BUSINESS MODEL OF PHYSICAL THERAPY TRICYCLE BY INTEGRATING LEAN CANVAS AND VALUE ENGINEERING

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ABSTRACT

Stroke is one of leading cause of short and long-term disabilities. Rehabilitation is an important part of post stroke patient care. Patients with motor impairments should be encouraged to do a routine exercise to improve their quality of living and increase their independence. Cycling is one example of suggested exercise that offers motor function recovery. This study is a partial part of a research that aims to commercially produce a physical theraphy tricycle for post stroke patient. Previous research has defined that the design of this tricycle is suitable for post stroke patient that could be seated unaided and it could be also utilized as a mode of transportation. Currently, this physical therapy tricycle development has completed its Beta prototyping stage. While, this tricycle design is still undergoing futher testing, a business model for a future company that will manufacture this tricycle is proposed by this study. Lean canvas is utilized to develop the business model. It is integrated with value engineering approach to specifically generate value proposition by using Function Analysis System Technique diagram. As a result, this study is not only to propose business model but also to provide recommendation for the latest design of physical theraphy tricycle. Addition of hand holder and pedal strap are suggested to improve the design of this tricycle.

Keywords: Physical therapy tricycle, Post stroke patient, Lean Canvas, Value Engineering, FAST diagram

1. INTRODUCTION

Stroke is one of the main cause of death. According to the data published by National Institute of Health Research and Development - Indonesian Ministry of Health (2018), there is a rise of prevalence of stroke in Indonesia from 0,7% to 1,09% between 2013 to 2018 or on average 3 millions people. Most of the patient are people on their age more than 55 and there are almost similar number of incident happened for both female and male.

In general, the surviving stroke patients undergoes from mild to severe disabilities. There are patients that incapable to walk without assistance because of their lower muscle can not support their body weight, while others highly dependen in all activities of daily living. Rehabilitation practices for post stroke patient is very important to improve walking ability which usually involving special equipment. For patient that could walk independently, treadmill is one of example of rehabilitation equipment. Cycling is another example of equipment that suitable for improving walking ability. Cycling and walking shares similar benefit as a rehabilitation method (Barbosa et al., 2015). However, cycling with mobile bicycle or tricycle also can be used as a transportation mode for post stroke patients when they want to go round outside their home enjoying talking with their nearby friends. Thus, cycling can be utilized not only as a method to rehabilitate patient physically but also psychologically (Batan et al., 2019).

Development of three wheeled bicycle (tricycle) in particular for post stroke patients has been started from 2013 by a team from Product Design and Development Laboratory of Institute Technology Sepuluh Nopember (ITS) Surabaya, Indonesia. The brand of this tricycle is SeraITS. At this moment, the prototype of the latest design (third version) has been tested by eight post stroke patients in Surabaya Indonesia. All of the respondents are male between 45 to 72 years of age and suffered Hemorrhagic type of Stroke (i.e.rupture of the weakened blood vessel). The testing result shows improvement of body fitness of these respondents (Batan et al., 2016). Despite of positive result on prototype testing from medical treatment point of view, there are several issues concerning the appearance and features of this tricycle. Dewi et al. (2019) has answered these concerns by utilizing Kansei method to capture hidden needs of customer in regards of tricycle appearance. Since the features has not yet considered, thus this study has two aims. First, this paper is aiming at improving design of the tricycle features to enhance customers satisfaction.

Nowadays, new product development process becomes more comprehensive and requires inter-disciplinary collaboration. Moreover, the latest trend shows that there is a need to also consider business model development simultaneously during product development processes, as suggested by Lund and Hansen (2014). This approach offers higher opportunity for a successful business (new product introduction) which is very important for business continuity. A popular business model that is able to facilitate inter-functional or even inter-organizational discussion during business model innovation by using visual representation is Business Model Canvas. However, the structure for integrating business model canvas to the product development process is not yet available. As product development stage of Tricycle has almost reached to the last step before design finalization and commercialization, therefore the second aim of this study is to propose integrated structure of product development with business model formulation based on SeraITS development case.

2. LITERATURE REVIEW

2.1 New Product Development

New Product Development (NPD) can be defined as “an interdisciplinary activity requiring contribution from nearly all the functions of the firm, whether it is an upgrade/ improvement of an existing product or a new concept either to the company or the market” (Haque et al., 2000). New product development and introduction contributes to continuity of any business by supporting company’s growth and profit. Thus, successful products/services introduction to the market is essential. However managing product development process is not an easy task. Some of new products can not reach to its intended market never due to many impediments (Unger & Eppinger, 2011; Pienaar et al., 2019).

From concept to launching new products, it consists of several interrelated stages. As can be seen in the table 1, example of three studies that propose different number of stages for new product development. These three studies share similar basic steps, they are: idea generation and evaluation, design, testing, production and finally commercialization or product launch. Commercialization as the latest step aims to determine how to supply product to the target market and anticipate potential impediment(s). Therefore a company should understand perception of customer on the new product and have a sound idea on how to enhance it. While similar view from supply chain management that sees product development and commercialization as one important process, which aims to "provides the structure for developing and bringing to market product jointly between suppliers and customers" (Rogers, Lambert, & Knemeyer, 2004).

Table 1. Variouse Steps on New Product Development according to several authors

Step	Booz et al. (1982)	Chunawalla (2008)	(Kenyon & Sen, 2015)
1	New product strategy	Idea generation	Marketing & evaluation
2	Idea generation	Idea evaluation	Planning
3	Screening & evaluation	Concept development	Design
4	Business Analysis	Marketing strategy	Test & verification
5	Design & development	Business Analysis	Production
6	Testing	Product Development	Commercialization
7	Commercialization	Test Marketing	-
8	-	Commercialization	-

In traditional manner, these activities are usually executed in sequentially/serially manner. Moreover, each of these development activities is usually under responsibility of (only) one function/department in a organization. For example: idea generation is executed by marketing departement only. Furthermore, the various functions/departments might be located separately in different places and sometimes in different countries. As a result, it usually leads to many iterations (design changing) due to "over the wall syndrome" (figure 1) which then lengthening the time to market (Boothroyd and Dewhurst, 2007). The consequence of delaying time for new product to enter its intended market could be resulted in losing sales as the competitor product already penetrate to the market.

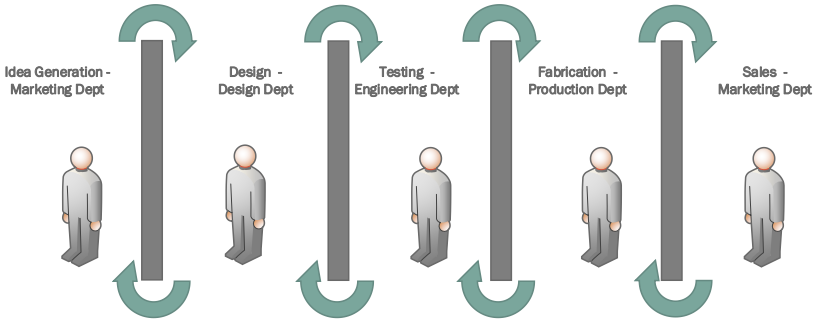

Figure 1. Iterations due to "Over the wall syndrome"

In the 80's, Concurrent Engineering (CE) or Integrated Product Development (IPD) is known as a new product development and starting to be implemented by many companies to avoid those problems that happened in a traditional way. Within Concurrent Engineering environment allows different tasks/stages of the product development process to be carried out concurrently rather than sequentially. All tasks are done in integrated and simultaneously manner, from design, testing, manufacturing and process planning through logistics (figure 2). As the result, potential problems in fabrication, assembly, support and quality could be identified and resolved early in the design process. Furthermore, from the beginning of NPD, it is conducted by integrated and cross-function teams (within and between organizations) which eliminates "Over the wall syndrome" problem (McGrath 1992, Izuchukwu, 1992). In the shorter word, CE has two important aspects, which are cross-functional integration and concurrency. These aspects distinguish CE from the traditional (sequential) new product development approach.

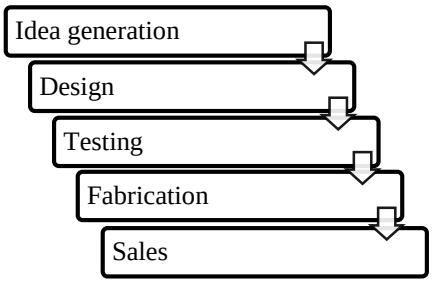

Figure 2. Simultaneous Product Development Stages

According to Cooper (1994), there are three generations of product developmet process (PDP) models. The first generation is proposed by NASA in 60s which is called Phased Review. This model emphazises on technical (engineering) issues and does not consider collaboration with other functions within/between organization or commercial aspects. The second generation, which is known by State Gate process, has already integrated manufacturing and marketing into product development process as well as adopted cross functional/organization approach. The third generation is introduced to improve shortages in the previous model, such as rigid and inflexible structure, that leads to lengthening product development process This model offers faster product development by using ovelapping and fluid gates, flexible, conditional "Go" decision, and projects prioritization methods. It consists of : (1) Stage 0 - *Discovery*: identify opportunities and create ideas, (2) Stage 1- *Scoping*: investigate for narrowing the project scope, (3) Stage 2 - *Build the Business Case*: Conduct further technical and market investigation for project selection, (4) Stage 3 - *Development*: new product detailed design up to laboratory testing including production and product launch, (5) Stage 4 - *Testing and Validation*: Tests, verify and validate the new product (beta test) including its operations, sales and marketing, (6) Stage 5 - *Launch*: execute full operations, marketing and selling. The typical State Gate Model can be seen in Fig 3.

The modification of Stage Gate Model to accomodate open innovation is presented in Cooper (2008). This model is developed to allow external organization (partners, alliances and vendors) involving in product development process from idea generation through to launch. In a more recent study, Cooper (2016) presents Agile – Stage Gate Hybrid model which is integration of the Agile (IT product) development method into Stage Gate in developing a new physical products in a more flexible way, faster, and improved communication.

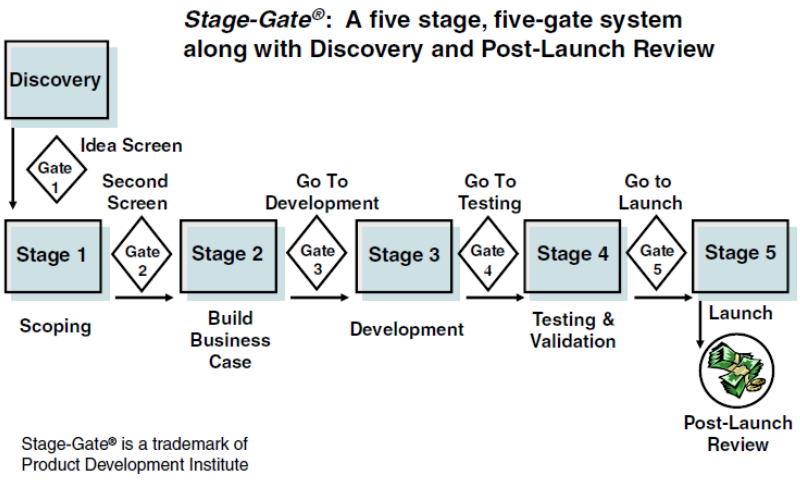

Figure 3. Typical State Gate Model (Cooper, 2005)

Lund and Hansen (2014) suggest that there is a close relations between development of a new products/services with development of its business model to ensure successful product introduction which leads to business continuity. Thus, the fourth generation of PDP model is predicted to take into consideration business model perpectives concurrently during product development process. In spite of this, there is no specific framework availabe yet for integrating product development process with business model so it could be conducted simultaneously.

2.2 Business Model

Business model is a statement that explains how enterprise work (Margretta, 2002) or it "describes the logic of how an organization creates, delivers and control value and how money are earned in a company" (Osterwalder & Pigneur, 2009). There are many business model concepts proposed by various authors, for example: Afuah (2003), Watson (2005), Johnson et a. (2008) Mullins and Komisar (2009), and Kraaijenbrink (2015). Analysis of different business model concepts has been conducted by Štefan & Richard (2014).

Visualization in the business model, such as Business Canvas Model, is essential since it provides support for product development (cross-functionals/organizations) team to discuss, design, and develop new business model. Osterwalder and Pigneur (2010) propose Business Model Canvas (BMC) that representing business model in nine components, they are: customer segments, customer relationships, distribution channels, value proposition, key resources, key activities, partners, cost structure and revenue streams. BMC offers a powerful visualization tool by depicting all these nine components and their relationships.

Since BMC introduced, there are modification of the original model also proposed. One of them is Lean Canvas (LC) that is proposed by Maurya (2012). This model offers a more actionable, fast, concise and effective to cater specifically for entrepreneur (startup). In Lean Canvas, there are four components that are modified, they are: Problem, Solution, Key Metrics, and Unfair Advantage replacing Key Partners, Key Activities, Key Resources and Customer Relationship which are the original components of the BCM respectively (Fig 4) . Lean canvas could give a more effective guidance in building business model and determining solution to fulfill customer requirements (Abdoun & Ibrahim, 2018). As can be seen in Fig 4, in the centre of both Business Model is value proposition component, which can be defined as the means to solve the customer needs (Payne et al., 2008).

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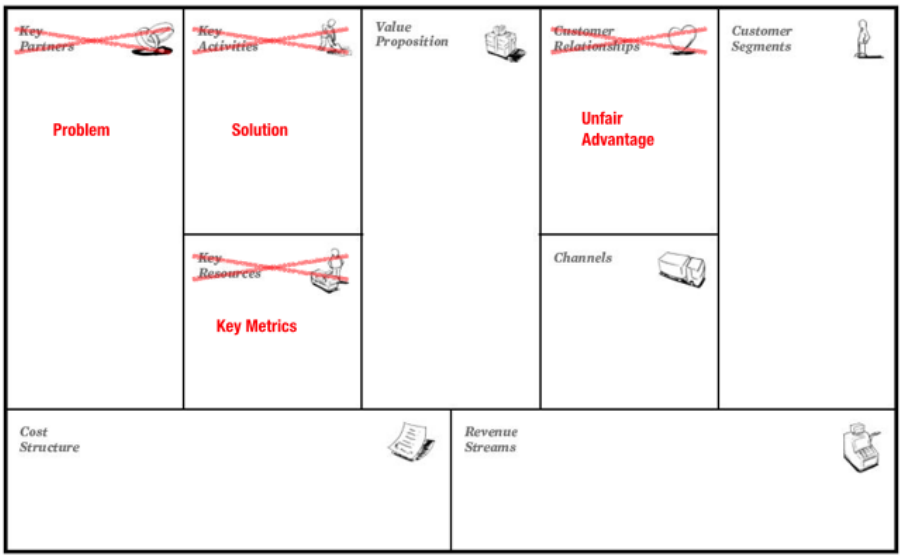

Figure 4. Lean Canvas vs Business Model Canvas (www.leanstack.com)

2.3 Value Engineering in Product Development

Value engineering (VE) is defined by SAVE International Society (1998) as "systematic application of recognized techniques that identify the functions of a product/service, establish a monetary value for the functions, provide the required functions at the lowest overall cost". The main principle of Value Engineering is there is no trade off between preserving the basic functions and pursuing value improvements. In other word, VE is utilized to maintain the best balance between the product or service cost, its reliability and its function. This can be achieved by designing a product with the desired attributes including its required lifetime, so costs can be saved. Value in VE is a function of cost and function (V = f (F, C) = F / C). Based on this formula, to improve product value in product design can be conducted in five alternatives ways (Duan, 2012), they are: (a) Improving function and reducing costs, which is the best option, (b) Keeping the same function and reducing costs, (c) Improving the functional, and keeping the same cost, (d) Improving the functional value and increasing the cost, (e) Reducing function slightly and reducing the cost significantly.

Value Engineering consists of six phases (Park, 1999), they are as follows:

(1) Information phase: to define problem through orientation, determine project cost, set goal for achievement, define function, construct FAST diagram, locate the problem, and define targets for opportunity,
(2) Creative phase: to develop alternatives,
(3) Evaluation phase: to screen and evaluate all ideas and identify concepts,
(4) Planning phase: to develop concepts and plan for recommendation,
(5) Reporting phase: to organize recommendation,
(6) Implementation phase

Product Development Process is essential for any company to achieve competitive advantage by not only focus on product quality but also on its cost and functionality by conforming with customer values/needs (Ibusuki & Kaminski, 2007). Park (1999) compares several tools (e.q. DFA, FMEA, QFD, TQM, TRIZ, VE etc) that is dedicated for improving product development

project. However only Value Engineering that could push people (team) during new product development process to think differently based on the best value.

3. PROPOSED FRAMEWORK FOR NEW PRODUCT DEVELOPMENT MODEL

Based on review on literature in the previous section, it can be summarized that a framework that could integrate concurrently product development process with business model development is needed to cope with challenges in today's highly competitive business environment. Thus to withstand this challenges, when developing a new product, the NPD team should consider simultaneously quality, cost and functionality while answering the customer values/needs. Therefore, this study proposes to integrate Value Engineering and Lean Canvas Model as a framework of new PDP, which is elaborated in this section. Lean Canvas Model is selected as this model can help NPD team during discussion (work) as it provides visualization for the team member. In addition, the case study in this paper is related to development of a new product for a new business.

One of Lean Canvas component is value proposition which can be defined as the means to solve the customer needs, so this component perform as the main link between Value Engineering with Lean Canvas. The integrated structure can be seen in Fig 5. This framework is called Design for Business Launching (DfBL) which means that developing new product design in parallel with designing the business model. This framework also utilize cross functional team within and between organizations (with vendors and distributor/customers) and should be conducted in simultaneously (overlapping). Thus, this framework could be conducted following Stage Gate manner. As a result, Stage 0,1, and 2 can be utilized as it is, but a minor modification for stage 3 and 4 which should also cover business model development, testing and validation.

4. APPLICATION OF PROPOSED FRAMEWORK FOR TRICYCLE CASE

This section describes application of Design for Business Lauching on development of SeraITS, a physical theraphy tricycle project in ITS Surabaya which is already at the Testing step (Stage 4 in Stage Gate Model).

Table 2. Priority of voice of customer for Tricycle from QFD analysis

Attribute	Importance Weight
Easy handling	0,28
Ride safety	0,24
Ride comfort	0,17
Easy movement	0,11
Low maintenance	0,11
Durability	0, 09

The first component of Lean Canvas (i.e. Customer Segment) and Value Engineering Phase (i.e. Information) can be conducted concurrently as both are related to customers. Based on historical data from Health Minister of Indonesia, potential market for this tricycle is around 3 millions people. However only around 66% of this post stroke patients is suitable to use this tricycle which are able to sit down but still have difficulty in walking (with/without supporting equipment). Furthermore, this product is also targetted for middle class and above groups which is around 20% of population. Thus approximately 400.000 people in Indonesia is the ideal customer for this product (customer

segment). The information phase of VE is conducted using Quality Function Deployment (QFD) analysis. The result of QFD shows that there are 5 attributes (voice of customer) that are should be considered in tricycle design with easy handling is the most important attribute (table 2). The next step is developing Function Analysis System Technique (FAST) to achieve an effective means of product features. FAST is very effective to encourage thinking process of NPD group. FAST diagram of Tricycle (Fig 6) identifies that the main function of tricycle are rotate wheel and align component. These two main functions are related to easy handling and it is still an on going problem for patient that complaining during testing session of the last tricycle prototype (Problem component in Lean Canvas). Therefore, opportunity for design improvement can be defined, they are: a better control of handlebar (steering) and applying better torque (pedal) by adding hand holder and pedal strap in tricycle (target for opportunity in VE).

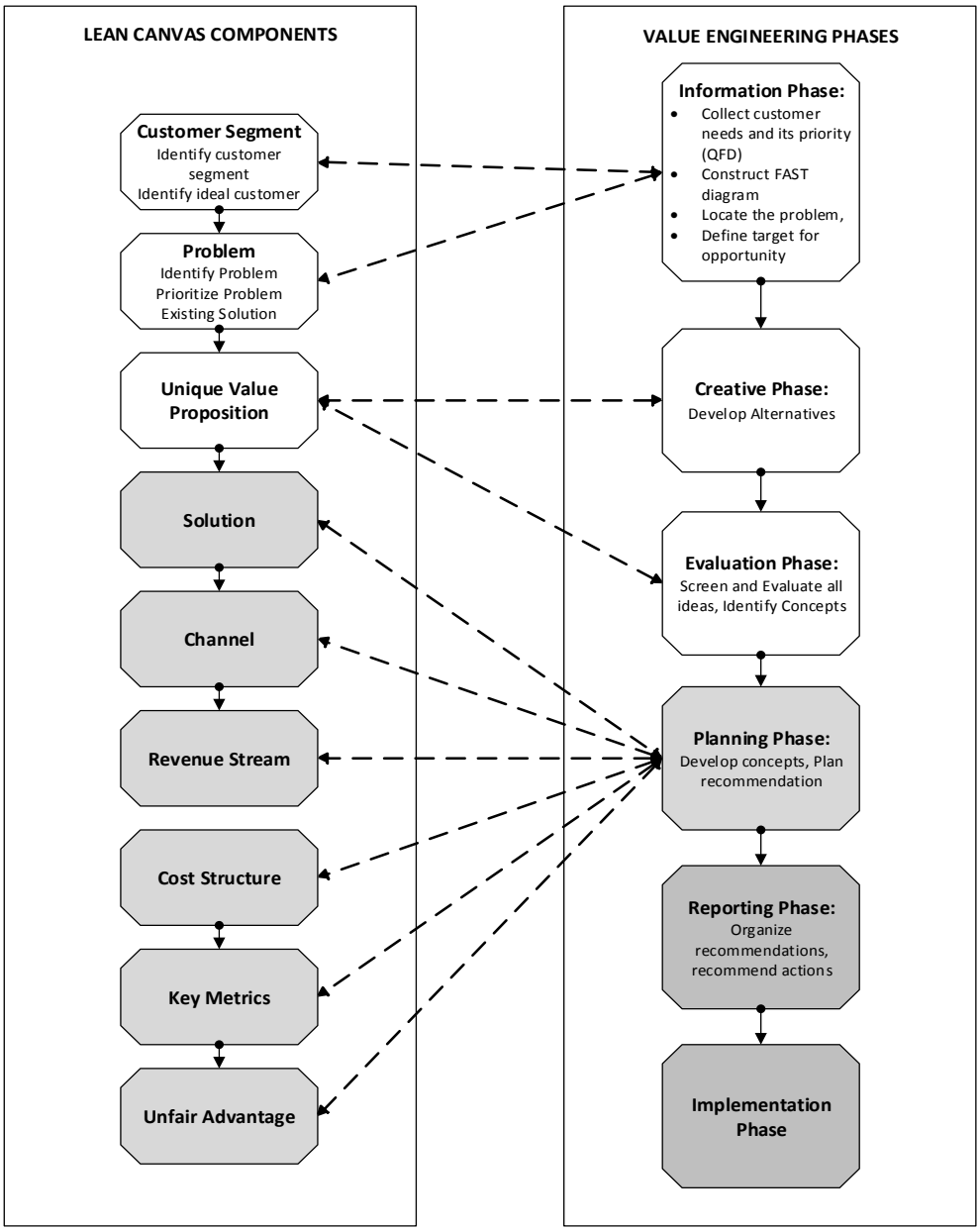

Figure 5. Integrated Lean Canvas and Value Engineering for NPD

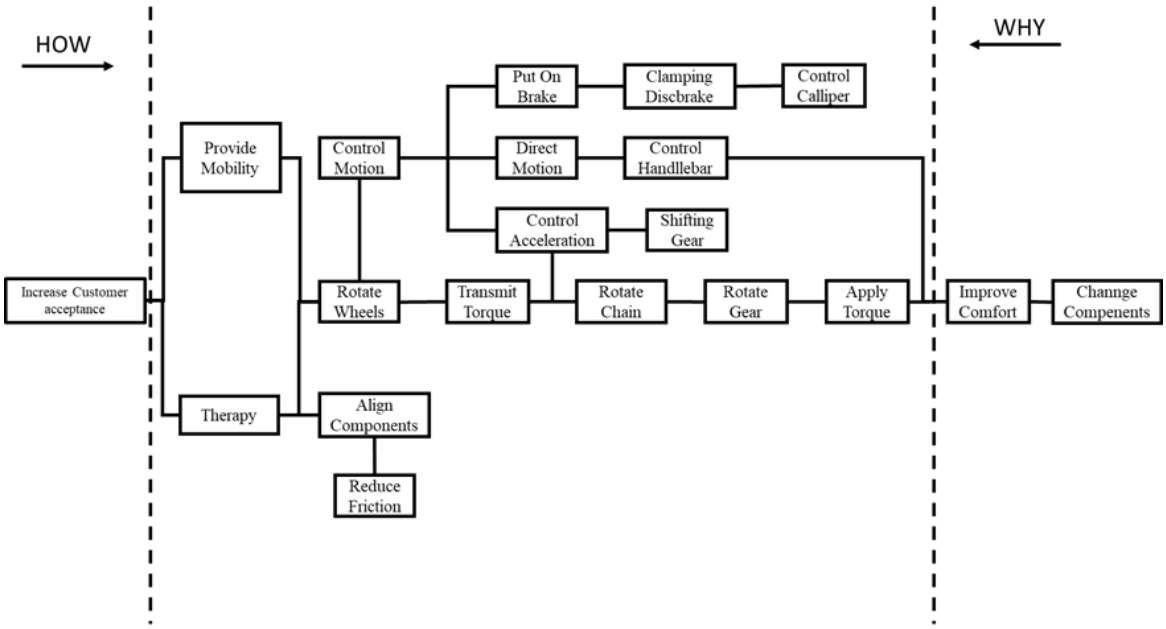

Figure 6. FAST diagram for SeraITS – a Physical Therapy Tricycle

Based on Information phase of VE, then the Creative phase can be conducted by developing alternatives of additional feature for tricycle which are hand holder, pedal & strap, and pedal strap (table 3). Based on combination of the alternatives in table 3, then 12 concepts (combination of hand holder with pedal & strap or pedal strap) is formulated.

Table 3. Alternatives of SeraITS features

Additional Tricycle parts	Alternatives		
	1	2	3
Hand Holder	*Gloves Brace Elderly Fist Stroke Hemiplegia Hand Training* Rp 360.853,57/pair 	*Biange Rehabilitation Finger Gloves* Rp 337.309,96/ pair 	
Pedal & Strap	*Strapped Heel Support Pedal* Rp 2.022.565,45/ pair 	*Surepromise Thread Exercise Bike Pedals with Adjustable Straps* Rp 195142,69/ pair 	*Bike Pedal Straps and Widened Straps* Rp 195.003,21/ pair 
Pedal Strap	*Sunlite Adjustable Heel & Toe Support* Rp 730.215,87/ pair 	*Outus Pedal Straps Bicycle* Rp 34.271,89/ pair 	*Dorsal Splint AFO Orthotic* Rp 265.025,82/ pair 

In the evaluation phase, cost-function value analysis is conducted. First, function value for each concept is measured based on concept value for each attribute (likert scale) and the weight of each attribute (from QFD result). There are two respondents (post stroke patients) that involved in this assessment. The result for Function Value Analysis can be seen in table 4, while the function value for tricycle without alternatives features (original concept) is 1,89.

Table 4. Function Value Analysis for 12 concepts

Atributtes	Weight	Concept Value											
		1	2	3	4	5	6	**7**	8	9	10	11	12
Easy handling	0,28	2	2,5	3	2	3	3,5	**2,5**	3,5	2	2	4	3
Ride safety	0,24	4	3	2,5	3,5	2	2	**4**	2,5	2,5	3	2,5	2
Ride comfort	0,17	2,5	1,5	1,5	2,5	1,5	2,5	**3**	3,5	3	2,5	3	2
Easy movement	0,11	2,5	2,5	2,5	2	1,5	2,5	**2,5**	3	2	2	2,5	1
Low maintenance	0,11	3,5	3	2,5	2,5	4,5	2	**3,5**	3	2	3	1,5	2
Durability	0,09	4	2	1,5	3	2	2	**4**	1,5	2	4	1,5	2
Function		2,97	2,46	2,38	2,59	2,42	2,56	**3,19**	2,97	2,29	2,62	2,81	2,17

Next, the cost for each alternatives is calculated based on material cost. To calculate Cost-Function Value for each alternatives, function value should be converted into value of money in Rupiah (Indonesia Currency) based on multiplication of function value for each concept with its cost of original desigh (without features Rp 4.115.000) and divided by function value of original concept. Then, value for each alternatives is calculated by dividing function value (converted in Rupiah) with cost value, and the result can be seen in table 5. Concept 8 that has the highest value (1,44) is selected. Thus, combination of Gloves Brace Elderly Fist Stroke Hemiplegia Hand Training for hand holder and Outus Pedal Strap Bicycle for pedal strap is added to the original design of tricycle as the selected features.

Table 5. Cost - Function Value Analysis for 12 concepts

Concept	*Function* Value	Cost	*Value*
1	Rp6.472.666	Rp6.458.419	1,00
2	Rp5.370.239	Rp4.630.996	1,16
3	Rp5.195.597	Rp4.630.857	1,12
4	Rp5.654.032	Rp6.434.875	0,88
5	Rp5.272.003	Rp4.607.453	1,14
6	Rp5.588.541	Rp4.607.313	1,21
7	Rp6.963.846	Rp5.206.069	1,34
8	Rp6.483.581	Rp4.510.125	1,44
9	Rp4.999.125	Rp4.740.879	1,05
10	Rp5.708.607	Rp5.182.526	1,10
11	Rp6.123.382	Rp4.486.582	1,36
12	Rp4.737.162	Rp4.717.336	1,00

Based on result from Evaluation Phase of VE, then Unique Value Propostion component of Lean Canvas can be formulated, that is "A way to gain healthier and happier living by SeraITS, a physical theraphy and comfortable tricycle". Further analysis is then conducted to develop all components of Lean Canvas. The completed business model for SeraITS can be seen in Fig 7 in the appendix.

5. CONCLUSION

New product development is very essential for every business to keep it sustain in the highly competitive environment. Product development process should be able to answer all customers need for a high quality, low cost product and functionality fit.With new trend in the business environment, a new framework that could integrate concurrently product development process with business model development is required for business to survive. This paper proposes a framework on Product Development Process that integrate Value Engineering and Lean Canvas Model, which is called Design for Business Launching(DfBL) based on Stage Gate model. This framework then is applied to a case of development SeraITS, an Physical Therapy Tricycle which already at Testing and Validation Stage. Result of the case shows that the design of SeraITS should be improved by use combination of Hand holder and Pedal Strap as an important feature to support easy handling.

For future study, this framework should be tested by applying to different cases of new product development project to ensure that this framework generally applicable. Further, this framework may be also adopted for new service development.

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