

A New Product Development Framework for a Timber Processing Company

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Abstract— Customer perceptions of products continuously change over time. Marketing specialists are generally tasked with the responsibility of rebranding and product changes. However this is normally technology driven, with inputs from engineering designers and manufacturers providing the designs and feasibilities for either modifying existing designs or developing new ones. An opportunity arose at a timber processing company where a variety of products such as domestic and commercial furniture are manufactured. This paper reports on the development of a framework for formulating new products using the wide array of hard and soft wood that the company processes. A detailed work study was conducted focusing on the company's production capacity, sales history of the company's twenty-three products, market trends and interviews with current customers. The research set out to develop innovative and new product platforms (product families) that are unique and represent the company while satisfying customer needs and requirements. A stage-gate model of the New Product Development (NPD) using the stage gate model, Weighted Objectives and Quality Function Deployment (QFD) methods were the engineering techniques employed in this model and a four-wheeler coffee table was developed into a prototype using QFD. Implementation of the stage-gate model and further research into the four-wheeler coffee table were recommended as well as other areas related to NPD.

Index Terms—New Product Development, Quality Function Deployment, Stage Gate Modelling, Value Engineering.

I. INTRODUCTION

THE timber processing holding company is divided into four subsidiary business units that are all involved in processing timber to produce a wide variety of products.

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Due to the economic recession that most countries suffered around 2008 [1], the group had been undergoing some form of rehabilitation in order to bring it back on track and be competitive. Most companies in Zimbabwe were affected by the global recession with some being liquidated. Those that were fortunate enough to escape the crisis still faced the challenges brought on by global competition. Although the government of Zimbabwe at the time put measures in place to protect local manufacturers, these were only useful for the local markets and yet better margins can be realized by exporting. Thus, companies needed to be competitive globally in order to survive. A team of engineering academics from the University of Zimbabwe set out to assist and rehabilitate this holding company by setting up operating systems, reorganize plant layouts and process flows as well as assisting the company in modern methods of manufacture as part of research at minimal or no cost to the company but with the ultimate objective of improving efficiency and productivity to enhance profitability. One of the tasks that the team embarked on was to look at the company's product portfolio and then set out to introduce new techniques that would see the company rapidly introducing new products or modifying existing ones.

The four subsidiaries are involved in the manufacture of a variety of furniture with each one specializing in a particular range of products to complement and not compete with the others. The division where this research was carried out, specialized in the manufacture of children's furniture (nursery), leisure and occasional furniture, dining room suites and coffins. It is one of the leading local manufacturers of children's furniture and supplies all the major furniture retail outlets in Zimbabwe. It however faces stiff competition from other local manufacturers, let alone the ability to export and compete globally, hence the need to come up with new strategies and engineering techniques to enable the company to rapidly prototype and produce attractive and competitive products that could possibly be considered for export. The unit is run by a production manager assisted by the unit's bookkeeper while the rest of the plant has skilled and semi-skilled craftsman from machinists to carvers and fitters.

From a socio-economic point of view, a new product is one, which greatly increases customer satisfaction and has no significant substitute. New Product Development (NPD) refers to the overall process of strategy, organization, concept generation, product and marketing plan creation, evaluation, and commercialization in the process of developing it. This may involve original products, product improvements, product modifications or new brands. To be

competitive on the global market, companies need to develop new technology and launch new products in the market [2]. From a business viewpoint, careful technology and product planning have been considered a continuing challenge in building profitable businesses. An NPD framework is thus a disciplined and defined set of tasks and steps, which describe the normal means by which a company repetitively converts embryonic ideas into saleable products. This research aimed at establishing a basis for NPD at the subsidiary company with the objectives to:

- Establish engineering strategies that guide product innovation program at the company,
- Find ways that the company may organize for NPD,
- Identify the major sources of new product ideas and how concepts may be generated,
- Create a marketing plan leading to commercialization of new products,
- Establish the position of each of the company's products on the product life cycle and make recommendations.

Following the recession, the company had limited success with new products on the Zimbabwean market due to the non-existence of a formal NPD process which has mainly been left as a preserve of the production manager. The manager has usually been busy managing existing product lines with no Research and Development unit within the company. Little thought has therefore been given to new products other than brand modifications or extensions. Considering the strong competition and the current state of the Zimbabwean political and economic scenarios, the company's current offerings are facing shortened life spans. These ought to be replaced by newer products. The risks of innovation are as great as the rewards since new products can fail, thus the need for a formal and robust NPD framework which is technology driven [2]. The key to successful innovation lies in developing better organizational arrangements for handling new product ideas and developing sound research and decision procedures at each stage of a defined NPD model or framework. This research therefore focused on coming up with a framework that encompasses all the processes and strategies necessary for successfully developing a new product that will satisfy the customer and bring profits, growth and prosperity to the company.

II. BACKGROUND AND LITERATURE REVIEW

A. *New Product Development*

Organisations are increasingly recognizing the necessity and advantages of developing new products and services. Their current offerings face shortened life spans and must be replaced by newer products. New products, however, can fail and companies have to develop sound organizational procedures in an NPD process. The NPD process consists of several stages such as; idea generation, idea screening, concept development and testing, marketing strategy development, business analysis, product development, market testing and commercialization. The purpose of each

stage is to decide whether the idea should be further developed or dropped. Customers usually specify requirements and preferences for a product which can be further broken down into market segments and then further grouped into homogenous preferences [3]. Segmentation of the product market is necessary in order to achieve better value settings of engineering characteristics of new products. One of the requirements set by the company at the onset of the research was that they wanted to minimize the chances of poor ideas moving forward and good ideas being rejected.

Each commercialized product exhibits a life cycle marked by a changing set of problems and opportunities. Integrating life cycle assessment, which considers the product's whole life cycle, will also be useful for assessing the environmental impact of products and processes [4]. The sales history of a typical product follows an S-shaped curve made up of four stages. Slow growth and minimal profits mark the introduction stage as the product is being pushed into distribution. If successful, the product enters a growth stage marked by rapid sales growth and increasing profits. During this stage the company attempts to improve the product, enter new market segments and distribution channels, and reduce its prices slightly. These are followed by a maturity stage in which sales growth slows down and profits stabilize. The company sought innovative strategies to renew sales growth, including market, product, and marketing mix modification. Finally the product enters a decline stage in which sales and profits deteriorate. The company's task during this stage is to identify the declining product and decide whether to maintain, harvest, or drop it. In the last case, the product can be sold to another firm or liquidated for salvage value [5].

B. *Quality Function Deployment*

A comprehensive method for matching customer requirements to engineering characteristics is the quality function deployment method (QFD). In engineering design methods for new product development, QFD is an important methodological approach to increase customer satisfaction and reduce the product costs and development cycle time. According to the House of Quality (HoQ) chart, the most recognized and widely used form of QFD is the voice of the customer which can be translated into engineering characteristics [3], [6]. The technique is one of those modern tools that has been successfully employed in industries around the world for various product development activities [7]. QFD was originally developed at Mitsubishi's Kobe shipyards in 1972. In Japanese, the phrase means the same as strategic arrangement (deployment) throughout all aspects of a product (functions) of appropriate characteristics (qualities) according to customer demands. QFD was subsequently introduced to the USA at a motor vehicle manufacturing company and has been successfully applied at other companies since then. [11]

The QFD method recognizes that the person who buys (or who most influences the buying decision for) a product is the most important person in determining the commercial success of a product. If customers do not buy the product, then, no matter how well designed it may be, it will be a

commercial failure. Therefore ‘voice of customer’ has priority in determining the product’s attributes [6]. This means taking care to identify who the customers are, to listen carefully to what they specify, and to determine the product’s engineering characteristics to enable the smooth development and design and ultimately selling of the product [7], [8]. Companies can speed up the effect of new products on corporate growth and profits by managing the way they develop products better. The art and science of NPD has advanced enormously in recent years and is providing the foundation for positive re-engineering of this critical function within a wide range of companies. The leading-edge concepts and techniques of NPD can be summarized as follows:

- Focusing on the ‘fuzzy front end’ of NPD by bringing order and efficiency to a previously chaotic, meandering early part of the new product process [4].
- Paying close attention to both the voice of the customer and the voice of the user, and employing new techniques to capture their input at early stages of product development [6].
- Use of multifunctional, empowered project teams to drive NPD in shortened time spans [9].
- Creating new product platforms (product families) rather than isolated efforts [3].
- Designing ‘stage-gate systems’ with both ‘teeth’ and flexibility to provide discipline and structure to the overall NPD process [5].
- Implementing new product portfolio management, so resources are allocated most effectively and the focus on key projects and overload is reduced [8].
- Emphasizing speed with ‘time to profit’ rather than ‘time to market’ [8].

In QFD, engineering characteristics design requirements affecting the product performance are identified in order to improve the product performance and optimization to customer specifications and needs [10]. In recent years, the concept and technique of QFD has been used in conjunction with fuzzy approaches in new product development and design by incorporating failure modes and effects analysis into the QFD processes [12]. The use of fuzzy cognitive network process and aggregative grading clustering as applied by Reference [13] enabled rating flexibility for the expert judgment to handle uncertainty in new product development. This has assisted engineering designers and product development specialists to cope with the sometimes vague nature of the product development process. Today’s product marketplace is full of various and innovative product offerings owing to dynamically changing customer desires and rapid changes and advances in technology and manufacturing systems [14]. This presents challenges but also opportunities for designers and developers of products to keep abreast of these advances to remain competitive. A house of quality was proposed to critically analyse factors involved in QFD in the development and planning for new products to reflect the knowledge and differences among various customers regarding their requirements [15]. However this was limited to non-homogeneous assessments

of the evaluation of requirements whereas it is vital to seek opinions from different market segments in the new product development cycle. QFD is also a critical and effective engineering design tool to integrate ergonomics needs and comfort when designing products that are used by people in everyday life such as furniture as this also has the capabilities of translating customer specifications into engineering characteristics [3], [16]. Quite often engineering designers develop their products paying little or no attention to the environment, yet the production of the eventual product may have a negative impact on the same, hence the need to integrate life cycle analysis into green design during the product development and design process [17]. The theory of inventive problem solving technique (TRIZ) was successfully applied in conjunction with QFD to develop an improved Grey Quality Function Deployment (GQFD) which can assist new product designers and developers to identify important engineering characteristics during the product development stage [18]. Some of the principles and techniques outlined in this literature review were applied in this research at the timber processing company in the development of the four-Wheeler coffee table.

III. CASE STUDY OF THE TIMBER PROCESSING COMPANY

The holding company employs 50 permanent workers, 6 supervisors, 1 journeyman, 3 accounts personnel, 4 sales representatives and the production manager. All decisions to do with development of any new products is the responsibility of the production manager. Their major source of new product designs and ideas are magazines and in some cases, interaction with customers. The subsidiary case study company uses the cheapest pine timber (industrial grade) and manufactures to order, over 20 different products but these are not branded. There was minimal or no quality control but merely checked by warehouse/dispatch clerk. The costing of products had not been consistent, in some cases leading to higher or lower prices compared with competitors. These were some of the challenges observed at the onset of the research, as such consideration of these factors had to be taken into account during the execution of the project.

TABLE I
ANALYSIS OF THE COMPANY’S PRODUCTS

Product	Sale Per Month Z\$	Quantity Sold Per Month	Recommended PLC Stage
Baby Cot C4	113594.33	40	G
Baby Cot C3	43436.32	19	D
Baby Cot C1	44564.91	22	D
Juvenile Bed	31301.50	12	M
Bunk Bed	51085.60	19	G
Baby Tender	111010.18	32	G
Baby Chair	18425.81	14	M
Chest of Drawers (6)	44044.20	6	M
Chest of Drawers (4)	31572.65	14	M
D/D B/R Cabinets	19816.09	12	M
S/D B/R Cabinets	12569.63	13	M
Flat Lid Coffin	100706.50	77	M
Open Face Coffin	62025.27	42	M
3 Tier Coffin	41607.82	21	M
2 Tier Coffin	53526.23	34	G
Casket Coffin	83668.73	5	M
Jewish Coffin	4233.22	4	M
V/Yard D/Room Suite	20797.13	1	D
Headboard	29674.71	5	M
L/Door Wardrobe	10266.73	2	D
Kist	4863.50	1	D
Swinging Crib	6124.37	5	D
Play Pen	3222.21	2	D

The sales history of the company and the trends, drawn from records, interactions with staff and customers over a period of a year was analyzed, from which it was evident that some of the products were in high demand and sales growing (G), some were still being sold but sales were stagnant as these may have reached their maturity (M) stage while the rest recorded decline (D) in sales. Table I shows the summary of the company's products and what the researchers deemed to be the Product Life Cycle (PLC) Stage derived from the sales trends and records. During the execution of the research, visits were made to a number of retailers where the company's products are marketed and sold and the following was revealed.

- Level of stocks in shops too high.
- Normal daily turnover less than Z\$100 000.
- Majority of shops selling on cash basis only.
- Beds are the fastest selling type of furniture.
- Manufacturers have generally increased their prices in the past few months.
- The ordinary person now prefers to buy cheap furniture
- There has been a general increase in the number of suppliers.
- The range of designs available to the retailer is very broad but less appealing and not very aesthetic.
- Certain type of furniture such as swinging cribs and playpens have become luxury and those buying indicate that these are for friends or relatives as gifts or presents.

A. The Proposed NPD Stage-Model

The foregoing analysis indicated that the company has potential but currently experiencing a setback on sales volumes. The ability to grow into a leading furniture manufacturing company was there considering the large variety of products and services its units can offer, hence the need for new strategies to win the market share. Formalizing the NPD process is critical in that it reduces the risks associated with commercializing new products generated from poor ideas. Having a formal process on paper was not good enough but the process had to be fully operationalized i.e. it has to be functional. The thrust in coming up with the NPD framework for the company was to develop innovative new product platforms (product families) that were unique and represented the company while satisfying customer needs and requirements. Considering the low success rate of company's 'new' products it was essential to come up with new product families that would have a competitive edge over the competitors' current and future offerings. There was also a need to create products that customers can identify with the company. Identification does not have to be necessarily from branding but from the style, the design, the quality etc. Producing a family of products leads to continuous improvement at the same time reducing the risks associated with coming up with a single product. This strategy had to be known and understood company wide, from the general hand to top management. It was also necessary to post this strategy on all notice boards, in the offices, factory, staff and workers' etc. As new product development was the preserve of the production manager

alone, it became necessary and critical to integrate the process with the rest of the staff for the success of launching new products. Creation of an empowered NPD committee could alleviate this problem. This committee would also be responsible for assessing the company's current offerings and trimming any excess products. The search for line extensions and improvement of current product lines could also be a priority for this group.

Fig. 1 shows the proposed procedure that the company has to go through when introducing new products. The committee must successfully complete a prescribed set of tasks (in a set time) in each stage before proceeding to the next one. Gates are there to make the following decisions; go, kill, hold or recycle. The committee needs to agree on a decision after each stage although the production manager has the final say. After assessing the completeness of the tasks, voting could be used initially to obtain a rough idea of the confidence the committee has on the project. This could be a starting point for discussion leading to an agreed decision. Use of the proposed NPD model requires training of all employees of the company for a buy-in, otherwise lack of interest and moral can sabotage the success of implementing the stage gate model. It also needed to be understood and with time this is possible. The committee must also focus on continuously improving the model so that development can be made faster. Activities carried out at each stage in the NPD process are carried out in parallel and not in sequence. This helps in integrating the committee and with time every member of the committee should be able to carry out any activity. The committee should also learn not to 'kill' projects no matter what stage the development process is. This helps in avoiding costs associated with developing a weak product.

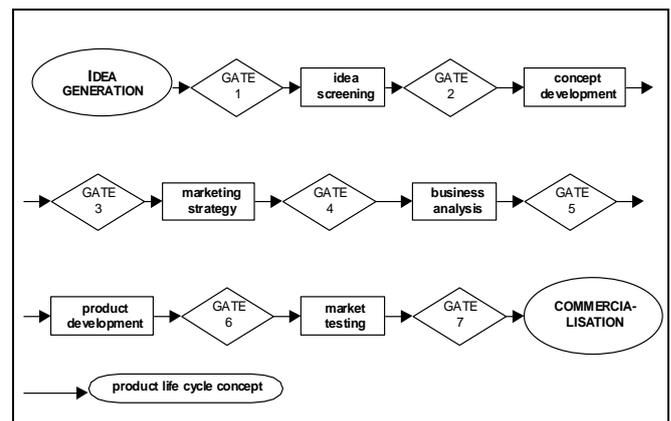


Fig 1 Proposed NPD Stage-Gate Model for the Company

B. Development of the Four-Wheeler Coffee Table

From the research there was a realization that the majority of Zimbabwean families have their meals in the lounge rather than the dining room, which in most cases is used mainly when there are visitors. Coffee tables in the lounge are usually meant to be positioned in one spot. During the meals, one member of the family usually drags the table to where they are sitting and dishes his or her food and then

pushes it to the next member. This has resulted in the failure of the leg joints of the table leading to frequent repair. These families would like to have a ‘coffee’ table that can withstand these frequent repairs while still satisfying the customer’s desire for aesthetics to complement the pleasantness of the lounge. QFD was used to come up with a prototype, Fig 2. to deal with this problem. Morphological charts, Value Engineering and Weighted Objectives were complementary tools that were used in conjunction with QFD to design and develop the coffee table that included wheels on the legs.

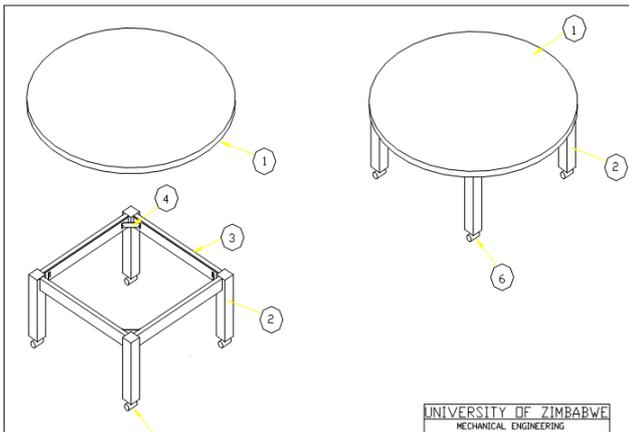


Fig 1. The Four-Wheeler Coffee Table

For the final prototype and considering the company’s layout, it will all be assembled at once. For the top of the table (Part 1), pieces are glued together and the circular shape cut by a bend saw. A router was used to create the mortise where the legs and supports fit. The leg support (Part 3) follows a manufacturing procedure similar to the one for the leg (Part 2) besides that a tenoner was required instead of a mortiser. The mortise and tenon joints were glued together and the joint brackets (Part 4) screwed on across. The top of the table and the legs and supports were then screwed together using the top bracket (Part 5). Eight top brackets were required, equally spaced on the leg supports.

Part No.	Description	Material	Dimensions
1	Table Top	Pine	Φ 1000 x 30
2	Leg	Pine	270 x 50 x 50
3	Leg Support	Pine	530 x 70 x 20
4	Joint Bracket	Mild Steel	55 x 20 x 2
5	Top Bracket	Mild Steel	5 x 10 x 20
6	Leg Wheel	Hardened Plastic	Φ 30; 50 x 50

Fig 2. Parts List for the Four-Wheeler Coffee Table

This prototype was further developed using the proposed stage-gate model. A family of such products can be generated from this prototype to cater for all classes of income earners. The Four-Wheeler coffee table is a universal table that can be moved easily around the lounge without any difficulties. The wheels on the legs of the table can revolve 360° enabling the table to be moved in all directions easily. A screwing-on metal bracket was also added across joints for rigidity.

IV. DISCUSSION AND RECOMMENDATIONS

Conservatives may argue that formalizing an NPD process is not necessary, but when the company is trying to grow or recover, this could be instrumental for success. The designed stage-gate model for the NPD process involves the following nine stages; idea generation, idea screening, concept development (technical), marketing strategy, business analysis, product development, market testing, commercialization and product life cycle concept. From idea screening to commercialization, each stage is preceded by a gate, giving a total of seven gates. The committee members are the gate keepers with the production manager having the overall say. The rigidity of the model is there to avoid errors in the product development process.

From the sales history of the company’s products, the majority are in the maturity stage of the product life cycle. The general trend of the company’s product offerings is U-shaped with sales being lowest during the November to January period. Analysis of market trends showed that the company should focus more on manufacturing and developing product families of children’s furniture and coffins. The implementation of the stage-gate model was recommended with an empowered NPD committee carrying out the tasks and making decisions in the model. Further research and development of the Four-Wheeler coffee table was also recommended. A standard costing system and a workable quality control system by the NPD committee were also recommended. A buy-in from all stakeholders especially staff at all levels is necessary for the success of the proposed stage-gate model. However the results and benefits of NPD cannot be realized in a short space of time but with time and experience the proposed NPD committee should be able to skip or combine stages hence speeding up the NPD process bearing in mind that the majority of innovative new ideas come from listening to the customer. At the end of the developed NPD stage-gate model the company must consider the product life cycle by recording sales history and trends to determine when to move on to a new idea or rebranding and making appropriate and strategic decisions at each stage in the life of a product.

From the available sales history of the company’s products it was evident that they needed to phase out some of the products such as playpens and swinging cribs which were clearly in the decline stage of their life cycle. It was also recommended that the NPD committee should come up with modifications of its current products in children’s furniture and create product families for each product just like the cot bed range. New products should also be related to these products so as to use the information that is already available concerning the performance of these products.

The QFD which was employed in the development of the Four-Wheeler can be effective if implemented in an environment where every effort is geared towards total quality improvement. It is an effective tool in capturing and displaying data and serves as a communication vehicle for generating structured discussions amongst committee members in order to meet customer requirements. The active presence of a quality improvement system creates a high level of experience in working with multi-functional teams

and establishes a problem solving environment. The NPD committee may have to lead in identifying and providing the environment, systems and skills needed to ensure effective and consistent use of QFD within the company. There may be a need to put more resources into the training of those involved in product development on how QFD works. The rigidity of the proposed NPD stage-gate model is meant to take care of all possible mistakes along the development of a new product considering that this concept was new to the company. It is for this same reason that all the processes are defined in great detail. With time and experience overlapping of stages should be possible.

V. CONCLUSIONS

An NPD strategy that focuses on developing unique product families was proposed. The formation of an integrated fifteen member NPD committee was suggested. Customers were identified as the major source for new ideas. A stage-gate model for the NPD process was designed with nine stages and seven gates. The sales history of the company's over 20 products indicated that the majority are in the maturity stage of the product life cycle. A case study example in the form of a Four-Wheeler coffee table was developed into a prototype using the QFD method and the proposed stage-gate model. The company adopted the strategy and has since developed other products. The model proved to be quite useful in that the company can now rapidly modify existing products or develop new ones, thus maintaining a competitive edge and reasonable share of the market. By coming up with product families the company now has options to consider if one product fails. The suggested NPD committee, whose terms of reference are to develop new products as well managing and rationalizing the existing ones, includes personnel from manufacturing, accounts, finance and sales, which invariably speeds the NPD process and makes the development of new products more efficient. Customers were identified as the major source of new ideas, which were extracted by way of focus groups, customer surveys, inquiries and complaints.

Implementing the findings and recommendations of this research and adopting the stage-gate model greatly enhanced and assisted the company recover from the recession and has been growing steadily since. This has undoubtedly positioned the company to be a market leader in the development of new, innovative and aesthetic products and manufacture of furniture in Zimbabwe. However, the development process and manufacture of these products is still largely manual, thereby slowing the process resulting in costly products. Modern machinery that are computer numerically controlled will be useful to enhance time to market. This is capital intensive but can be considered as an option, especially from the financial returns of the adopted model. It is also further recommended that the NPD committee be extended to cover Research and Development requirements for the company.

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