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Prototyping in new product development: Strategy considerations

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Abstract

Prototyping is an important activity in most new product development processes. Whether the aim is to explore new opportunities or refine existing solutions, prototyping can be a valuable tool. This paper takes a look at the diversity of prototyping practices and the contextual factors that may have an impact on the prototyping strategy. Through existing literature and industrial as well as academic case studies, several prevailing contextual factors are identified and used as a basis to propose guidelines to aid practitioners in making important decisions when formulating a prototyping strategy.

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1. Introduction

Prototyping is an activity and a tool that has received considerable attention in the product development research communities in recent times. With the increasing interest in adopting Design Thinking (DT) in various business and product development domains, early-stage prototyping has become an important activity. Contrary to the ‘proof-of-product’ role that prototyping often is given in traditional engineering design [1], prototyping in DT takes on a more exploratory role. As pointed out by Seidel and Fixson [2], instead of validating ideas, prototyping can be used to stimulate imagination [3] or be used as a tool for “building to think” [4]. Thus, the speed of prototyping and subsequent testing become critical factors. Available technology has played an important role with regard to prototyping capability in the development process. Combining digital and physical prototyping such as in *mixed prototyping*, for example, has great potential for developing and evaluating the usability of product interfaces [5]—a critical aspect of most new product systems. By utilizing digital tools, it is possible to create highly flexible prototypes that enable short learning cycles at an affordable cost.

Regardless of whether the prototyping medium is physical or digital, it is important to choose the right strategy for prototyping. In the context of new product development, Ulrich and Eppinger [6] provide useful information for product

developers by outlining important principles of prototyping [6, p. 297] and propose how prototypes should be planned for in a product development project [6, p. 303]. These guidelines can be a valuable overview and starting point for product development practitioners who wish to learn more about prototyping in general and, more specifically, utilize prototyping as a tool in the development process. However, considering the breadth and diversity of the research on prototyping, there seem to be a need for a synthesized overview that collects research from the various research domains and provides insights for product developers. Additionally, it is crucial to identify predominant contextual factors in order to make sound strategic decisions.

Therefore, the purpose of this paper is twofold:

- To provide researchers and practitioners with a brief overview of prototyping research in various domains that may have great impact on new product development and shows promise for future research.
- To take the first step towards a strategical framework consisting of contextual elements and practical principles for carrying out prototyping in a product developing organization, thus expanding on the work by Ulrich and Eppinger [6].

This topic is investigated and strategic guidelines are proposed by revisiting the data from two previous industrial case studies, see [7] for more details. Additionally, two recent cases where prototyping was actively used in the early development stages in a far more exploratory manner are included in the sample.

2. The diverse roles of prototyping

The research on prototyping branches out into a wide variety of research domains. From engineering design [1, 6, 8] to human-computer interaction (HCI) [5, 9-13], Design Thinking [2, 14, 15] and software development [16-18]. To illustrate the diversity and give the readers an overview of the various roles that prototyping takes on, brief descriptions are given below.

2.1. Engineering design

Prototyping in engineering design usually serves a wide variety of purposes. The most common being to verify and validate assumptions, calculations and decisions during the development, as well as answering two fundamental questions: “Will it work?” and “How well does it meet the customer needs?” [6]. The perhaps most common use of prototyping in engineering design is the development of “milestone prototypes” that often are denoted “proof of” prototypes, as well as alpha, beta and pre-production prototypes [1, 6]. Early-stage prototyping is often not formalized and is performed when ‘deemed necessary’ by the development teams. Although, some companies are known to extensively use formalized prototype-driven approaches in the early phases [19, 20].

2.2. Human-computer interaction

In HCI, prototyping is given an integral role in the overall development process and prototyping is acknowledged to “Support creativity, helping the developer to capture and generate ideas, facilitate the exploration of a design space, and uncover relevant information about users and their work practices” [9, p. 122]. Since HCI deals with human behavior and interaction, prototyping is a useful tool to ensure that the user is involved in all phases of development, for example through participatory design [21].

2.3. Design thinking

In DT, prototyping take on quite a different role. Here the main purpose is commonly to facilitate the development and transform novel ideas into preliminary models that can be evaluated [2]. Prototyping—in the very early phases—can also be used as a tool to “get going” by building to think [4]. In this sense, DT is a prototype-driven development process or philosophy. It is common for development teams to build and test prototypes from the very beginning in a project. This means that the speed is crucial. How fast the team is able to build prototypes, test prototypes and implement lessons learned in the next iteration is a critical factor for progress.

2.4. Software development

Much like HCI and DT, prototyping in software development can have an integral role in the overall development process. Since software is not physical, working through multiple prototype iterations and thus using prototypes to drive the development process forward can be a cost efficient and viable development approach. The ‘movement’ that believes in a prototype-driven process (e.g., Agile Software Development) [22] stands in stark contrast to the former, more traditional waterfall approach [23] where planned iterations are avoided.

As can be seen from the brief descriptions above, prototyping is a versatile tool that may take on many roles and can be used in the very early as well as in the late development stages. Since the focus of this paper is on developing physical product systems, the remainder will revolve around physical prototyping.

3. A brief overview of the cases

This section gives a brief presentation of four case studies. The data in Cases 1 and 2 are revisited from a prior study [7]. These cases were the study of two product systems that were developed and produced by an automotive OEM. Cases 3 and 4 are early-stage development projects that are conducted as a collaborative effort between academia and the industry.

3.1. Case 1 – Prototyping in the development of a panoramic roof module

The panoramic roof module was a novel design developed by the OEM in collaboration with an external supplier. Prototyping in this case take took place after careful CAD and FEA studies ensured confidence in the design. Several critical function prototypes were developed and tested to explore and ensure manufacturing capability since the design was unproven.

The project was commenced on the initiative of two experienced engineers within research and development. In the final stages, a comprehensive system prototype was developed and thoroughly tested to gain support from executive management, thus increasing the likelihood of implementation in production vehicles.

3.2. Case 2 – Prototyping in the development of an inflatable seatbelt

The inflatable seatbelt was developed by the same automotive OEM as in the previous case. The product system was a breakthrough new-to-the-world innovation when it was first introduced in the marketplace. With a total development time of thirteen years it was a challenge that relied on maturation of several technologies to be successfully developed.

In this case, the development team prototyped extensively throughout the development process. Due to the newness of the product, digital prototyping was not used in the early phases to evaluate the concept. The team instead made a series of ‘cobbled up’ prototypes to test whether the concept would work or not, and then prototyped to further refine the design. One of the

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