Application of Value Analysis to Increase Customer Satisfaction in Product Development: A Case Study on Tree Climbing Devices

Celestine Aguwa, VMA; Egbe-Etu Etu; Joshua Emakhu; Oluwatoba Osoba; Darlington Egeonu; and Leslie Monplaisir

Industrial and Systems Engineering, Wayne State University

4815 Fourth Street, Detroit, MI 48201

Abstract

In the global economy today, customer satisfaction is a top priority for organizations who develop new products and services. Customer satisfaction is a marketing term that measures how products or services supplied by a company meet or surpass customer's expectation. Value analysis (VA) follows a methodology of distinct phases, which searches for and uses current technology to creatively furnish technically sound alternatives to satisfy the user's needs at the appropriate life cycle cost. Failure to resolve product issues leads to poor product quality which is a major reason for customer dissatisfaction. The aim of this study is to use VA to improve product development thereby increasing customer's satisfaction. The six-step VA job plan approved by SAVE International which consists of; information, function analysis, creative, evaluation, development and presentation phases will be used on a case study of tree climbing devices where customers have displayed dissatisfaction with the product quality and safety. The result of this study leads to a safe and better product at the appropriate cost that meets customer's expectations. This increases customer's loyalty in the products and services offered by the company.

Keywords: SAVE International, Value Analysis, Customer Satisfaction, Product Quality, New Product Development

Introduction

In market and engineering research, product development (PD) deals with the complete process of introducing a new product to market. According to Kahn (2012), PD is the transformation of a market opportunity into a product available for sale. The product can be tangible or intangible. For PD to be successful, it requires an understanding of consumers needs and wants, the competitive environment, and the nature of the market (Aguwa et al., 2017a). The variables that drive customer needs include cost, quality and time. Aiming at these variables, organizations develop continuous practices and strategies to better satisfy customer requirements, increase their market share and stay competitive by a regular development of new products.

Aguwa et al., (2017c) states that the success of a product or service in the market depends on customer satisfaction. Thus, the primary mission in any industry is to cater to the needs of the customer. Improving customer satisfaction includes a range of research aspects from reducing the time and cost of services in supply chain networks, auto industry, service industry and customer relation to product-based procedures such as new product development (Olya, 2014; Fuchs, 2011 and Matzler, 1998). To improve customers' satisfaction, various techniques such as dynamic optimization, time-cost analysis, lean manufacturing, value engineering methods may be used during PD.

Value engineering (VE) is defined as a systematic method applied to improve the value of products and services by using an examination of function (SAVE International, 2017; MVF, 2017 and King, 2000). VE is also referred to as value management or value methodology (VM), and value analysis (VA). Value analysis is a problem solving and decision-making technique that bypasses learned responses to produce alternative solutions achieving all required functions of the original design at the appropriate cost over the life of the product (Aguwa et al., 2017b; 2017d). It follows an established, organized, job plan, and problem identification format approved by SAVE International that promotes objectivity and stimulates creativity. When VA methodology is followed precisely, beneficial results are ensured. VA examines systems of design and breaks them into components which are then described in terms of intended use. The intended use called a function is described in just two words, an active verb, and measurable noun.

Motivation

Intense worldwide competition in the global market is providing a demanding environment for companies (Gerhardt, 2006). Organizations that cannot provide high-value products and services to their customer's experience:

- Poor product quality and product development process
- Low customer perception / satisfaction
- Increase in cost and time of service

Objectives

Addressing the motivation, VA will be used to improve the functionality of a product thereby;

- Increasing product quality at appropriate cost
- Increasing customer satisfaction and loyalty

Literature Review

The urge to continually improve on existing product and innovative technology has been increasing rapidly in the last decade. The level of successful new products that meet customer wants and needs has generally been low. Robert Cooper in his 3-section arrangement on "Benchmarking Best NPD Practices" demonstrates that roughly one of every ten product ideas succeed financially (Cooper et al, 2004). Thus, organizations utilize distinctive procedures with a specific end goal to make better products and services that will fulfill their customers' needs (Ali, 1994; Bettis, 1995; Prahalad, 1998). This procedure incorporates the utilization of VM with a specific end goal to enhance the value of the products and services they offer to their customers.

(Akbari and Zanjani, 2014) stated that VE is dedicated to an imperative system for efficient utilization of funds. (Annappa and Panditrao, 2012), carried out a study on the utilization of VE to minimize cost on a universal testing machine (UTM) indicated how data analytics was utilized to gather and evaluate the data required for the information phase of the study. Consumer satisfaction corresponds to the value of the goods and services and is thought to be a component of the product and service in return for the cash that pays for merchandise or services. (Annappa and Panditrao, 2014) investigated the use of VE for cost minimization of household furniture product. They utilized the VE job plan for their work and implemented the use of functional evaluation and decision matrix for analysis in the evaluation phase. Customer satisfaction is important as it provides companies with a metric for measuring, managing and improving their businesses.

Based on a study carried out by (Aguwa et al., 2017c), the success associated with product and services in the market is attributed to customer satisfaction. Be it as it may, the voice of the customer is essential in any business venture. Therefore, to cater for customer needs, a program of new product development must incorporate activities intended to minimize product cost and to improve the value to the customer, due to the emerging growth in competitiveness, customers tend to demand new products with better quality and functionality, without an inflation in price (Roy et al., 2004).

Methodology

The proposed methodology of using VA for the improvement of a product to increase customer satisfaction during PD process is implemented using a case study. The VA six-step job plan in figure 1 is followed systematically to accomplish this task.

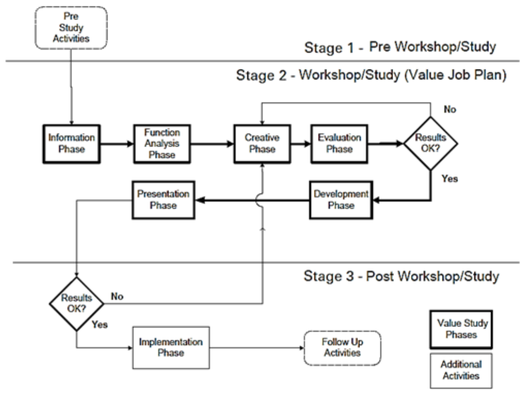

Figure 1: VA six-step job plan. (Source: SAVE International, 2017)

Case Study on Value Analysis of "Tree Climbing Device"

A case study was selected and used to demonstrate the proposed methodology. Tree climbing devices are used by agricultural farmers in Nigeria, India, South Sudan, and Bangladesh for the harvesting of fruits from coconut and palm kernel trees. The problem statement of the case study is the low customer satisfaction and complaints received from farmers about the product in Nigeria. 94.7% of the farmers surveyed complained about safety, affordability, and ease of use of the product. This caused 7.9% of the farmers to withdraw from their occupation making them unemployed. The objective of the case study is to create a better product that is safe, economical and has the required functions to meet customer's expectations and increase satisfaction. Three major modifications will be carried out to the existing product namely: height adjustment feature, size/weight, and safety feature.

Step #1: Information Phase

This phase ensures that the objectives and purpose of the study are completely understood to ensure relevant gathering of information. Data was collected via interviews and questionnaires to get first-hand knowledge of the farmers' perception of the product, as correct information is essential to making a sound decision. From the survey, it was found that the current device has 1 single solid frame, heavy, no safety feature and is not adjustable to ensure comfort for the farmers while climbing (see fig. 2). Data on the cost of each component was collected (see Table 1). The device components serve as input for the function analysis phase.

Figure 2: Current Tree Climbing Device

Table 1: Costs of current component in the market

Part No.	Component	Cost ($)
1	Solid Steel Frame	7.88
2	Sliding frame	3.94
3	Steel Wire Rope	14.18
4	Steel Wire Holder	5.51
5	Fixtures	3.94
6	Foot Rest	1.57
	Total	37.02

Step #2: Function analysis Phase

This phase defines the functions using a two-word abridgment of an active verb and a measurable noun. Analysis of the components is carried out to determine which component needs to be improved or eliminated to meet the research goals as seen in Table 2. A function cost matrix is prepared to identify the cost of providing each function by associating the function with a component part of the product (see Table 3). Product functions with a high cost-function ratio are identified as opportunities for further improvement. From table 3, we can deduce that improving the friction of the device is important as it has the highest function percentage. Using the functions in table 2, a functional analysis systematic technique (FAST) diagram is created to show how each function of the case study is being used to improve the product. In addition, figure 3 shows how the functions are identified in the model, organized and classified.

Table 2: Function Analysis of the Current Device

#	Components	What does it do?		Function	Cost ($)
		Active Verb	Measurable Noun		
1	Solid Steel Frame	Hold	Assembly	Basic	7.88
		Maintain	Stability	Secondary	
		Direct	Motion	Basic	
2	Sliding Frame	Lock	Rope	Basic	3.94
		Provide	Comfort	Secondary	
		Hold	Slit	Basic	
3	Steel Wire Rope	Create	Friction	Basic	14.18
		Grip	Tree	Basic	
4	Steel Wire Holder	Equip	Wire	Secondary	5.51
		Provide	Friction	Basic	
5	Fixtures	Connect	Components	Secondary	3.94
		Attach	Holder	Basic	
6	Foot Rest	Support	Weight	Basic	1.57
				Total	**37.02**

Table 3: Function Cost of Existing Device

Part	Qty	Cost	Function – Active Verb / Measurable Noun						
			Hold Assembly	Maintain Stability	Direct Motion	Restrict Movement	Provide Comfort	Improve Friction	Connect Components
Solid Steel Frame	1	$ 7.88		75%					25%
Sliding Frame	1	$ 3.94			75%	25%			
Steel Wire Rope	2	$ 14.18				50%		50%	
Steel Wire Holder	1	$ 5.51		25%	25%			50%	
Fixtures		$ 3.94	25%			25%			50%
Foot Rest	2	$ 1.57					100%		
Total		$ 37.02	$ 0.98	$ 7.28	$ 4.33	$ 9.06	$ 1.57	$ 9.85	$ 3.95
Function - Percentage		100%	2.65%	19.67%	11.70%	24.50%	4.24%	26.61%	10.67%

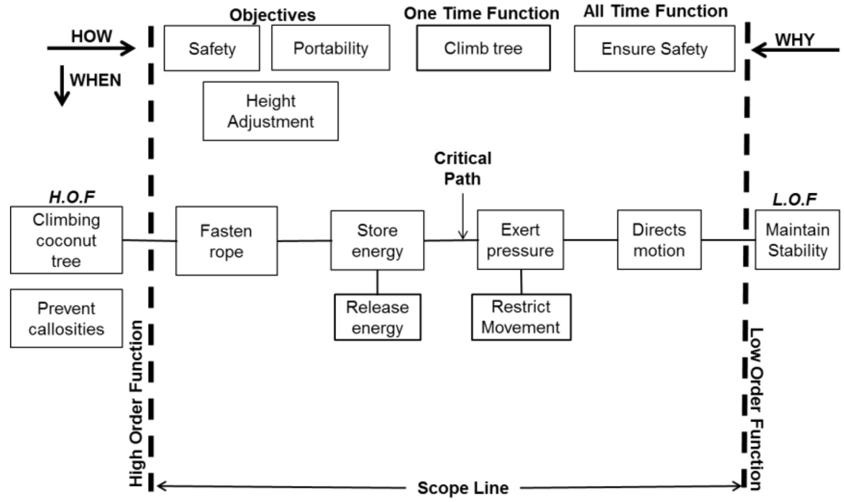

Figure 3: FAST Diagram Model

Step #3: Creative Phase

This phase deals with generating alternatives that can perform the basic functions identified in the function analysis phase. The table below shows the different ideas generated for the project to achieve the objectives. Table 4 & 5 shows the alternatives for the functions and the components in the device.

Table 4: Alternatives for the functions

Functions	Existing component	Alternative 1 (Adjustable standing type)	Alternative 2 (Sitting type)	Alternative 3 (Automatic)
Fasten rope	Small sliding frame without spring	Long sliding frame with spring	Rubber bushes	Wheel
Store/release energy	No component	Spring	Dead weight	Motor
Restrict movement	Fixture	Locking screw	Bottom & top support	-
Directs motion	Solid steel frame	Upper frame & lower frame	Top support	Motor

Table 5: Alternatives for the components

	Material of components			
	Upper / lower / sliding frame	Steel wire rope	Steel wire holder	Footrest
Alternative 1	Mild steel	Single strand (Steel)	Rubber tire	PVC
Alternative 2	Aluminum	Double strand (Steel)	Steel holder	Polyester fiber
Alternative 3	Stainless steel	-	-	Canvas

Step #4: Evaluation phase

The purpose of this phase is to select for further analysis and refinement the most promising alternatives from among those generated during the creative phase and the cost of each alternative is evaluated. Table 6 shows the different alternatives evaluated for the existing components shown in Table 4. Alternative 1 is selected as the best alternative that satisfies the customers need.

Table 6: Evaluation of alternatives for existing component: Small sliding frame without spring

S/N	Alternative	Advantages	Disadvantages	Cost ($)	Overcome
1	Long sliding frame with spring	Easy to climb	Increase in weight and cost	11	By using mild steel
2	Rubber bushes	Flexible	Difficult to climb by balancing one's complete weight in sitting position	7.86	Using a standing type device
3	Wheel	Automatic	Too costly	23.58	Choosing alternative for motor

Table 7: Evaluation of alternatives for existing component: No component

S/N	Alternative	Advantages	Disadvantages	Cost ($)	Overcome
1	Spring	Not much effort to climb	Increase in weight and cost	7.07	By using spring steel
2	-	-	-	-	-
3	Motor	Automatic	Costly	15.72	Using a standing type device

Table 8: Evaluation of alternatives for existing component: Fixtures

S/N	Alternative	Advantages	Disadvantages	Cost ($)	Overcome
1	Locking screw	Easy height adjustments	Might break if low quality is used	3.14	Use good quality and according to design calculation
2	Bottom and top support	Flexible	Too many components	11.0	Using fewer components
3	-	-	-	-	-

Table 9: Evaluation of alternatives for existing component: Solid steel frame

S/N	Alternative	Advantages	Disadvantages	Cost ($)	Overcome
1	Upper and Lower frame	Height adjustments, portable and increase in strength	Increase in weight and cost	12.58	By using mild steel
2	Top support	Lightweight	Difficult to climb by balancing one's complete weight in sitting position	7.86	Using a standing type device
3	Motor	Automatic	Too costly	23.58	Choosing alternative for motor

Step #5: Development phase

The purpose of this phase is to develop specific alternatives having the most potential for savings and acceptance. Using the basic functions and the ideas generated which have been analyzed and evaluated, the solid steel frame is selected and a new design for the device is made. The proposed cost of the components for the new device is shown in Table 10. Note: The final cost of the device is an estimate which includes the cost of labor and manufacture.

Table 10: Costs of proposed component in the market

Part No.	Component	Cost ($)
1	Upper frame	5.51
2	Lower frame	8.26
3	Sliding frame	3.94
4	Helical spring	7.08
5	Steel wire rope	14.17
6	Steel wire holder	1.57
7	U-bolts	4.72
8	Locking Screw	3.15
9	Safety belt	3.15
10	Footrest	1.57
	Total	53.12

Product Design Specification (PDS):

The product design specification is a set of defined information that helps to meet the design considerations & the requirements. It gives the details of all the considerations from design to manufacturing. In the PDS all the specified data must be defined properly (See Table 11). PDS is used to carry out design calculations for the frame of the device, thickness of the plate, locking screw, bolt and safety harness.

Table 11: Product Design Specifications

Target users	Farmers, residents and professional tree climbers
Target customer	Agricultural development boards, farmers, residents and professional tree climbers
Weight	11 lbs. – 19.8 lbs.
Cost	$50 - $100
Type of tree climbing device	Standing type
Materials	Mild Steel Steel rope wire Rubber pad
Safety	No sharp corners, grip and smooth material for handles, safety belt
Features	Simple mechanism, ergonomic and improved safety
Performance	Continuous
Environment	Exposure to moisture will cause rust. Coating and painting will be done
Maintenance	Periodic maintenance after 100 trees approximately
Packaging	Cover with polythene sheet
Manufacture	Single or Batch production

The proposed tree climbing device is shown in figure 4 with an estimated cost of $55 which is $18 higher than the current device but has all the required functions needed by the customers.

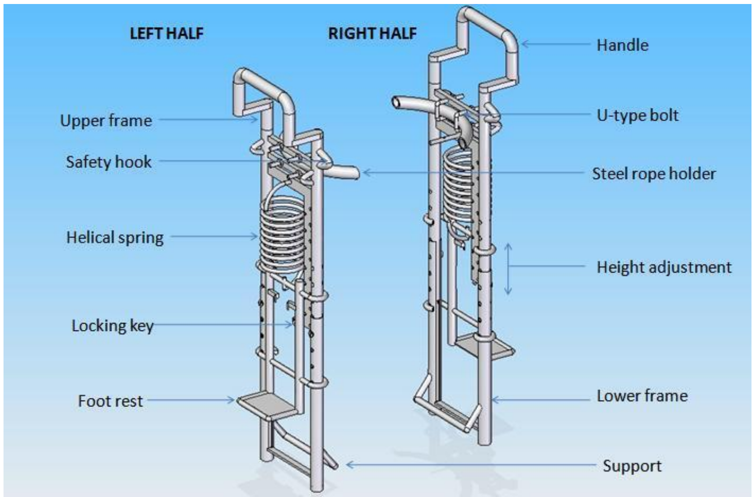

Figure 4: Proposed Tree Climbing Device

Step #6: Presentation phase

A report is prepared to document all the information, design calculations and analysis done on the project.

Conclusion

Value Methodology is a systematic and structured process which aims to investigate and evaluate all activities performed in a project. It is one of the most efficient tools for driving economic improvement by increasing the value of a product and ensuring customers satisfaction. The study describes how VA is used to examine the current product and proffer alternatives for the design of a new product that meets customer's expectations. From the results of the case study, the proposed tree climbing device is shown in figure 4 with an estimated cost of $55 which is $18 higher than the current device but has all the required functions needed by the customers. The new device has a safety hook that ensures the safety of users. It is portable, has a footrest and a height adjustment feature for the comfort of the users. These new additions resolve all the concerns and complaints of the farmers.

References

1. C. Aguwa et al., (2017a). Modeling of fuzzy-based voice of customer for business decision analytics, Knowledge-Based Systems, http://dx.doi.org/10.1016/j.knosys.2017.03.019

2. Celestine Aguwa, Drew Algase, Leslie Monplaisir (2017b). Advancement of Value Engineering through Collaboration of Universities, SAVE International & Industries. www.value-world.org/wordpress/
3. Celestine Aguwa, Egbe-Etu E. Etu, Darlington Egeonu, and Leslie Monplaisir, (2017d). "Application of Data Analytics and AHP on Value Methodology", 2017 Conference Proceedings on SAVE International. Pg. 4 – 8
4. Celestine C. Aguwa, Egeonu Darlington, Egbe-Etu E. Etu and Leslie Monplaisir (2017c). "Fuzzy-Based Integrated Customer Satisfaction Index to Enable Engineering Change", Proceedings of the 2017 Industrial and Systems Engineering Conference, Pg. 1036-1041.
5. Don J Gerhardt (2006). Managing Value engineering in New Product Development. Value world, Vol. 29 – No. 2. www.value-world.org/wordpress/
6. Fuchs, C. and Schreier, M. (2011), Customer Empowerment in New Product Development*. Journal of Product Innovation Management, 28: 17–32. doi:10.1111/j.1540-5885.2010. 00778.x
7. K. Matzler, H.H. Hinterhuber. How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment, Technovation 18 (1) (1998) 25–38.
8. Kahn, Kenneth B. (2012). The PDMA handbook of new product development (3 ed.). Hoboken, New Jersey: John Wiley & Sons Inc. ISBN 978-0-470-64820-9. A thorough understanding of customers' needs and wants, the competitive situation, and the nature of the market is an essential component of new product success.
9. King, T.R. (2000). Value engineering: theory and practice in industry. Washington, D.C.: Lawrence D. Miles Value Foundation.
10. Lawrence Miles Value Foundation http://valuefoundation.org/Educate-Ed-Program.htm Accessed December 30th, 2017
11. M.H. Olya, Applying Dijkstra's algorithm for general shortest path problem with normal probability distribution arc length, Int. J. Operation Res. 21 (2) (2014) 143–154.
12. SAVE International. http://www.value-eng.org/about_vision_and_mission.php. Accessed: December 30th, 2017
13. Cooper, R. G., S.J. Edgett and E.J. Kleinschmidt. Benchmarking Best NPD Practices-I, II & III". Research-Technology Management. Industrial Research Institute. 2004.
14. Ali, A. (1994). Pioneering versus incremental innovation: Review and research propositions. Journal of Product Innovation Management, 11(1), 46-61. DOI: 10.1016/0737-6782(94)90118-x
15. Bettis, R.A. and Hitt, M.A. (1995). The new competitive landscape. Strategic management journal. 16(S1): p. 7-19.
16. Film Value Engineering (National Iranian Productivity Organization).
17. Annappa, C.M., & Panditrao, D.K. (2012). Application of Value Engineering for Cost Reduction – A Case Study of Universal Testing Machine. International Journal of Advances in Engineering & Technology, 4(1), 618-629.
18. Annappa, C.M., & Panditrao, D.K. (2014). Application of Value Engineering for Cost Reduction of Household Furniture Product - A Case Study. International Journal of Innovative Research in Science, Engineering and Technology, 03(10), 16577-16583. doi:10.15680/ijirset.2014.0310024
19. Prahalad, C.K. (1998). Managing discontinuities: The emerging challenges. Research Technology. 41(3): p. 14.
20. Roy, R., Colmer, S., Griggs, T., 2004. Estimating the cost of a new technology intensive automotive product: A case study approach. International Journal of Production Economics 97 (2), 210–226.
21. Akbari, H., Zanjani, H. J. (2014). Studying the effect of implementing value engineering to increase productivity in service - education profit firms