
Developing a Cardio Simulator: More Real and Quicker

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Abstract: The purpose of this study is to develop a conceptual framework for practical and theoretical roles of "design prototyping" in product development process. Design prototyping is regarded as one method of product design in product development process. This method contributes not only to accelerate product development process, but also to create a sample model from ambiguous customer needs. In this paper, we will introduce one unique method to substantiate ambiguous and uncertain customer needs through a case study of a Japanese high-tech venture. The company solved these problems by "design prototyping". This method works as if a mechanism which substantiates tacit knowledge into a concrete entity. We will formulate this case theoretically, and develop a conceptual framework for our next empirical study in this paper.

Keywords: Design prototyping; rapid design; product development; fuzzy front end; dispersion order; Japanese high-tech venture.

1 Problem

This submission focuses on development of a cardio simulator by a Japanese high-tech venture, CrossEffect Co. LTD (hereafter CrossEffect). The cardio simulator is a real replica of human heart. This simulator is expected to contribute for cardiac surgery by many ways, but the primary one is to reduce the duration of operation by far.

The cardio simulator in this study was made by special resin which has been developed for 3D printer. Though similar simulators (products) exist, these products can be delivered, at least, in four days because these are casted by die and mould. Therefore, prices are twice expensive than this cardio simulator is. Moreover, this simulator can be customized by each client.

CrossEffect specializes on design and prototyping by 3D printer. The company began to develop a sample model in late 2009, and it was its first experience to cope with the cardio simulator by 3D printer. The company took for 4-year experiences to achieve the viable cardio simulator in 2014. Now, CrossEffect can deliver the customized cardio simulator in two days, and almost half price compared with existing products. For this quick development, the company should secure and capture not only the quick prototyping capability (it is called rapid design prototyping), but also the precise and rigorous transcription capability from CT and MRI scan data.

The specific innovation management problem in this case was to develop the capability of complement and supplement for insufficient data (ambiguous condition). Insufficient meant not only actual lack of information, but also communication problems between physicians and engineers. This submission will focus on this innovative design prototyping method.

2 Current understanding

This study focuses on to capture the capability of rapid product development under ambiguous conditions. In product development management, the prototypes play very important roles for above issue. According to one prevailing understanding of product development, it is, indeed, problem-solving activities (Clark and Fujimoto, 1991). Product development process is constructed by the problem-solving cycle as follows: design - prototyping - evaluation - decision-making. In this perspective, efficient product development means to prompt a problem-solving cycle quick.

Accelerating of product development cycle has been regarded as competitiveness of the firms (Millson et al., 1992). According to this finding, the companies tried to accelerate their product development projects by mainly five approaches: (1) eliminate delays, (2) eliminate steps, (3) speed-up operations, (4) parallel processing, and (5) simplify. These approaches assumed that correct and plenty of information could lead correct and right answer (activity). For example, correct target users could express their needs and wants exactly. It can be said that such information could eliminate process delay and steps.

Compared to these five approaches, our case indicated that a tentative model accomplishment can contribute for further communication rapidly and quickly. In the early stage of produce development process, customers often could not explain their needs and wants exactly. Our study shows how the company can complete the tentative

model under ambiguous customer needs and wants at the early stage of product development. Our study focuses on this issue.

3 Research question

As theoretical hypotheses, the research has mainly two goals. The first one is focused on how the company secures rapid design prototyping capability. The second one is referred to transcription of medical information. The case company can mould a first prototype in two days. Then, the engineers modify the first model precisely and rigorously in a few hours. Thus, research question will be on how CrossEffect can do that.

The purpose of this study is to develop a conceptual framework for practical and theoretical roles of "design prototyping" in product development process. Design prototyping is regarded as one method of product design in product development process. This method is classified in "Rapid prototyping" method. Not only recent studies on it (Campbell et al. 2012; Fumo and Noorani, 2015; Suresh and Narayana, 2016), but also it has been taken more than four decades for studying rapid prototyping since early 1970s (Ciraud, 1972; Kodama, 1981, Swaison, 1977). Most of them have positive opinions to rapid prototyping, which improved product development efficiency.

It has been said that the reasons why rapid prototyping enabled to improve product development efficiency were mainly two. First, rapid prototyping solves early stage problems in the product development process (Herstatt et al., 2004; Kim and Wilemon, 2002; Leon et al., 2013). Typically, modification cost in the late stage in product development must be getting higher. Hence, early stage problem solving can maintain the total cost of a product development project. Second, a prototype (a sample or trial model of the product) works as a communication tool, not only in the product development process (Houde and Hill, 1997), but also cognitive science (Bannan-Ritland, 2003; Lakoff, 1999).

A typical practical problem of product development is how substantiate customers' needs into articulate and concrete functions. If a company could comprehend customers' needs articulately and concretely, its product development would be almost guaranteed for success. However, rare customers can express their needs articulately in the early stage of product development process. Customer needs are still uncertain and ambiguous. Rapid prototyping contributes to substantiate a concept and/or image into a physical entity in the early stage of product development process.

In this paper, we will introduce one unique method to substantiate ambiguous and uncertain customer needs through a case study of a Japanese high-tech venture. The company solved these problems by "design prototyping". This method works as if a mechanism which substantiates tacit knowledge into a concrete entity. We will formulate this case theoretically, and develop a conceptual framework for our next empirical study in rest of this paper.

4 Research design

This research has been conducted as single longitudinal case study. The purpose of this research is mainly to accumulate knowledge on the mechanism and efficiency of rapid product development, hence, longitudinal case study will be appropriate to the purpose. This research is mainly consisted with interviews. The research employed semi-structured questionnaire, which was based on published documents and articles. Keywords from both interviews and archives have been classified and logically clustered by KJ method (Scupin, 1997).

5 Findings

The main finding from our study is how CrossEffect achieved to develop the cardio simulator. As a result, the development is the result of experiences, which the company had many varieties of customers. From automobile to home appliance industries, the company has received many excessive orders for long time. Accumulation of 3D printing experiences contributes to organize the needs and solutions pairs (von Hippel and von Krogh, 2016). It means feasible technological solutions between accumulated technology in the company and customer's needs. It is called technological drawers in the company.

To achieve rapid design prototyping in two-days delivery, the company must start the development under ambiguous customer's requirements. In this case, prototyping must begin with some past experiences and prejudices. To do so, relationships between physicians remarkably importance.

6 Contribution

Current result is expected to contribute an issue for comparative study of innovation style. Authors expect that the result can be adopted in the Western firms, but are wondering the result is unique for Japan, more generally high context language countries. Our finding will be regarded as ambiguous and vague condition. Though ambiguity has been known as a kind of drivers to progress the businesses and innovations (March and Olsen, 1985), the Western thought still believes that management can be organized by rationality. Therefore, if our finding can be theoretical formulated by additional comments, current innovation theory can comprise even ambiguous innovation implementation.

7 Practical implications

Our findings can be used by product development managers. They often encountered some trade-off. Sometimes, it was creativity and efficiency, in other case, it was quality and cost. Our case, product development under ambiguous customer's requirement, will contribute such trade-off condition. Specifically, quick delivery and rapid product development have been regarded as competitiveness since 1990s. Rapid product

development can reduce opportunity cost, then, resource can be diverted into another opportunity.

8 Feedback form

We would like to advance this work more and more. Specifically, these three issues shall be discussed. The first issue is the case itself. Since a good case study can derive readers' sympathies and commitments, such case is valuable even without rigorous theoretical frameworks and hypotheses. However, this evaluation to the good case varies by some reasons. This is easy to recognize, for instance, when we assume a blockbuster movie in USA. It will not be necessarily to be the same in Japan. In our case, we are interested in the Westerners' recognitions to our case. Generally said, what types of (case) stories the Westerners felt them as good.

The second one is a theory and theoretical framework. It is natural that there are many approaches to develop the theoretical framework for this single case study. We know the efforts which develop theoretical frameworks and theories well (Eisenhardt, 1989; Christensen and Carlile, 2009). These studies described the formal approach to developing theoretical framework from the case study. Here, rather we would like to discuss on appropriateness of the case. As there are huge numbers of management practices around the world. But, only a few practices can be the case study. So is theory development. We are interested in what theory the Westerner generally develops from a case.

And thirdly, comparative understanding, we would like to know the Westerners understanding to this case. Japanese researchers generally begin with the research from a why question. This Japanese trait can be said as, so called, grounded theory approach (Glaser and Strauss, 1967). Japanese prefer to begin their theory development with evidence which is not only results (data) but also management practices (case stories). Our study is regarded as research-in-progress, but we will not advance this research as quantitative survey (statistical test type research). In this way, we are interested in appropriate methods to develop our case as management theory.

Furthermore, we welcome feedback not only from innovation researchers, but also marketing scholars because design prototyping requires customer information.

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