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Integration of Quality Function Deployment and Value Engineering: A Case Study On Waiting Chair Products

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ABSTRACT

The purpose of this research is to determine a better alternative to the development of waiting chair products by using the integration of QFD method and value engineering so that the product obtained by the appropriate and to reduce production costs without eliminate the product functions. 40 respondents taken in incidental sampling techniques and provides data through the transfer of the questionnaire to obtain the attributes of the consumer's need for a waiting chair product while 5 teams from the manufacturer accommodate through the attributes of technical needs with House of Quality to get priority product technical improvement. Value Engineering aims at finding alternatives and identifying product concepts that have greater value. The result of this research show that the integration of Quality Function Deployment and Value Engineering can identify the priority of product improvement based on customer's needs and decrease the cost of making the product with the highest ratio value is in the alternative II of 0.00634. If viewed from the cost of making the initial product is IDR 546.500,00 then after the stage of this research, the cost of making decrease of IDR 90.625,00.

Key words : Quality function, House of quality, Value engineering, QFD

1. INTRODUCTION

Industrial Engineering at the Kadiri University Faculty of Engineering has conceptualized the waiting chair product at the previous drawing engineering practicum in 2017. According to the results of a questionnaire distributed to 40 respondents, stated that the existing seat model is less comfortable (can cause back pain to the pelvis and so on) and when tidied takes up a lot of places. Then the physical prototype is continued in the manufacturing process in 2018. From the waiting chair product concept, we need to do research that has the aim to develop a product concept design that meets customer demand appraisal and low production costs. According to [1] product development aims to develop existing products, so that customer satisfaction will increase and even be met as a whole.

Economic success most companies depend on their ability to identify customer needs and full their needs so it can be manufactured at low cost [2]. Quality Function Deployment is one of method that use for development product and increase the quality of product. Quality Function Deployment is a product development and quality management methodology that was first introduced in Japan as a quality enhancement tool. Product development and quality improvement are based on the principle of customer demand [3]. QFD methods are used in developing products upon request from customers [4]. The overall concept of QFD provides a means of translating customer requirements to the technical requirements for each stage of product development and production [5].

Products made with regard to overall quality will incur high production costs, therefore many companies that want to reduce costs in production by not eliminating the functions of the product [6]. Value engineering is a system used to create a design by establishing a clear purpose and expanding it as desired [7]. SAVE (Society Of American Value Engineering) mentions that value engineering as a technique to develop product functions in a low cost [8].

Submitting a new product successfully to the market is the result of a well-defined new product development process [9], which includes planning , concept development, system level design, detailed design, testing and debugging, and trial production phases [10]. The new product development process begins with the planning stage [11]. The outputs of this phase constitute the introduction of the concept development phase at the same time, and these inputs lead to the new product development team. The final stage of the new product development process is to present the product to the market and make the product ready for purchase [12].

The integration concept of QFD and value engineering methods has been conducted by [4] by adding the Design for Manufacture and Assembly (DFMA) method to the design process of a product [13]. Where the integration between QFD and value engineering has the main objective to choose a better alternative in product/service planning or process products/services that not only produce higher value for customers, but also not increase the cost of products/services. More detail can seen in Figure 1 about releationship between QFD and Value Engineering [4].

2. METHODOLOGY

The product planning process based on QFD principle starts by taking into customer needs and requirements. Product characteristics associated with this requirement are determined. Solutions (alternatives) contribute to the fulfillment of these needs identified. Then use the value engineering technique as a solution that has a higher value index for the selected customer. Integration Conceptual QFD Model & Value Engineering can be seen in Figure 1.

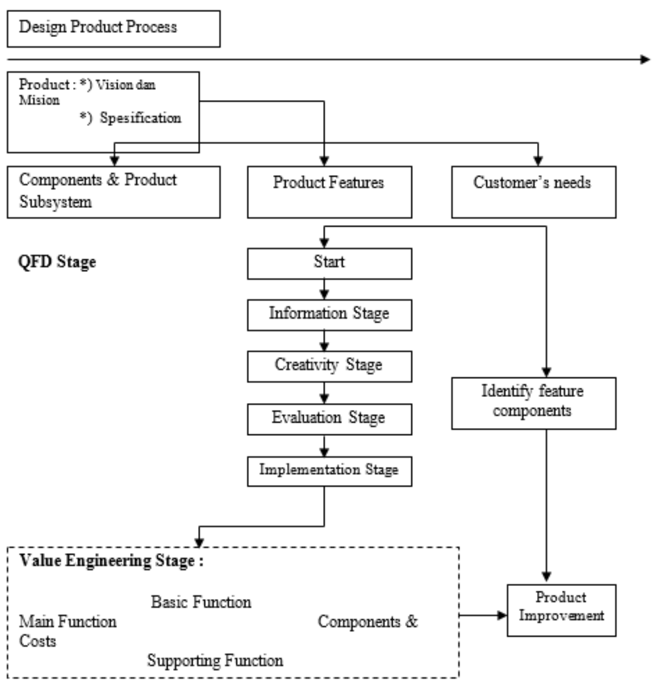

Figure 1: Integration conceptual QFD model & value engineering

This research is product development because the process identifies improved product attributes better. Development research as a systematic assessment of the study, development, and evaluation of programs, processes and learning products that must meet the criteria for validity, practicality, and effectiveness [14]. The research did in the Laboratory of Industrial Engineering major of Kadiri University with waiting chair products.

Customer requirements are changing very quickly [15]. Thus, it is very important for firms to be able to respond to customer requirements quickly and accurately so that they can take more shares in the market [16]. At the first stage of the design process, customer requirements should be determined and a list of product specifications should be developed based on these customer requirements. These specifications must be ensured by the product. The next stage of concept design is the design process and involves the establishment of subsystems. Once the various concepts are identified, the best combination of the sub-sets with the highest performance and lowest cost is selected. This process is called concept selection [17]. After this phase, the design process progresses towards a detailed resolution. The goal of the concept selection, which is one of the stages of the concept development process, is to choose the most appropriate one at the beginning of the process [18]. So, the purpose of this research is to determine a better alternative to the developed waiting chair products using the integration of QFD and value engineering methods.

An open questionnaire is given to 40 customers who use the waiting chair who already represent from the waiting chair user. Question on the open questionnaire is when and why do you use this waiting chair? what is the advantage of the waiting chair you are currently using? What is the lack of a waiting chair that you use today? What are some things you consider when buying a waiting chair? What improvements do you want to have on your existing waiting chair?

On the closed questionnaire the data collection can be said to be the most effective because the respondents can directly provide answers with a checklist (√) in the column that has been provided. There are several stages in a closed questionnaire, such as:

1. Enter the attribute of the need statement derived from the open questionnaire as a query in the closed questionnaire [19].
2. Spreading the questionnaire closed to the respondent [20].
3. Analyzes data tabulation from closed questionnaire [21].

A closed questionnaire question was given to customer who used a waiting chair of 40 respondents who already represented a multifunctional waiting chair user with incidental sampling techniques. Closed questionnaire to know the level of importance of each attribute. The range assessments on the questionnaire are closed as follows (1 = very not important), (2 = not important), (3 = pretty Important), (4 = Important), (5 = very important).

The value of relationship in relationship matrix is determined by the observation and also the interview of the manufacturer. How to fill this matrix by determining the appropriate impact between the relationship needs of techniques and customer needs.

On the increase of the technical interest is divided into two parts, first is value of absolute importance and second is value of the relative importance. This value shows which activities need to first take precedence among other activities. The value of absolute interest is obtained by the way of the customer interest that has a relationship with the attribute of technical needs with the value of the relationship of customer expectation with the attributes of existing technical needs with the formula as:

$$AI = \sum(Bti \times Hi) \quad (1)$$

Explanation :

AI : The absolute significance value for each attribute
Bti : Weight of the desires of consumers who have relationships with the attributes of technical needs.
Hi : The value of the relationship of consumer desires by attributable to existing technical needs.

To find the value of relative interest gained by calculating using the way each value of absolute interest multiplied by one hundred percent (100%) with the formula as follows :

$$RI = [(Kti/\sum Kti) x100\%] \quad (2)$$

Explanation :
Kti : Value of the absolute importance of technical needs
Σkti : Total of absolute value interest from technical need

Some examples of product development process can be found in [22] and [23]/

3. RESULT AND DISCUSSION

In this study requires really reliable and valid data, then in this case the questionnaire will be tested first before being used as a primary data in the research. All of the above tests are done in order to obtain evidence of how far the precision and accuracy of the measuring instrument is in performing its measuring function. In this testing variable 7 attributes adapted from the customer needs attributes include comfortable, there is backup, strong material, appropriate body size, easy to use, multifunctional, and reasonably priced.

Table 1: Customer needs and technical needs

No	Customer Needs	Average Customer Expectations	Technical Needs
1	Comfortable	4.67	Comfortable seating mat
2	Reasonably priced	4.30	Competitive price
3	Multifunction	4.00	Other functions besides waiting chairs
4	There is backup	3.93	Additional facilities
5	Easy to use	3.67	Assembling
6	Ergonomic	3.63	Appropriate body size
7	Strong material	3.33	Material quality

The result of the validity test with a factor analysis indicates a KMO value of 0.584 from the result indicating that the instrument is valid because it already meets the 0.50 (0.584 > 0.50) limit. The anti-image correlation results in a correlation greater than 0.50 for each attribute, i.e. 0.530 (X1); 0.638 (X2); 0.666 (X3); 0.576 (X4); 0.566 (X5); 0.604 (X6); 0.619 (X7). Based on the correlation result is high enough, that can be expressed 7 attributes can be used to measure the contraction of the product-forming criteria. While Cronbach's Alpha value in the results of reliability test = 0.669 with a number of items = 7 items, then on the reusability of Cronbach's Alpha test > The minimum value of Cronbach's. Minimal Cronbach 0.6.

3.1 QFD Phase

In making the product design matrix, the most important step is to translate the customer needs into technical needs, this aims to explain the specifications in general the design will be developed. Technical needs data is obtained by interview methods to 5 teams of waiting chair products that accommodate the customer needs. As for the techniques needs that customers expect based on each voice of customer can be seen in the Table 1.

This section shows the direction of improvement to any existing technical needs can be seen in Table 2.

Table 2: Target technical needs

No	Technical Needs	Target
1	Comfortable seating mat	Add sponge in seats
2	Additional facilities	There is backup
3	Material quality	Using iron.
4	Appropriate body size	Adjust the average body size of Indonesian anthropometry.
5	Easy to assembly	Adjust the sitting position only or with the table at once.
6	Other functions besides waiting chairs	Can be used as chair, and table.
7	Competitive price	Not more than IDR 500,000

The correlation matrix is a triangle-shaped image resembling a house roof, and the matrix is usually combined with the technical needs. Usually this correlation of matrix is at the very top of the QFD matrix can be seen in Figure 2.

Following an example of the calculation of absolute importance on the technical needs of pricing, absolute interest is calculated in the following: AI = (3,93 x 3) + (3,33 x 9) + (4 x 3) + (4,30 x 9) = 92,4. Calculating the value of absolute interest is done on all technical needs.

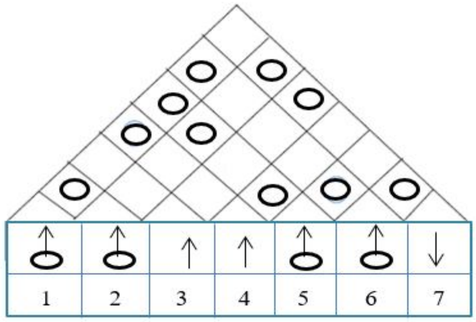

Figure 2: Correlation between technical needs

Following the calculation of relative importance on the technical needs of pricing, relative interest is calculated in the following : Σkt*i* =84,6+32,9+68,6+86,6+103,1+63,7+92,4 = 532,24. Then the value of relative importance (RI) = 92,4/532,24x100% = 17,3 .Likewise, by calculating the needs of other techniques, this is done in the same way until all is completed. Relation Matrix, absolute importance, and relative importance can be seen in Table 3.

Table 3: Relation matrix, absolute importance and relative importance

Customer needs	IR	Technical needs							
		1	2	3	4	5	6	7	
Comfortable	4,67	9	1		9	3			
There is backup	3,93	1	3		1	1	1	3	
Strong material	3,33			9				9	
Ergonomic	3,67	3			9	1			
Easy to use	3,63	3	1		1	9	3		
Multifunction	4,00	3			1	9	9	3	
Reasonably price	4,30	1	3	9		3	3	9	Total
Absolute Importance		84.6	32.9	68.6	86.6	103.1	63.7	92.4	532.24
Relative Importance		15.8	6.19	12.9	16.2	19.3	11.9	17.3	100

Value of absolute interests technical needs comfortable seating 84.6, additional facilities 32.9, material quality 68.6, ergonomic 86.6, easy in assembling 103.1, other functions besides the waiting seat 63.7, competitive price 92.4. While the value of the relative importance of technical needs is the comfortable seat mat 15.8, additional facilities 6.19, material quality 12.9, ergonomic 16.2, easy to assemble 19.3, function besides waiting chair 11.9 competitive price 17.3. The biggest value on the relative importance of technical needs is prioritized for consideration of product development i.e. easy-to-assemble attributes.

3.2 Phase Value Engineering

At this information stage focused on the value of the relative importance of product technical needs at the QFD stage. The results of interviews with the manufacturer of product manufacturers describe the waiting seat products that are based on hollow pipes and wooden planks. The base material used is 2x2 pipe size and 3x3 full pipe, with a seat height of 450 mm, width of 380 mm, length 2,000 mm. While the table height is 790 mm, width 300 mm, length 2,000 mm. Seating area and desk are fitted with wooden planks. In addition, there is information that the cost of making a waiting chair product according to specification above is IDR 546.500,00 Here's the picture that shows the production of waiting chair products from industrial Engineering of Kadiri University. Figure 3 shows from dise view and Figure 4 shows from back view.

FAST (*Function Analysis System Technique*) is a way of mapping functions and techniques of solving problems by way of identifying functions. This is FAST diagram of waiting chair product can be seen in Figure 5.

From the results of the analysis on the figure 5, it shows that in making creative stage is more pressed on the product dimensions to accommodate from the value of the importance of the relative technical needs of the product.

Figure 3: Side view

Figure 4: Back view

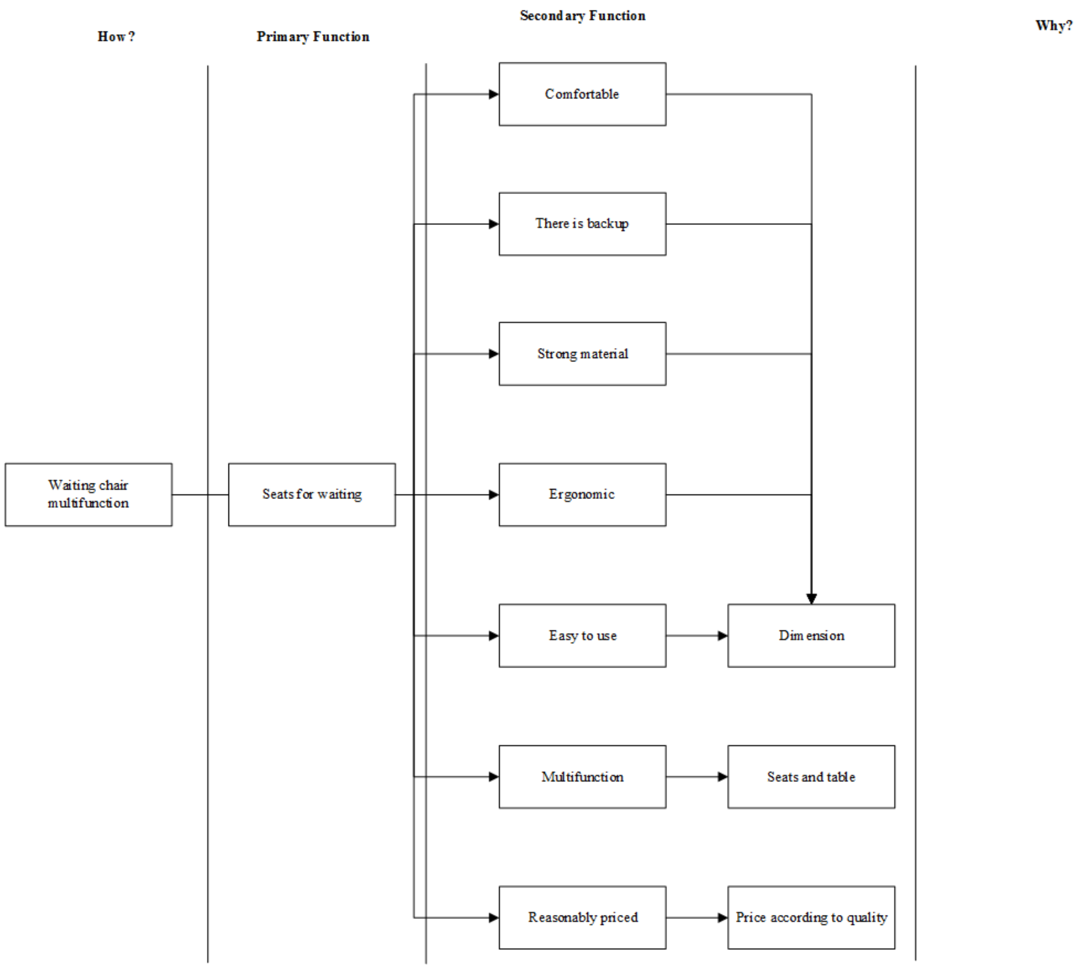

Figure 5. FAST diagram

Table 4: An alternative to multifunctional chair design

Product Spesification	Alternative I	Alternative II	Alternative III
Basic size under table and chair	Length =1990mm Width = 430 mm	Length = 1800mm Width = 350 mm	Length = 2000mm Width = 350mm
Seat size	Length = 1990mm Width = 383mm	Length = 1800mm Width = 350mm Height = 400 mm	Length = 2000mm Width = 350 mm Height = 410 mm
Table size	Length =1990mm Width = 300mm Height = 725mm	Length =1800mm Width = 400mm Height = 700mm	Length = 2000mm Width = 300 mm Height = 660 mm
Lock of table and chair	-	Iron Elbow Locking	Locking Metals
Main material	Iron	Iron	Iron
Seat material	Wood plank with the thickness 20mm	Wood plank with the thickness 20mm and covered with sponge	Wood plank with the thickness 20mm and covered with sponge
Table mat	Wood plank with the thickness 20mm	Wood plank with the thickness 20mm and removable sponge	Wood plank with the thickness 20mm
As multifunction waiting chair	Waiting chair can have a function to be a table	Waiting chair can have a function to be a table	Waiting chair can have a function to be a table

At this creative stage is analyzing the same functions to meet other alternative uses. Based on the level of information criteria customer needs waiting chair product is developed alternative products according to the results of the level of information visible on the table 4. At this stage is analyzing the same functions to meet the usability of other alternatives. Based on the information criteria of the customer needs of the waiting chair product is made basic consideration to develop the waiting chair design. The criteria of customer needs is in the function of the waiting chair itself. For alternatives can be seen from the following table.

To make weighted criteria, the analysis of the product formation of waiting seats to the proposed alternatives according to their respective criteria. The data presented is the data in the assessment of the 5 panelists that includes users and producers to each proposed alternative by delivering a value range of 0-100 per product requirement criteria. The results of the performance analysis can be seen in table 5.

Table 5: Alternative performance

Need's criteria	Alternative		
	1	2	3
	Weight	Weight	Weight
Comfortable	380	390	407
There is backup	395	390	385
Iron material	405	385	410
Ergonomic	365	377	383
Easy to use	391	402	392
Multifunction	408	398	395
Reasonably priced	383	382	390
Total of product performance	2727	2724	2762

Table 6: Calculation of alternative I

No	Material	Diameter	Unit Price	Amount	Total
1.	Hollow Iron 3x3	1.2 mm	IDR 66,000	3.5	IDR 231,000
2.	Wooden Planks		IDR 70,000	1	Rp 70,000
3.	Electrode	2 mm	IDR 70,000	½	IDR 35,000
4.	Zinc Chromate		IDR 33.000	½	IDR 16,500
5.	Putty		IDR 13,000	250 gr	IDR 13,000
6.	Paint		IDR 54,000	¾	IDR 40,500
7.	Welding Wire		IDR 7,500	1 kg	IDR 7,500
8.	Nuts and bolts		IDR 5,000	12	IDR 60,000
Total					IDR 473,500

At this development stage, an alternative cost analysis is used to determine the price of the product in each making 1 unit of each alternative available in Table 6, Table 7, and Table 8.

Table 7: Calculation of alternative II

No	Material	Diameter	Unit Price	Amount	Total
1.	Hollow Iron 3x3	1.2 mm	IDR 66,000	2	IDR 132,000
2.	Hollow Iron 2x2	1 mm	IDR 62,000	1	IDR 62,000
3.	Wooden Planks		IDR 70,000	½	IDR 35,000
4.	Bracket		IDR 27,500	2	IDR 55,000
5.	Sponge 1x1		IDR 17,500	1	IDR 17,500
6.	Zinc Chromate		IDR 33,000	½	IDR 16,500
7.	Putty		IDR 13,000	1	IDR 13,000
8.	Paint		IDR 54,000	½	IDR 27,000
9.	Electrode	2 mm	IDR 70,000	¼	IDR 17,500
10.	Welding Wire		IDR 7,500	1 kg	IDR 7,500
11.	Screw bolts		IDR 11,500	¼	IDR 2,875
12.	Hinge		IDR 5,000	14	IDR 70,000
Total					IDR 455,875

Table 8: Calculation of alternative III

No	Material	Diameter	Unit Price	Amount	Total
1.	Hollow Iron 3x3	1.2 mm	IDR 66,000	2 ½	IDR 165,000
2.	Hollow Iron 2x2	1 mm	IDR 62,000	1 ½	IDR 93,000
3.	Lock		IDR 20,000	4	IDR 80,000
4.	Wooden Planks		IDR 70,000	1	IDR 70,000
5.	Sponge		IDR 17,500	1	IDR 17,500
6.	Zinc Chromate		IDR 33,000	½	IDR 16,500
7.	Putty		IDR 13,000	250 gr	IDR 13,000
8.	Paint		IDR 54,000	½	IDR 27,000
9.	Electrode	2 mm	IDR 70,000	½	IDR 35,000
10.	Welding Wire		IDR 7,500	1 kg	IDR 7,500
11.	Screw bolts		IDR 11,500	¼	IDR 2,875
Total					IDR 527,375

After calculating the cost analysis of the product manufacture each alternative further determines the ratio value of Value Engineering. A product or service can be said to be good if the product has good performance and accordingly. Cooper [10] said that value is an approach that uses consumers as its orientation. In other words, it is a consumer approach that uses products to get the value of the performance as expected. The last stage in the value engineering is determining the measured value of the performance score divided by the basic cost of the product in each alternative. So the result can be seen in Table 9.

Table 9: Price of the product calculation result

Alternative	Price of the product	Performance Score	Value	Ranking
Alternative I	IDR 473,500	2727	0.00576	2
Alternative II	IDR 455,875	2724	0.00598	1
Alternative III	IDR 527,375	2762	0.00523	3

The images below (Figure 6 to Figure 9) show the development of an alternative II that can change based on the functionality.

Figure 6: Design I

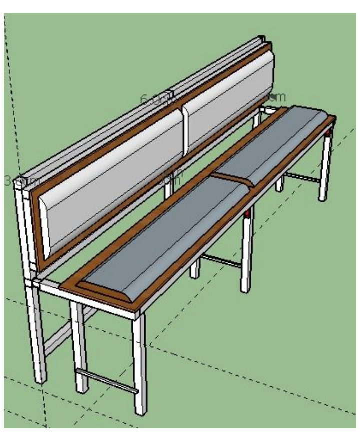

Figure 7: Design II

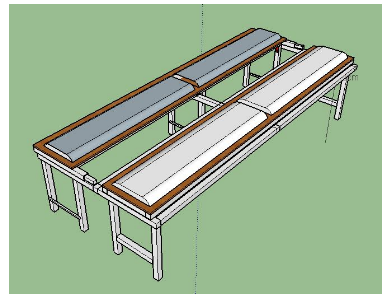

Figure 8: Design III

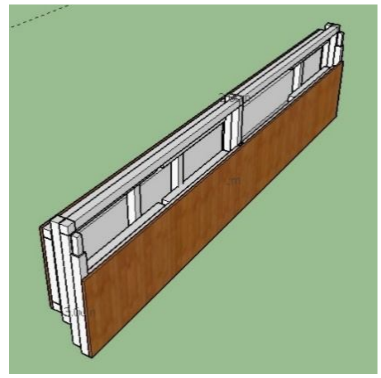

Figure 9: Design IV

4. CONCLUSION

The integration of QFD and Value Engineering in this study seeks to produce products that fit the needs of customers and reduce the cost of manufactured products but does not eliminate the functions that exist in previous products. The conclusion from this research is there is three alternative designs for waiting chair product. The otal of product performance from each alternative is 2727, 2724, and 2762. The cost from each alternative is alternative 1 IDR 473.500, alternative II IDR 455.875, and alternative III IDR 527.375. The results showed that increasing the development of waiting chair products in this case could reduce product manufacturing costs by Rp. 90.625. The weakness from this research is the product still in prototype design.

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