98	-	-	-
Feb.	4.38	-	-	-
Mar.	5.36	4.56	-	-
Apr.	5.59	-	2,721,926	4,683,354
May.	-	12.49	2,594,528	4,587,744
June	8.36	11.74	2,638,691	4,406,004
July	4.30	2.83	2,707,549	4,510,334
Aug.	9.20	3.69	2,687,962	4,253,711
Sept.	1.97	-	2,675,161	4,395,586
Oct.	-	-	2,716,448	4,206,598
Nov.	13.83	16.39	-	-
Dec.	6.75	-	-	-

Table 2. The Data of Initial Stock, Inventory Cost, and Average Purchasing Price

	Initial stock (m^3)	**Inventory cost (Rp/ m^3/year)**	**Average purchasing price (Rp/ m^3)**
F/G-GF	4.62	-	-
F/G-IND	3.71	-	-
Board-GF	-	430,980	14,363,996
Board-IND	-	430,980	14,363,996
Log-AII	26.69	107,745	3,591,499
Log-AIII	31.62	107,745	3,591,499

Table 3. The Conversion Value Of Finished Goods To Log, Board, And RST

	Log type	Requirement (m^3)		
		Log	Board	RST
F/G-GF	AIII	5.2	2.6	1.898
	AII	20	10	7
F/G-IND	AIII	12.2	6.1	4.453
	AII	4.95	2.5	1.75

Table 4. The Result of Decision Variables Calculation

Period	Procurement of log		Inventory of log		Inventory of board	
	AII (m^3)	AIII (m^3)	GF (m^3)	IND (m^3)	GF (m^3)	IND (m^3)
Jan.	-	35.16	-	31.138	-	3.708
Feb.	255.94	22.78	-	287.083	-	-
Mar.	-	57.13	29.094	271.937	-	-
Apr.	-	-	-	271.937	-	0.798
May.	-	43.48	43.482	208.511	-	-
June	-	-	-	151.993	-	-
July	-	224.77	202.440	137.965	-	-
Aug.	-	-	154.621	119.680	-	-
Sept.	-	-	144.377	119.680	-	-
Oct.	-	-	91.361	119.680	26.5	-
Nov.	-	-	72.487	38.554	-	-
Dec.	-	-	37.413	38.554	-	-

Table 4 shows summary of the solutions obtained from the application. These results are calculated for 1-year planning horizon. Based on Table 4, we can see that the application is able to determine the value of the decision variables such as procurement of log, average inventory of log, and average inventory of board during the planning horizon.

From the result obtained from this application, we can see that if compared with current system, the use of this application to determine the value of the decision variables will provide more optimal results. Table 5 shows the comparison of the value of the decision variables between the current system with the proposed system, which using the application. Based on the results were summarized in Table 5 can be seen that by using this application, the amount of purchase log AII decreased by 47%, and the amount of purchase log AIII decreased by 32%. While for average inventory of log, the model yields reduction 55% and for average inventory of board, the model yields reduction equal to 91% than the existing system respectively.

Table 5. The comparison of decision variables value between current and proposed system

Decision variable		Current system (m^3)	Proposed system (m^3)	Decrease
Purchase log	AII	481,14	255,95	47%
	AIII	563,35	383,33	32%
Inventory	Log	480,48	214,33	55%
	Board	32,41	2,89	91%

The decrease of the amount of the purchase and inventory of raw materials have significant impact on the decline in the total cost of procurement and the manufacture of raw materials, which is the accumulation of the purchase cost of raw materials, raw material storage cost, and direct labor cost. The proposed system, which use the application in determining the decision variables, is able to provide saving equal to 41.67% than the current system as we can see in Table 6. Therefore, this application can be used as an appropriate application for the furniture industry to overcome problem of the high cost of production.

Table 6. The comparison of total cost between current and proposed system

Cost	Current system (IDR)	Proposed system (IDR)	Decrease
Procurement of log	3.807.109.929	2.315.450.124	39,18%
Inventory of log	51.768.962	23.093.859	55,39%
Inventory of board	13.968.078	1.247.022	91,07%
Regular labour cost	140.674.100	59.148.625	57,95%
Overtime labour cost	99.268.540	-	100 %
Total cost	4.112.789.609	2.398.939.630	41,67%

5. CONCLUSION

This application can be used as an educational tool in one of the SCM technology implementations in the furniture industry. This application can determine the optimal amount of the procurement and inventory of log and board, so the furniture company can minimize the production cost of furniture. Through this application, the furniture company employees can understand the intent and the use of mathematical models to solve problems.

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