Mock-Ups as a Tool for Assessing Customer Value Early in the Development Process

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Structured Abstract

Purpose – This paper proposes an approach to broaden the focus of a low-fidelity prototype (i.e. mock-up) to enable user experimentation in a real environment at the early stages of the product development process. The functionality approaching a real solution enables customers to experience the key functionality, and therefore, the perceived customer value of the new product idea before major investments in the development.

Design/methodology/approach – The study is based on an interventionist case study in a manufacturing company. The researchers were involved in (1) the development of two new products, and (2) analysing the potential process and cost implications.

Findings – Mock-ups enable the preliminary measurement of cost and value implications of a new product at the early stages of the development process. This holds significant potential for advancing development practices and reducing the uncertainties present in such processes. Thus, the business case at the early stage of the development process can be argued with 'user-experienced' cost information and, therefore, also 'perceived' customer value.

Originality/value – The originality of the paper lies in broadening the focus of mock-ups to enable user experimentation in a real environment at the early stages of the development process.

Practical implications – The use of mock-ups to gain customer feedback is well aligned with the fail-fast mentality emphasised in the contemporary start-up scene, but this study also encourages developers/practitioners from mature industries to use mock-ups to assess perceived customer value.

Keywords – value creation dynamics, cost management, design, prototypes, mock-ups

1 Introduction

Overall, companies aim to offer products and services that customers find attractive. However, customers consider a product attractive only if the benefits they perceive as coming from product usage surpass the sacrifices necessary for acquiring the product (Khalifa, 2004). This requires that the offering result in perceived customer value that can be assessed and measured even in monetary terms. However, one of the main challenges in gathering information on perceived customer value and assessing value is that customers perceive the real value of the product, by definition, only after experiencing the product in use (Lanning, 1998; Woodruff, 1997); this highlights the relevance of value-in-use (see McDonald *et al.*, 2011). To improve market success, the perceived customer value of a new product offering should be captured at the early stages of the development process. However, instead of perceived customer value, previous attempts to analyse perceived customer value at the early stages tended to result merely in a study of customer expectations.

This paper aims to contribute by integrating two contemporary aspects: customer value and prototyping. Prototypes help companies to communicate their ideas in the development process and give customers a chance to experience the product in use. On the one hand, in the early stages of the development process, diverse prototypes, including mock-ups, are built to test the core functionalities of the final products using cheap materials (Preece *et al.*, 2002). On the other hand, during the later stages of the product development process, prototypes are built out of the same materials and components as the final product and offer an equal level of functionality (Yang and el-Haik, 2003). However, there has been a large gap between the different prototyping methods (see Karimian Pour, 2015), and as a result, customers have only been able to experience the real product usage very late in the development process with more sophisticated prototypes. At this stage, over 80% of product life cycle costs have already been committed, making changes in the product architecture expensive (Turney, 1991).

This paper proposes an approach that broadens the focus of a low-fidelity prototype, namely, mock-ups (Brandt, 2007), to cover most product functionalities while still building them using cheap materials to enable user experimentation in a real environment at the early stages of the development process. Despite the low-fidelity nature of the prototype, the functionality approaching a real solution enables customers to experience its key functionality, and thus the process and cost implications of the new product idea. With this approach, the development team is able to gain access to experience-based knowledge on perceived customer value at the early stages of the development process.

This paper examines how mock-ups enable assessment of customer value in the early phases of the product development process. The empirical part of the study is based on an interventionist (see Jönsson and Lukka, 2004) case study in a company manufacturing safety accessories for hose assemblies. One research team member has been involved in (1) the development of two new products that assist customers in using these accessories during the assembly process, and (2) analysing the process and cost implications. Following the idea of interventionist research (see Suomala *et al.*, 2012; Lyly-Yrjänäinen *et al.*, 2017), the researcher provided cost management expertise to the case company. The four-year research collaboration enabled a deep access to the product development process.

2 Literature

2.1 Prototypes and Mock-Ups

Using various models has been considered important in the product development process for a long time (Brandt, 2007). Hatmann and Klemmer (2006) mentioned that prototyping was the core activity in innovation, collaboration and creativity in design. Zorriassantine *et al.* (2003) believed that the successful introduction of new products in a competitive global market was dependent on the efficient and extensive application of prototypes (see Liu *et al.*, 2013; Schlecht and Yang, 2014).

In the early stages of the product development process, prototypes are built to test the core functionalities of the final products using cheap materials (Preece *et al.*, 2002). The prototypes used in the later stages are built out of the same materials and components as the final product, offering a functionality that is comparable to the final product (Yang and el-Haik, 2003).

Yang and El-Haik (2003) offered the most comprehensive categorisation of prototyping methods; they divided prototypes into analytical and physical. First, analytical prototypes can include (1) a paper prototype (e.g. a sketch of the product, a storyboard focusing on the functionality of the product or a fictive user interface), (2) a mathematical model of the product concept or (3) a computational model (i.e. a virtual model) of the product. Second, physical prototypes include (1) experimental (similar to mock-ups), (2) alpha, (3) beta (using real materials and components but not the real production process) and (4) pre-production prototypes (used for testing the real production process).

This paper examined the use of prototypes at the early stages of the product development process. Prototypes used in the early stages tend to focus on core functionalities (called ‘focused’ instead of comprehensive prototypes, see Yang and El-Haik, 2003) and are not made of the same materials as the final products (hence why they are called low-fidelity prototypes, see Preece *et al*., 2002). Such prototypes using cheap, easily available materials are often called mock-ups. Limbuddha-Augsorn and Sahachaisaree (2010) defined mock-up as a scale or full-sized model used for demonstrating and evaluating the functionality of a design. According to Brandt (2007), the use of mock-ups in a product development process evokes different aspects; even a simple mock-up clarifies many benefits and drawbacks of a product concept. Furthermore, mock-ups are important for facilitating interactions; tangible mock-ups can help all project stakeholders gain a visual and tactile feeling about the product concept and reduce uncertainties as well as misunderstandings regarding the product under development (see, e.g., Schlecht and Yang, 2014). Thus, prototypes serve as tools that are conceptualised as ‘technology and design demonstrators’ and ‘boundary objects’ that refer to ‘artefacts which help mediate in the boundary between actors with different perspectives, knowledge, skills, locations or status in social systems’ (Moultrie, 2015, p. 2). However, such simple mock-ups, when built in a way that enables testing in a real-use environment, can also provide information on perceived customer value at the early stages of the development process when product modifications are less costly. This leads to the discussion of customer value.

2.2 Perceived Customer Value

The prototype approach is applied to the assessment of customer value discussed next. Customer value is considered as the sum of all the benefits provided by an offering. However, these benefits do not come for free – the buyer needs to make some sacrifices to gain access to these benefits. The difference between the total customer benefits and the total customer costs is perceived customer value, as defined in cost–benefit models (see, e.g., Khalifa, 2004; Lapierre, 2000; Menon *et al*., 2005). In the literature, perceived customer value is also referred to as customer-perceived value (Kotler and Keller, 2012), customer incentive to buy (Anderson *et al*., 2004) and value for customer (Woodall, 2003).

Thus, customers consider a product attractive only if the benefits perceived from product usage surpass the sacrifices necessary for acquiring the product (Lapierre, 2000).

However, one of the main challenges in gathering information on perceived customer value is that, by definition, customers perceive the real value of the product only after experiencing the it in use (Lanning, 1998; Woodruff, 1997). In other words, perceived customer value is not customer value until a customer has experienced the value in use. This statement emphasises the fact that no matter how careful the calculations a supplier has prepared, it is ultimately the customer who experiences the benefits, and eventually, the value in use (see McDonald *et al*., 2011). This difference in the customer's perception and the supplier's expectations is called an 'experience gap' (Parasuraman, 1997). However, to make things more interesting, according to Woodall (2013), the perceived value can evolve during use, and as a result, there are four different forms for customer value: ex ante, transaction, ex post and disposition value for the customer. Thus, customer value is realised and experienced during the entire lifetime of the product.

Various tools have been developed to assess perceived customer value. These tools include, for example, internal engineering assessment (in which the supplier engineering team estimates the benefits a product/solution provides to the customer), importance ratings of product features, field value-in-use analyses and focus group value assessment. Regarding these examples, only the latter ones evaluate customer value since, by definition, the value is something the customers must experience themselves and is impossible at the early stages of the product development process. However, perceived customer value can be assessed using simple mock-ups that possess the key functionality of the product under development.

2.3 Mock-Ups as a Tool for Assessing Perceived Customer Value

As discussed, mock-ups are typically built in a way that is not possible with real customer experiments. Mock-ups made of cheap materials enable 'proof of concept' regarding key functions. However, such prototypes typically only enable key functions to be tested separately; therefore, they cannot enable testing in real usage situations.

This paper argues that by combining the characteristics of low- and high-fidelity prototypes, it is possible to test a new product idea in a context that is similar to the real user environment at the early stages of the product development process. Thus, the usage situation based on such a mock-up can be used to prepare time studies on the implications that these new ideas would have on the customer's process. When the customer has been able to 'experience' these cost benefits in the real context during the test, it is possible to talk about customer perceived value instead of customer expectation.

Despite the low-fidelity nature of the prototype, the functionality approaching a real production solution enables customers to experience its key functionality, and therefore, the process implications of the new product idea in the real-use context; with this approach, the development team can gain access to experience-based knowledge on perceived customer value in the early stages of the development process. In this way, success stories quantified in monetary terms (see Keränen and Jalkala, 2013) can be built early on in the development process, unveiling the new value creation opportunities for the customers' processes.

3 Case – Assessing Value when Developing Production Machines

3.1 Machines for Installing Hose Safety Accessories

The next section describes and analyses a case where mock-ups are used for customer value assessment in the early phases of product development. The chosen case focuses on one business unit of a mid-sized textile company. The business unit manufactures safety accessories for hydraulic hose assemblies. The customers of the case company find these safety products difficult to install, and as a result, the company has invested in the development of machines that speed up the installation process. This study focuses on two main safety products within the company's portfolio: spirals and sleeves.

Safety spirals are placed on top of a hydraulic hose in order to reduce external wear. For example, in mining or tunnelling machines, the hoses may be under constant rock rain, so the safety spiral works as an extra skin reducing external wear. In addition, spirals are used for bundling several hoses into a larger bundle. Whereas spirals protect the hose from wear and tear, safety sleeves are designed to protect the operators and other personnel located close to the machines. In case the hose has a small leak (called a pinhole), a sharp hot oil spout, for example, can be lethal for those standing up to several meters away. The safety sleeve is designed to absorb this force, hence protecting the operators in case of such a hose failure.

In order to meet the tightening safety regulations, original equipment manufacturers (OEMs) should use such safety products in their hose assemblies. However, at the same time, the assembly operations of these safety products are time consuming, causing hose assembly manufacturers to become displeased with these products. As the business unit manager explained,

> New machine standards require OEMs to increasingly use safety products; hence, both OEMs and hose assembly manufacturers are constantly asking us how to speed up the assembly processes in production.

First, safety sleeves are woven from nylon; therefore, once they are cut, they tend to unravel themselves. To prevent this, the sleeve edges are often melted with hot iron after the cutting. According to the business unit manager, many companies offering cutting devices have been eager to provide different types of hot knives for this purpose. However, once the samples have been sent to these suppliers, the suppliers are no longer convinced of their solutions. When such devices are used for cutting the nylon sleeve, the two sides melt together; instead of a sleeve, the output is a bag that is sealed on both ends.

Second, one of the challenges in placing the safety spiral on top of the hose assembly is that, for the spiral to sit tightly on the hose, the inner diameter of the spiral must be smaller than the outer diameter of the hose. This results in a situation in which the length of the spiral is reduced once the spiral has been placed around the hose. If the spiral is too short, the hose assembly has to be spiralled again, and if the spiral is too long, waste is created. In addition, placing the spiral on top of the hose is tough on workers' wrists and elbows. Again, OEMs would like to spiral the hose assemblies used in their machines, yet the hose assembly providers are not keen to do this due to the laborious process it requires.

Despite the embedded potential fuelled by legislative changes, the industry has been slow to respond to customer demand for improvements in the assembly process. However, the new machine directives increase the demand for these products, attracting new players. At the same time, a company selling off-the-shelf spiral manufacturing equipment has emerged, further changing the competitive landscape. As the business unit manager said,

> The changes in the market have forced us to think about ways to differentiate from our competitors. Finding solutions to these problems would do exactly that.

Thus, the researchers helped to set up a project to develop new ways of using these two products in hose assembly manufacturing. It was agreed that the researchers would be brainstorming new ideas together with the management team, and as soon as there were some ideas, these ideas would be tested with very simple mock-ups. The mock-ups, however, would not only be used for enabling the ‘proof of concept’ from the feasibility point of view, but they would also include the analysis of the potential process implications and cost impact.

3.2 A Sleeve-Cutting Machine with a Plywood Frame

The collaboration began with the development of the machine for sleeve cutting. First, when attempting to solve the issues, many out-of-the-box ideas were brought up, some more and some less successful. For example, one attempt was made to blow air into the sleeve in order for the two sides to be separated while using a hot knife for cutting. Unfortunately, the air blow tended to cool down the blade, diminishing the smoothness of the cutting process. A rotating hot blade was also tested, without much improvement. These tests with mock-ups, however, helped the team to understand the challenges related to cutting the sleeves.

Interestingly, during a very informal discussion, one customer pointed out that most the sleeves they cut were less than two meters in length. This simple observation resulted in a completely new approach for sleeve cutting. Thus, if there was a tube on top of which the sleeve would be stretched, the hot knife could be used to cut the sleeve right at the edge of the tube without melting the two sides onto each other, resulting in a clean cut. The idea was tested immediately, and the managers were very pleased with the cut. This proof of concept then initiated a new development cycle. It is important to note that, thanks to the unsuccessful attempts done earlier, there was a hot knife already present at the company, enabling the ‘proof of concept’ within minutes of the new idea.

However, when testing the concept with the first mock-ups, an idea was born that it might not be necessary to stretch the sleeve completely open; as long as there was a tube inside the sleeve, it was enough to separate the two sides from one another for a clean cut. As soon as this was discovered, a more powerful hot knife was purchased, allowing for a faster cutting speed. The cutting process was also improved by attaching the hot knife to a pneumatic cylinder controlled with a foot pedal. This freed the operator’s hands to hold onto the sleeve that was now only loosely fixed around the tube (in the previous version when the sleeve was stretched, the operator did not have to hold the sleeve while cutting). In addition, when the sleeve roll was positioned properly, pulling the sleeve on top of the tube became easier. The machine frame, however, was made of wood and plywood to eliminate the need for mechanical engineering and to enable fast modifications.

This development resulted in an operational mock-up of the sleeve-cutting machine. The mock-up was operated just like a real production machine even though the frame was made from cheap materials, as mock-ups typically are. Furthermore, although the machine certainly did not look professional, it was used for cutting some real customer orders. The only limitation was that, since the hot knife was not designed for continuous production, the hot knife had to be cooled down after a dozen or so cuts. Nevertheless, this simple mock-up enabled one customer to cut sleeves for their orders a dozen or so at a time, simulating the real production process.

3.3 A Spiralling Machine Using Two Battery-Driven Screwdrivers and a Plastic Tube

Development of the spiralling machine began a few months later with the same philosophy. The initial idea was to place the spiral on top of the hose straight from the box without cutting the spiral first, eliminating work phases and possibilities for error and rework as well as material waste. Some simple experiments were done with the spiralling process, though without much success. The business unit manager provided the key design principle:

> In all the spiralling applications I have seen, the spiral is coming to the hose with a 90-degree angle using some sort of a pin. The spiral then goes on the hose by rotating the hose itself.

This idea was tested with a pen, a stick and some small-diameter spiral placed in a small cardboard box. When a few rounds of spiral were placed on the pen and the pen was rotated, this rotational movement simply pulled the spiral on top of the pen, guided by the stick. However, when the spiral came directly from the box, the box also had to be rotated; this was illustrated well by this simple experiment, which highlighted the two-drive system needed for the solution.

The other interesting discovery was that when climbing on the hose, the spiral pushed the hose forward. Here, there was no need for a control system that pushed/pulled the hose;

thus, changing the rotating speed did not require a control mechanism to manage the horizontal movement of the hose – a major discovery from the cost management point of view. The only prerequisite was that the hose and the drive simply had to be able to move when the spiral pushed them forward.

The solution was then tested with a Lego mock-up with two drives. Since the Lego mock-up seemed to work, the idea was pushed forward. The next step was to make a fully functional mock-up using plywood and plastic tubes. In this mock-up, two battery-driven screwdrivers were used as drives that were connected in series. This simple mock-up enabled two-meter hose assemblies to be spiralled.

3.4 Mock-Ups Enabling the Assessment of Perceived Customer Value

The mock-ups built rapidly using cheap materials and without mechanical engineering were good enough to be tested in real production. With the sleeve-cutting machine, the only limitation was that the hot knife had to cool down after every dozen or so sleeves. In contrast, the spiralling machine was limited by the fact that special fittings were needed for the hoses to be connected to the screwdriver. Otherwise, the process was identical to the real manufacturing process, and the tests were based on real customer orders. In other words, despite the limitations of both machines, the manufacturing processes enabled the possibility to not only test the functionality of the machines, but also to gain access to the process and cost implications of the new machines.

In terms of the sleeve cutting, the case company had been offering its customers a sleeve-cutting service using an automated cutting machine. However, after the cut sleeve ends were manually melted with a hot iron plate, and the time needed for making one sleeve totalled about 40 seconds. The new method cut the time down to ten seconds despite the fact that the machine had been built using wood, plywood and aluminium tubes. When the more advanced version was produced and sold to customers, the cycle time remained the same, as it was mainly the function of the cutting speed allowed by the blade temperature. Thus, it was a surprise how well the mock-up reflected the eventual process implication of the real machine sold to customers.

Regarding the spiralling process, previously, it consisted of three stages: (1) measuring and cutting the spiral, (2) spiralling and (3) packaging. The key change with the new solution was related to the fact that the hose was spiralled from the box without measuring and cutting the spiral first. The manual spiralling process of a two-meter hose with the existing tools took about four and a half minutes and caused material waste. With the new spiralling machine, the process required three activities: (1) attaching the hose assembly in the machine and connecting a few rounds of spiral to the hose, (2) spiralling the hose assembly and (3) cutting the spiral at the right place and detaching the hose assembly from the machine. The new process took 65 seconds, reducing the cycle time to about one-fourth of the original. When the first machine was built and delivered to a customer, the cycle time for a two-meter hose was about 60 seconds. Thus, the mock-up indicated the productivity leap with only minor changes when the real machine was built.

4 Conclusions

The findings suggest that low-fidelity mock-ups can become valuable prototypes for actually examining the core functionalities and mechanisms of value creation of new products (see, e.g., Preece *et al.*, 2002; Schlecht and Young, 2014). In both cases, the early mock-ups were shown to the customers (i.e. companies making hose assemblies) to gather feedback about the ideas. In addition, the mock-ups were used in real production at the customer site to enable testing in the real production environment. This not only enabled customer feedback about functionality and output quality, but it also provided information on production cycle times based on real user experience, hence fulfilling the requirements of customer-experienced value in use.

Regarding customer value assessment, which has attracted increasing amounts of attention in the literature (Macdonald *et al.*, 2011), the mock-ups examined in this paper provided remarkable possibilities for investigating and quantifying products' value potential. Interestingly, the cycle times measured via the mock-ups were almost the same as the eventual final products. Nevertheless, the question regarding how close the cycle time measured with the fully functional mock-up was to the real one is not that relevant. With both machines, the mock-ups showed cycle time reduction to about one-fourth, indicating a major productivity jump that was later confirmed with the real machines. In other words, the most important role played by the mock-up was to show the 'range' regarding the productivity potential of the new ideas, and with the results in both cases, some fluctuation in the real process cycle times no longer made a difference. In the end, the key drivers of the cycle times with the real machines were based on rotating speed and cutting speed. The shift from the mock-up design to the final product design did not impact the speed; rather, this was based on the limitations of the final components that were selected.

Finally, with both machines, thanks to the experiments with the mock-ups, the sales material was prepared at the early stages of the development process, including quantifiable value propositions. Again, this was possible when the cost implications for the customers' operations were taken into consideration in the early stages. The uncertainties related not only to the customer preferences but also the perceived customer value were significantly reduced with the use of the mock-ups. The use of mock-ups to gain customer feedback is aligned well with the fail-fast mentality emphasised in the contemporary start-up scene. However, the use of mock-ups could be more explicitly connected to the assessment of perceived customer value in the early stages of the product development process.

Though the machines in this case study were relatively simple, they were new solutions within the industry, requiring time and iterations to eventually fulfil the process needs. Nevertheless, these products prompted the idea to use mock-ups to gain customer feedback not only regarding the product functionality but also process implications. An interesting topic for further research is to examine the feasibility of the idea in more complex product and service development processes. Furthermore, such experiments can also be used more actively in pushing development work further internally in the company. For both machines, the initial sales material drafts were made as soon as the mock-ups had been 'approved' by the first customer experiments with clear payback tables based on the process implications of the mock-ups. Customer testimonials included in such sales material drafts are a powerful tool to push development work forward internally.

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