Early Prototyping in the Digital Industry: A Management Framework

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Abstract. A rising complexity of products, an on-going digitalization and an accelerated shift of market demands lead to a rapidly growing number of uncertainties in business environments. Firms require new approaches to deal with these challenges and have to take a proactive step towards uncertainties and the mitigation of related risks. One way to do so is the adoption of iterative, learning-oriented methods and practices in order to incrementally adapt to rapidly changing environments and customer demands, arising for example, from digital transformation and industry 4.0. "Early Prototyping" and "Business Experiments" constitute two of those methods. In this paper we introduce an integrated and more general perspective on managing iterative methods within new product and service development projects. As a result, we are able to present a comprehensive framework for the management of early prototyping that has sufficient practical relevance and can answer current, practical challenges.

Keywords: Early Prototyping, Business Experiments, Agile Product Development, Digital Industry

1 Introduction

The omnipresent innovation imperative of the last decades has changed many business environments fundamentally: Steadily shortening product life cycles, the ever increasing speed of new technologies, an endless float of new product categories as well as rapidly changing customer needs bid defiance to companies. At the same time all-encompassing uncertainties are a fundamental part of modern business environments: A rising complexity of products, an on-going digital transformation - the use of new technologies like mobile, cloud, social networks, internet of things and Big Data - and an accelerated change of market demands dramatically complicate

companies' strive for long-term business success (cf. [1],[2],[4]). That is why companies have to accept that traditional planning paradigms do not work in an usual manner anymore. Consequently, firms have to find ways to cope with these challenges and take a proactive step towards uncertainties [5].

Some disciplines and professions cope with uncertainties by adopting iterative development processes: They consider prototyping and experimenting as a response to uncertain, unpredictable environments.

Mainly in the start-up and entrepreneurship space, iterative, learning-oriented approaches gained recent attention under the term "early prototyping" and "business experiments". These approaches highlight the importance of trial-and-error-learning and offer a process-view for the testing of ideas and prototypes with customers to optimize product and service development.

But how can insights from organizational learning, business experiments and design research on early prototypes be combined to a framework for the management of early prototyping in complex and fast changing business environments for industrial and service companies in the phase of digital transformation?

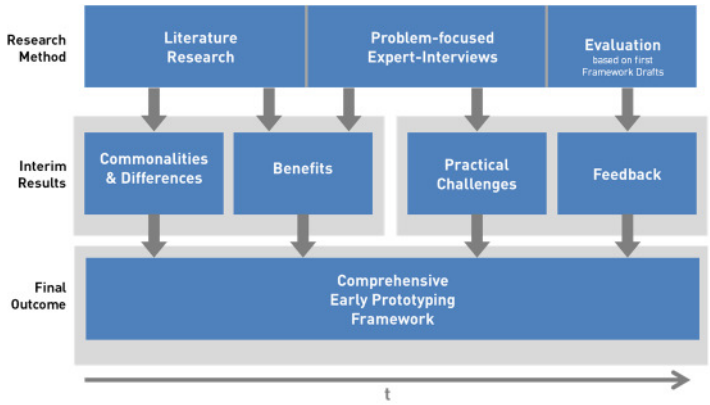
2 Research Design

The paper at hand aims at integrating knowledge from the research fields "early prototyping", "business experiments" into a comprehensive, practical-oriented framework for the management of early prototyping. By using this framework, managers should be able to achieve improved product market fit (cf. [5], [9]), save costs due to early problem identification (cf. [10], [11]) and enjoy a wide range of communicative advantages [8], by using the presented framework. Expert interviews ensure that the designed framework is capable of answering practical challenges innovating firms have while using early prototyping.

For this reason, the central research question is: How can insights from organizational learning, business experiments and design research on early prototypes be combined to a framework for the management of early prototyping in complex and fast changing business environments?

The research design is separated into three interrelated steps that lead to the intended "early prototyping framework". The process starts with a comprehensive literature review in all mentioned fields of interest. Simultaneously, the design and sketching of first possible early prototyping frameworks began. Afterwards, a qualitative expert interview series was initiated. Finally, after the results from the interview series had reached the necessary degree of saturation, the developed framework was evaluated with practitioners to assure that it has practical relevance and value. This feedback was incorporated into the final framework as well. The results of the problem-focused expert-interviews as well as the evaluation were directly integrated into the description of the "early prototyping framework" in order to present a conjoint explanation of the developed steps.

Figure 1 – Research Design



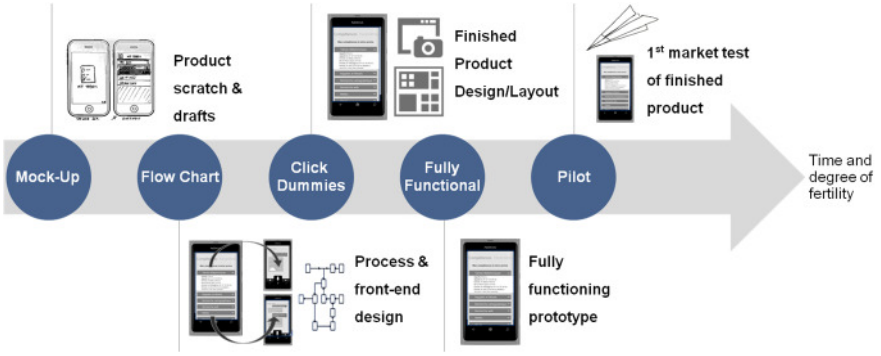
3 What's in a name? Defining the Key Terms

First of all, it is necessary to define the key terms on a relatively general level in order to sustain a broad applicability for different kinds of early prototypes as well as a wider spectrum of industries. Prototypes, by definition, are first or preliminary versions of future products and services. As such, their main purpose is to:

- Showcase an idea/concept to key stakeholders (e.g., investors, sponsors, potential buyers, and partners)
- Test and validate value propositions with actual users or customers
- Generate feedback to iterate and pivot a new product or service.

Prototypes can come in many different shapes [3]. For example, as mockups in a "fake it till you make it" fashion, as click dummies that simulate the user experience of apps on mobile devices, or fully functional prototypes (see Figure 2).

Figure 2 – Early Prototyping Process



For the purpose of this paper, we focus on a process-centered definition.

> *Early Prototyping is an iterative method for early phases of new product development. It explores and communicates representations of ideas concepts and experiments with them to sharpen their underlying problem definition.*

Of course, it is necessary to go on with developed prototypes: the creation and development of any kind of prototyping is only worthwhile when it is used for experimentation – for example, showcasing a prototype to a group of potential customers. It thus becomes obvious that business experiments and early prototyping can be seen as two methods that act as complementary extensions to each other.

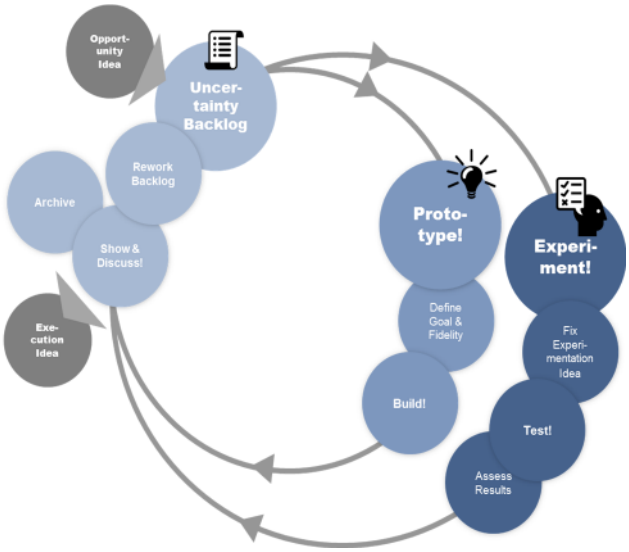
Accordingly, the following definition of business experiments includes notions of the definition of early prototyping in the same manner that the above-noted prototyping definition already hints at experiments:

> *Business Experiments are defined as an iterative method that utilizes early prototypes by designing, conducting and analyzing trial and error tests that check previously defined assumptions in a systematic manner in order to learn to better understand and decide in unknown, uncertain business environments.*

4 Management Framework for Early Prototyping and Business Experiments

The following framework (see Figure 3) is based on the previously gathered insights from literature research as well as expert interviews. The framework offers a comprehensive perspective on early prototyping by utilizing strengths of the design discipline as well as the literature on business experiments. The framework itself was designed in an iterative process by the authors and has been overworked and changed several times while reviewing the literature, conducting the interviews and gathering feedback from practitioners [3].

Figure 3 – Early Prototyping Framework



4.1 Opportunity Idea & Uncertainty Backlog

4.1.1 Opportunity Idea

To start the early prototyping process it is necessary to identify an idea that is worth investigating. The term opportunity idea refers to a first business idea that is based on a first problem identification. This opportunity idea is normally far away from a concrete realization and needs further refinements.

According to a broad set of management literature [7], it seems nearly impossible to identify the "right" opportunity idea that is worth to start with from the outset. As discussed, management has to accept that they cannot know if an identified problem and a corresponding idea is worth a further investigation.

Early prototyping can help to identify promising products by iterating quickly and cheaply through possible ideas by building prototypes and experimenting with them.

4.1.2 Uncertainty Backlog

It is the goal of the the so called *uncertainty backlog* to identify and list the most pressing problems of the opportunity idea that could potentially become critical show stoppers. The *uncertainty backlog* has to be seen as a starting point to separate predictable less uncertain assumptions from the most relevant pressing ones. By doing so it is central to test the riskiest assumptions first: "If you can't find a way to mitigate these risks toward the ideal that is required for a sustainable business, there is no point in testing the others." ([9], p.119).

In order to identify this *most critical assumption,* management has to prioritize all listed assumptions according to their impact on the opportunity idea. In the process, the team is well advised to agree on an appropriate level of detail: The granularity of the listed assumptions will increase with each iteration and will become more detailed. Thus, the validated learning-process of the framework leads to the "solving" of the listed assumptions.

Due to the flexible and learning-oriented nature of the framework, the backlog should be seen as never closed. The backlog has to be rethought after each iteration and will be resorted and aligned to new learnings. Therefore, the *uncertainty backlog* is a document that is an anchor for team meetings to further discuss, structure and realign the upcoming uncertainties. This notion of iterative rethinking is critical to managers' ability to incorporate so called "Unknown Unknowns" – uncertainties and assumptions that have not been identified upfront by the team.

In order to involve and engage the participating team into the process, it is important that the team "owns" the uncertainty backlog and is always allowed to rework and restructure it according to the actual situation. This aspect is especially stressed by several expert interview partners and culminates in the code "Freedom". Experts pointed out that the early prototyping teams need sufficient freedom to act in order to maintain identification with the project and to keep up their responsibility for it.

4.2 Prototype!

After preparing the *uncertainty backlog*, the team can start with the *most critical assumption* and develop first ideas about the upcoming prototyping iteration. Prototyping is used as a method to build artifacts for the assumptions listed in the *uncertainty backlog*, starting with the realization of the most critical assumption.

It is stated that prototyping teams have to give particular relevance to the goal and fidelity of their prototype in order to prototype efficiently.

As a result, the prototype phase will sharpen the understanding of the investigated opportunity idea and will refine the *uncertainty backlog*. With each iteration the team learns more about the opportunity idea as it resolves ([6], p.7), and adds uncertainties to the *uncertainty backlog*.

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4.3 Experiment!

The outer circle of the presented framework is dedicated to business experiments. In general, it is the goal of this phase to bring the developed prototypes into an external environment and test the opportunity idea and its most critical assumptions with customers. By doing so, organizations get the chance to understand their opportunity idea from a market perspective in contrast to the mere internal-oriented prototyping phase. Therefore, the prototyping phase is essential to further develop the chosen opportunity idea and understand it in more detail.

5 Benefits of Successful Implementation

5.1 Failing faster and saving costs

The central economic factor that has been raised by nearly all interviewed experts is the possibility to save costs and time early on. Expert statements show that changes in later project stages lead to significantly higher costs as they would cost in early phases. In this context, early prototyping enables managers to explore critical aspects of concepts as early as possible, which provides the potential to save budget and time by unearthing the critical show stoppers and unanticipated challenges in early project stages.

5.2 Staying lean and agile

Some interviewees stated that enterprises and corporations tend to invest too much innovation budget in the early stages. According to them, this leads to an overly complex team structure and analysis that could be prevented by focusing on fast and

agile prototypes and experiments. This is particularly relevant; if management is challenged to maintain flexibility in uncertain business environments (cf. [2]). .

5.3 Validating assumptions

According to a more business-oriented view on early prototyping and business experiments, some interviewed experts underlined the value of early prototyping for the validation of underlying assumptions regarding the uncertain business environment. They described the benefit of early prototypes and experiments to explore and understand uncertainties by gathering learning. On that note, the interviewees pointed out the importance of contact with real customers and the direct feedback from the market.

5. 4 Gaining acceptance

Another aspect raised by the interviewees is the relevance of internal acceptance for new ideas and concepts inside the organization.

The interviews revealed that the demonstration benefits of prototypes make it possible to use the artifacts as so called “boundary objects” that make it possible to discuss and represent new concepts to a wider audience with diverse professional backgrounds.

The value and importance of early inclusion of operative needs and requirements in projects with strategic relevance is discussed by several scholars from different fields.

Such an approach is not bottom up or top down but rather oscillates between a conceptualization stage and the operative level where affected employees can give their input as early as possible. We suggest to include stakeholders step by step in an iterative manner depending on newly identified demands of the project. Such a course of action fosters the successful implementation of new products and strategies. This is because the participatory nature of the process increases the internal understanding and commitment for the prototyped ideas.

5.5 Understanding each other

Several experts stated that the presentation of prototypes induces a significantly better understanding of an idea and brings discussions and feedbacks to a new level.

They explain that prototypes prevent misunderstandings and foster deeper interactions between team members. Teams are able to discuss concepts and suggestions in more detail and build a shared understanding. It is explained that the externalization of thoughts and vague ideas force designers to concretize their individual mental models while the resulting representation of the ideas gives the group a basis to agree on.

Furthermore, prototypes have the capability to transfer tacit knowledge between team members by constantly discussing and interacting with prototypes. Narrations and languages have an elementary part in such a process and can be understood as

“language games”: Teams discuss and cultivate a distinct vocabulary to make sense of their prototypes and form a mutual understanding of the built representations. All in all, prototyping is a social process that can be perfectly understood as a part of organizational learning. Furthermore, it is argued that building a prototype together improves the bonding of the team by establishing a collective ownership of the particular prototype.

6 Conclusion & Outlook

In this paper, we proposed a practical early prototyping framework. Initially, we introduced the so-called “uncertainty backlog”, as well as structured “show and discuss” sessions to manage the central steps "prototype!" and "experiment!”. Within the framework, the "uncertainty backlog" plays a central role and acts as an intersection point between the concepts as it allows for overlapping commonalities while keeping distinctive characteristics separated.

While designing the framework, the opinions and insights of practitioners have been included. The expert interviews revealed that topics with minor relevance in the literature often present the most pressing challenges in practice. For example, practitioners highlighted aspects like resource allocation or the internal acceptance of iterative methods as crucial. Hence, those challenges have been emphasized and possible solutions to deal with these aspects have been proposed. As a result, the framework guides managers in combining and steering iterative methods, like early prototyping and business experiments, in a structured manner.

The conducted evaluation phase has revealed that the designed framework can be applied to a diverse set of business problems and seems specific as well as adaptable enough to be helpful in different business settings.

This paper provides a contribution towards the understanding of prototyping as a management tool and to conflate the different involved research fields in order to extent the toolbox for managers with regard to innovation management. In the present paper, we linked the wide range of literature on early prototyping in design, the publications on business experiments and expert insights to a meaningful, comprehensive whole. It became evident that the two concepts share various benefits and commonalities and can be connected to already established research on organizational learning. This shows that it is generally feasible to establish a general management perspective on iterative working styles. Furthermore, new areas of research could have been identified by focusing on practitioners' challenges that have not yet been investigated by recent literature.

Our paper focused especially on the needs and challenges of innovation managers who have to find ways to cope with rising uncertainties and the problem of increasingly complex business environments. Therefore, this paper presents a framework that guides practitioners through early prototyping and business experiments. It gives them guidance on how to setup and steer early prototyping and highlights relevant stumbling blocks and optimization opportunities in order exploit the benefits of iterative working methods.

By applying the framework, managers can unhinge early prototypes and business experiments from their particular discipline boundaries and can unfold their benefits on a broader, organization-wide level. Furthermore, the implementation of the framework should shed light on the power and advantages of early prototyping and inspire managers to attach greater importance to it in order to improve organizational learning capabilities in the early phases of new product development projects and particularly in the development of innovative industry 4.0 products and business models. Ideally, managers are able to achieve improved product market fit, save costs due to early problem identification and enjoy a wide range of communicative advantages by using the presented framework.

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