Raising the Odds of Success for Innovative Product by Experimentation and Utilizing Input of Future User

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Abstract. A critical aspect of product development is inclusion of input from future users/customers. This input is invaluable for identification of innovative product features and functionality due to chaos, lack of predictability and structure that dominate at the first stage of innovative product development process, so-called Fuzzy Front End. This paper reviews the innovative product development challenges and aims to perceive how early-stage prototypes in combination with storytelling can help to better utilize user input and improve product management at the early stage of the process. We organized experiment-driven innovative product development process, immersed three cross-disciplinary product teams in design research and suggested them to experience through rapid prototyping. Guided by empirical exploratory study and statistical analysis we explore the accuracy of user input when it is provided based on different product representations (such as sketches, mock-ups and minimum feature set products) with and without storytelling.

Keywords: Innovative product development · Early-stage rapid prototyping · Storytelling

1 Introduction

In the era of "fast products" the process of new products development to meet customer expectations is becoming more challenging. A major reason of high failures rate of innovative products lies in misunderstanding who is user/customer/client and what they really need/want. In reality asking a customer about new product does not always result in the desired results, in particular when a radically new (breakthrough) product is being created [1]. Customers are not good in predicting what they really need/want and they are often not aware of potential solutions. Finding a different type of knowledge about user/customer "pains"/needs/wants can importantly contribute to product success. The critical questions here are how to avoid wasting effort by building a product that does not deliver value for users/customers and how to raise the odds of success of products that satisfy intended outcomes before running out of other types of resources.

This paper focuses on the collaborative exploration process for innovative product development (IPD). It evokes empathic resonance, co-creation and provides effective management of IPD process, which is of particular importance at the early and full of

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uncertainty "getting started" stage. Collaborative design, as an effective approach at that stage of IPD, includes communication, sharing information and working together in order to find an optimal solution. We assume that the effectiveness of IPD, both in terms of productivity of communication within product team and outside of it while working with potential users/customers substantially depends on the form of representations of current results of IPD process.

The objective of this paper is to study and discuss different kinds of representations (design artifacts) of current results of product design in combination with storytelling at the early stage of IPD process. We aim to examine the way they help to effectively manage customer/product discovery and validation, based on inputs of future users/customers, inspire individual and collective insights for various participants of IPD process.

In the following sections we first set the ground for empirical studies, in particular, experiment-driven approaches based on human-centered design and customer/product development. Then, we provide empirical research and discuss representations of the different kinds of design artifacts together with storytelling. We conclude with formulation of the results and further research.

2 Experimentation and Representation within Fuzzy Front End of Innovative Product Development

2.1 Fuzzy Front End of Innovative Product Development

Innovative product life cycle includes invention, design, manufacturing, marketing, distribution, sale, product support and utilization. IPD process can be represented as three sequential stages (see Fig. 1):

- Stg.#1: Pre-development (early) stage, so-called Fuzzy Front End of Innovation (FFEoI), where a concept of the product and its feature set are determined and validated [2];
- Stg.#2: New Product Development and Validation (NPD&V) is a stage where a product are actually developed and validated [3];
- Stg.#3: Production and Market Launch (P&ML) is a stage of commercialization where a newly developed product is produced and brought to the market [3].

FFEoI is the most crucial stage of IPD process, since here product features and functionality are determined [4, 5]. In FFEoI product managers are responsible for managing both the complex process and the people in the product team with different background [6]. He is requires coping with multiple, often conflicting contingencies and finding balance between different approaches and behaviors [7, 8]. One way to manage activities within FFEoI effectively and efficiently is to apply exploratory style of management based on experimental learning with participation of the key stakeholders of IPD process. It requires utilization of future users/customers input. There are different ways in which users/customers can play an active role in IPD process. Given the importance of these circumstances, we discuss the managerial approaches in the following sections of this paper.

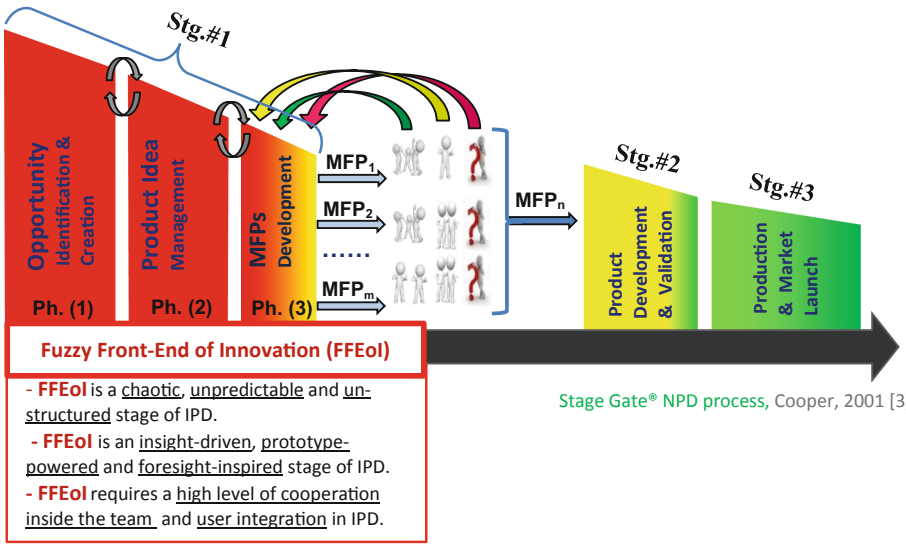

Fig. 1. Innovative product development (IPD) process.

2.2 Experiment-Driven Approaches with User/Customer Involvement

Experiment-driven approaches to IPD tend to focus on what to develop and are closely linked with customer development. Experiments involving users/customers are usually made to generate insights, getting feedback and to understand the relationship between specific actions, e.g. identification, creation and validation specific product features. Continuous experimentation is a basis of modern approaches/methods to create innovations. Among the most approved are human-centered design, customer development and lean product development.

Human-centered design (HCD) is a widely acknowledged creative problem solving approach which focuses on people and their needs/wants [9, 10]. HCD is a non-linear iterative process that begins with (1) definition of the problem and opportunity, followed by exploration of the user/customer and contexts of use, (2) generation of ideas through brainstorming, (3) building prototypes, (4) prototype testing, often carried out a number of times, and used of findings to refine the problem solution. Design thinking (DT) uses the designer's methods to match people's needs with what is technologically feasible, what a viable business can convert into user/customer value [11]. Participatory (so-called co-design) design is a form of HCD that actively involves users and others in all phases of a design process [12]. Users are not simply consulted at the beginning and invited to evaluate created product at the end. They are treated as partners throughout the process and become a part of IPD team as 'experts of their experiences'. In fact, the goal is to make IPD team and users work together, each contributing with strengths to clarify the problem and design task as well to explore design solutions. Participatory tools and techniques have a long-standing history in design studies and practice [13, 14].

Experimentation involving users/customers is a key part of the customer development approach [15, 16]. Similarly, continuous experimentation is also used in lean user experience and lean product development [17, 18]. Like the approaches mentioned earlier in this section, these approaches also strive to highlight user/customer centricity and aim at raising the odds of product success by reducing uncertainties. These experimental approaches are often referred to as "hypothesis-driven development" to maximize value for user/customer, reduce lead time and costs of IPD. Continuous experimentation implies constant testing of the product feature hypothesizes

and their user value as an integral part of the development process in order to evolve the products into high-value creation. Successive iterations of the "Hypothesis-Build-Measure-Learn" feedback loop structure IPD process within FFEoI domain and have value when the quality of the first guess is high, cost of rework is low and feedback is fast. Rapid prototyping enables rapid learning and minimizes mistakes. Thereby it raises chances to create the right features of the future innovative product.

For effective implementation of the experiment-driven approaches at the first stage of IPD process, i.e. within FFEoI domain (see Fig. 1, Stg.#1: FFEoI), continuous representation of the current results of product-concept development is very important. Early-stage prototyping is an activity and a tool valuable for understanding existing user/customer experiences and context, exploring and evaluating product design ideas, and communicating ideas/hypothesis within IPD team and to future users/customers [19].

2.3 Representation within Fuzzy Front End of Innovation by means of Early-Stage Prototypes and Storytelling

In FFEoI domain when many different ideas for a product are considered and accompanied by uncertainty prototyping focuses more on exploration [20, 21]. Early-stage prototyping, so called exploratory prototyping, is a tool to "get going" by building to think, helping a developer to uncover users/customers insights, generate and validate ideas, facilitate exploration of a design space [11]. Prototype is defined as a concrete representation of a part or a whole interactive system as an artefact, in particular, sketch, mock-up, CAD model, 3D print, simulation.

Early-stage/exploratory prototypes effectively serve within FFEoI domain of IPD process by aiding learning and communication. In the domain of learning prototypes often help to answer specific questions involving user interaction, for example, incorporating user feedback in a development process, assessing usability and definition of features and functionalities of future product together with users [19, 22]. Exploratory prototyping supports learning in two distinct ways: by framing design problems and exploration of various possibilities related to the product development, and by validation or verification of selected performance or functional aspects a product development [23]. Exploratory prototypes can also facilitate communication within FFEoI domain, both within the IPD team and with users/customers. They are one of the most effective tools to foster discussion to stimulate proactive thinking and a way to involve users/customers in participatory design [24, 25]. However, prototyping for rapid learning/communication is only feasible when artifacts are created quickly and inexpensively. Critical factors for progress within FFEoI domain are how fast the

IPD team is able to build prototypes, test prototypes and implement lessons learned in the next iteration.

In prototyping the contextual factors play a critical role in making decisions. By a context we mean surroundings and an entire setting or a situation. It is a risk to make decisions in IPD process without understanding and taking into account the context Storytelling can provide additional value to representation, in particular make it more realistic which assists to employment of user input [26]. A story comes into notice, provides clarity and inspires IPD team and stakeholders to act. There are many ways to communicate stories to our teams and stakeholders visually—storyboards, journey maps, empathy maps and scenarios of a user are just a few examples. Storytelling involves understanding of human motivations and emotions in order to truly move participants of collaborative activities. Stories build empathy and make the user needs and pain points memorable to IPPD team. Scenarios are descriptions users give by interacting with a product/system to achieve a goal under specified conditions and constraints. They provide information about a context in which a product has to operate in a user- and task-oriented way. Scenarios can be presented as rich narratives (e.g., day in the life of a user) or statements describing the triggers and a situation that encourages a user to interact with a product [27, 28].

In this study the different forms of storytelling are tested to improve learning and communication within FFEoI domain by better of representation in the beginning of IPD process by utilizing future user input.

2.4 Research Questions

Based on the literature review mentioned above, it is clear that representation by different forms of prototypes serves important purposes in IPD process of aiding learning and communication. To identify the benefits and impact of early-stage rapid prototyping within FFEoI domain of IPD process we organized co-creation design workshop to answer the following research question: How early-stage prototypes in combination with storytelling can help us to better utilize user input and improve management in FFEoI domain as well as to receive more valuable product concept?

This exploratory study is based on product design projects conducted by three teams in a framework of a 4-week co-creation design workshop. The workshop was organized for development of innovative product concept for fresh food delivery. The details of a design workshop, research method, data collection and analysis are presented in the following section.

3 Management of the Fuzzy Front End of Innovation by Utilizing Input of Future User

3.1 Co-creation Design Workshop “Innovative Product Design”

During a 4-week co-creation design workshop “Innovative Product Design”, three cross-disciplinary IPD teams of six members were immersed into design research and “do it yourself”. They gained experience in our rapid prototyping lab equipped with

facilities (3D printers, milling and laser machines, materials, etc.) and materials for modeling and creative spaces in "d.school style" for team work. Design workshop can be described as a combination of "hard" (a set of equipment for rapid prototyping and creative space for team/project work) and "soft" (modern management methods and tools such as design thinking, customer development, lean product development) components for creating successful innovative products. Design workshop instructors and IPD team supervisors are both from the university staff and industry representatives from design, engineering and management.

The IPD teams had to carry their projects through all the steps of the creative problem-solving product design process within FFEoI, i.e. identification of customer/market/technology opportunities, development product ideas to meet customer demand and development of a product concept. The goal was to develop and validate product concepts, i.e. minimum feature set products (MFPs), for fresh food delivery. The IPD teams worked independently and iterated "Hypothesis-Build-Measure-Learn" feedback loop in 3 phases of FFEoI domain based on experimentation with users/customers (see Fig. 1). In the beginning, in the first phase (Ph.1) "Opportunity Identification & Creation", all three IPD teams were involved in the design research (user in-context interviews and observation) to gain in-depth understanding and empathy for future product user. Interviews and observations were conducted in the everyday user context which gave deep and reach view of thoughts, behaviors and life of user. The aim is to uncover "pains"/needs and find insights. IPD teams used design thinking tools, such as empathy mapping, trend mapping, knowledge capture template, knowledge wall, persona profile.

Effectively accumulated information allows IPD teams to move on to the next phase (Ph.2) "Product Idea Management", where they generate and select product ideas using creative techniques (see Fig. 1). At this phase, the first prototype appears in a form of sketch of the future product and its brief description. Concept sketches were forms of visual communication within and outside of IPD team and used to provide a specific and detailed view of a particular design idea. They called input, especially related to the product form. The following gives a summary of all heading levels.

Mock-ups were the next step of prototyping activities of IPD teams. They were created to evaluate the intended form/size and key elements of a product concept. Their construction assumes exactly the same look, feel, materials and other attributes as a future product will have. So they are not fully-functional but are the same in every other way.

In the third phase (Ph.3) called "MFPs Development" the IPD teams prototyped and tested a number of minimum feature set product (MFP). MFP is a "product" which has just enough features to gather validated learning about the product and its continued development [15]. Validated MFPs can go to the next stages (NPD&V and P&ML) of IPD process (see Fig. 1).

Therefore, the product representation within FFEoI domain was carried out by three types of prototypes (sketches, mock-ups and MFPs) for experimental learning and communication within the IPD teams and outside with the aim to utilize input of future users/customers.

3.2 Research Method, Data Collection and Analysis

This empirical exploratory study is based on quantitative analysis. A total of 192 potential users of the product for fresh food delivery were selected for evaluation three types of prototypes (sketches, mock-ups and MFPs). 180 of them performed evaluation. Each of three types of prototypes, sequentially created by each IPD team during the co-creation design workshop "Innovative Product Design", was evaluated independently by 10 users. In the same way each of three types of prototypes in combination with storytelling was also evaluated independently by other 10 users. The evaluation data was collected via the completion of the USE Questionnaire [29] which is successfully used by many companies around the world. The USE Questionnaire was constructed as five-point Likert rating scales. Users were asked to rate agreement with the statements on a scale from strongly disagree (1 point) to strongly agree (5 points). The USE Questionnaire itself is divided into four categories: Usefulness (8 questions), Ease of use (11 questions), Ease of learning (4 questions), and Satisfaction (7 questions). Statistical methods (mean, median, standard deviation, mean difference) were used in data analysis.

3.3 Results and Findings

The results of statistical analysis (mean, median, standard deviation, mean difference) of evaluation of three types of design artefacts, sequentially and independently created by IPD teams (#1, #2 and #3) during the co-creation design workshop "Innovative Product Design", are demonstrated in Figs. 2 and 3.

All three IPD teams with three types of design artifacts (sketches, mock-ups and MFPs) demonstrated higher values of means for the case of the presentation in combination "exploratory prototype+storytelling". Apparently, a better understanding of the product being created and context of using by potential users allows them to give more accurate and valuable feedback to the product developers. Therefore they have an opportunity to do the right iterations in the FFEoI domain to create the desired products more efficiently, i.e. faster and less expensive. The finding of the study shows that the efficiency of storytelling is higher at the beginning of FFEoI, i.e. combination "sketch +storytelling", and decreases at a later stage of exploratory prototype development ("MFP+storytelling").

IPD team#1	A.m.	Mean difference	IPD team#2	A.m.	Mean difference	IPD team#3	A.m.	Mean difference
Sketch	1,73	0,52	Sketch	1,89	0,83	Sketch	1,96	0,87
Sketch + Storytelling	2,24		Sketch + Storytelling	2,72		Sketch + Storytelling	2,82	
Mock-up	3,26	0,76	Mock-up	3,59	0,73	Mock-up	3,91	0,58
Mock-up + Storytelling	4,01		Mock-up + Storytelling	4,31		Mock-up + Storytelling	4,49	
MFP	4,27	0,17	MFP	4,28	0,24	MFP	4,53	0,18
MFP + Storytelling	4,44		MFP + Storytelling	4,52		MFP + Storytelling	4,70	

Fig. 2. Results of evaluation of the design artifacts created by IPD teams (#1, #2 and #3).

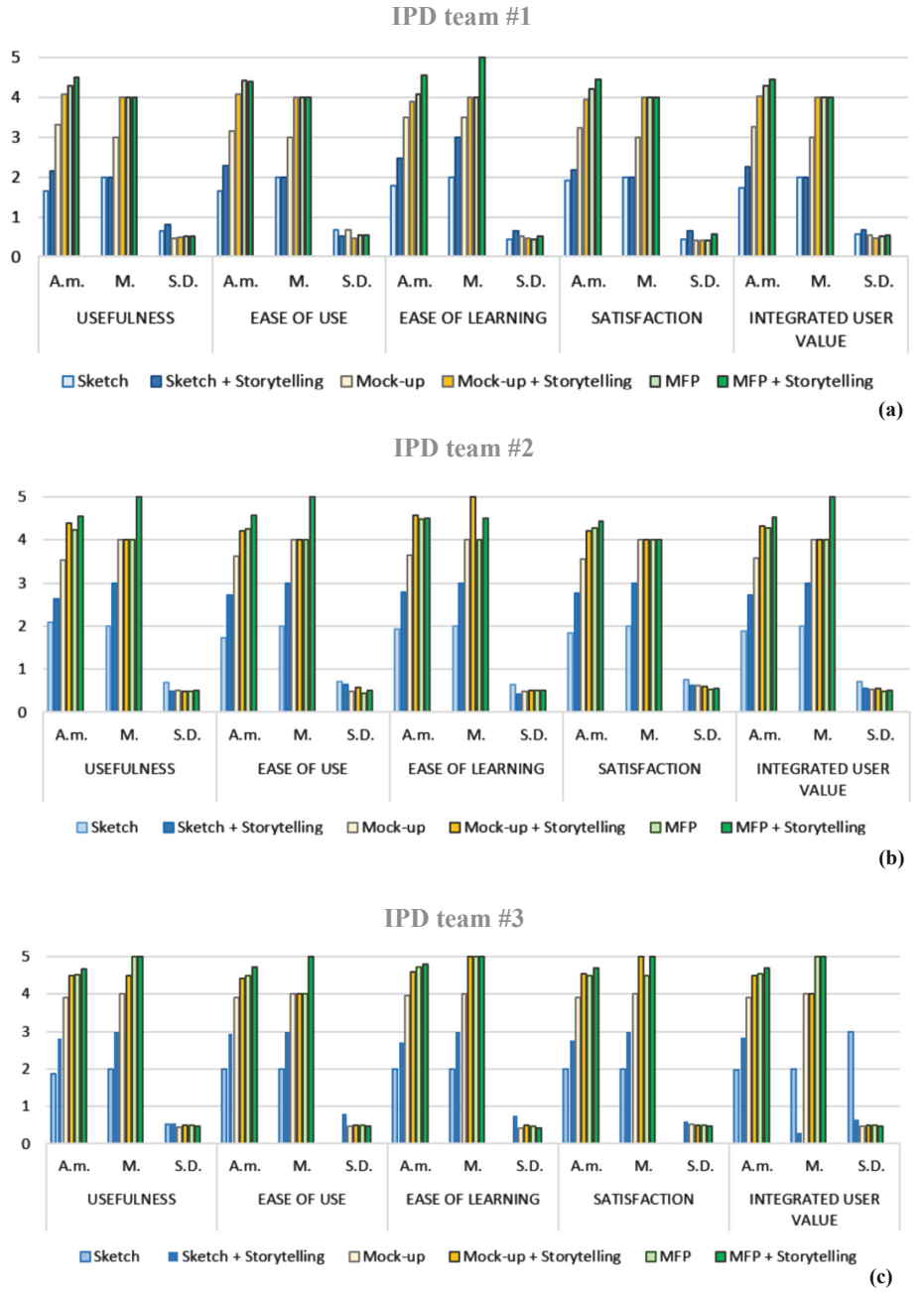

Fig. 3. Results of evaluation (usefulness, ease of use, ease of learning, satisfaction and integrated user value) of the design artifacts created by IPD teams (#1, #2 and #3). (A.m. - mean, M. - median, S.D. - standard deviation).

4 Conclusion

This paper presented results of exploratory study to identify the benefits and impact of early-stage rapid prototyping within fuzzy front end of innovative product development process. Experiment-driven approach involving users and exploratory rapid prototyping is a key part of in the early-stage of innovative product development process. We found that exploratory prototypes (sketches, mock-ups and MFPs) in combination with storytelling (storyboards, journey maps and scenario of use) can give great value for product developers within fuzzy front end of innovative product development process. A better understanding of the product being created and context of using by potential users allows them to give more accurate and valuable feedback to the product developers. Further work will continue to investigate different types of early-stage prototypes in combination with different ways to visually communicate stories and scenario of use to IPD teams and stakeholders, including digital format, to better utilize input of future users/customers.

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