USER FEEDBACK ON PROTOTYPES AND
ITS IMPACT ON THE SUCCESS OF FUTURE PRODUCTS

by

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ABSTRACT

A survey was conducted to review the literature that currently exists on the topic of user feedback received from prototypes. Special attention was paid to whether and how this customer interaction impacts the success of final products.

The findings of all reviewed literature were categorized as definitions, human and prototype factors that influence user response, or considerations in implementing user feedback. Although no consensus was reached across sources, compilation and analysis of these works was intended to contribute to the development of prototype-to-product processes.

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TABLE OF CONTENTS

I. Introduction .... page 4

II. Defining Categories of Prototypes .... page 4

III. How to Define Success .... page 6

IV. Factors That Impact User Response

1. High-Fidelity Versus Low-Fidelity .... page 7

2. Aesthetic Appeal .... page 9

3. Prototypes as Filters .... page 10

4. Material, Resolution, And Scope .... page 10

5. Novice Versus Expert .... page 11

6. Attitude, State, And Personality .... page 12

V. The Choice between Involved and More Involved .... page 12

VI. Benefits of Soliciting User Feedback on Prototypes .... page 14

VII. Precautions When Soliciting User Feedback on Prototypes .... page 16

VIII. Learning from Success .... page 18

IX. To Prototype or Not to Prototype .... page 19

References .... page 21

I. INTRODUCTION

Prototyping is widely used in industry to elicit feedback intended to improve the chances of success of the ultimate product. Yet, in spite of its widespread use, insufficient attention has been paid to prototyping itself. "Current prototyping research can best be describes as an ongoing attempt to come up with what to do with prototypes without understand what they actually are" [Lim, 2008]. What factors provide the optimal results, i.e. the information necessary for product improvement in the design and development stage? A survey of recent literature offers insight into some of the factors to be considered, with some both expected and unexpected observations and conclusions. The literature has focused on the prototype itself and the user. The following overview summarizes some of the studies and their findings. An objective presentation of what is known about several crucial elements in prototype testing and user feedback is likely to increase the awareness and success ratio of those involved in prototype design and testing.

II. DEFINING CATEGORIES OF PROTOTYPES

Different studies and experiments define prototypes in different ways, often depending on their purpose. There are several models that divide prototypes into categories, three of which are discussed here. Houde considers three aspects of the design of an interactive prototype to be important: role, look and feel, and implementation. Role refers to "the function that an artifact serves in user's life," look and feel refers to "the concrete sensory experience of using an artifact," and implementation refers to "the techniques and components through which an artifact performs its function" [Houde, 1997]. A prototype can either belong strictly to one of these categories, or represent a combination of two or all three of them.

Yang uses a set of four categories presented by Ullman in one of her studies: proof-of-concept, proof-of-product, proof-of-process, and proof-of-production. These four stages of a prototype frequently occur in sequence, each one building upon the result or conclusion of the last:

> **To better understand what approach to take in designing a product, a proof-of concept prototype is used in the initial stages of design. Later, a proof-of-product prototype clarifies a design's physical embodiment and production feasibility. A proof-of-process prototype shows that the production methods and materials can successfully result in the desired product. Finally, a proof-of-production prototype demonstrates that the complete manufacturing process is effective.** [Yang, 2005]

Floyd separates prototypes into only two categories: exploration and experimentation. While at first glance, these two seem to be very similar and almost indistinguishable, the definitions they are assigned are quite distinct and based upon "the goals one wishes to achieve" [Floyd]. Prototyping for exploration usually occurs in the early stages of design. Since "developers normally have too little knowledge about the application field, while the users have no clear idea of what the [product] might do for them… a practical demonstration of possible system functions serves as a catalyst to elicit good ideas and to promote a creative co-operation between all parties involved" [Floyd]. Exploratory prototyping generally presents several alternatives to a customer rather than one a particular solution. Prototyping for experimentation takes place once a proposed solution to a customer's problem exists. "There may be various areas of concern, including… the feasibility of a proposed solution with the available resources" [Floyd]. This phase of prototyping and feedback is generally carried out among the design team. Exploratory prototyping in collaboration with a user establishes what features the future product should offer. Then experimental prototyping in collaboration with other designers or engineers refines the products specifications.

An interesting point to mention here is that a prototype can and should be exposed to and discussed with different audiences depending what type of feedback the designer is seeking. If the purpose is to "evaluate their options… by critiquing prototypes of alternate design directions" a designer and his/her prototype should interact with a design team [Houde, 1997]. If a designer is interested in "feedback on evolving designs" he/she should implement user testing [Houde, 1997]. If the purpose is to give an indication or progress and direction, designers "show prototypes to their supporting organizations (such as project managers, business clients, or professors)" [Houde, 1997]. Equally important as selecting which audience to present a prototype to, a designer should prepare his/her audience in order to receive the most appropriate user response. "Be clear about what design questions are being explored with a given prototype—and what are not. Communicating the specific purposes of a prototype to its audience is a critical aspect of its use" [Houde, 1997].

III. HOW TO DEFINE SUCCESS

To determine the impact that user feedback on a prototype has on the success of the corresponding final product, one must first determine what definition and standard of success is being used. This definition is flexible and its ultimate determination can depend on several factors. Is achieving happiness on behalf of the designer considered success? Is achieving happiness on behalf of the customer considered success? Is the completion of a final product that does what it was originally intended to do considered success? The answers to such questions vary with each individual project. Arguably, all answers trickle down to one key factor—the purpose of designing the product.

One quantitative way to measure success, used primarily in educational product design and development courses, is grading. In one of Yang's studies, she describes that students in one such course were evaluated and assessed on "device performance… the design process used to achieve the design and the design itself… the overall concept, the details of the design, the fabrication of the device… the planning involved in the device… [and] the performance in competition" [Yang, 2005]. Exactly how these graded aspects translate to real-world design for industry is difficult to determine. Some however, for example device performance, one can reasonably assume play a part in any definition of success.

IV. FACTORS THAT IMPACT USER RESPONSE

1. HIGH-FIDELITY VERSUS LOW-FIDELITY

Across studies and literature, there are inconsistencies in the definitions of high- and low-fidelity prototypes as well as their suggested uses. For Rudd, a low-fidelity prototype provides a user a visual for what the product is supposed to do, but "may not respond to user input" [Rudd, 1996]. Rather than customers experimenting with the prototype themselves, it is demonstrated for them by a designer or other skilled operator.

A high-fidelity prototype, in contrast, responds to user input in the same manner than the final product would. "The user can operate the prototype as if it were the final product" [Rudd, 1996]. There is no third person acting as the liaison between prototype and user. "Because they are often demonstrated to, rather than exercised by, the user," Rudd asserts that low-fidelity prototypes may not be useful in soliciting customer feedback [Rudd, 1996].

Sauer's definition of fidelity takes into account how a prototype testing situation may differ from the actual future product usage situation. The level of a prototype's fidelity is directly proportional to its similarity to the ultimate product's actual intended usage. Sauer rates fidelity in four categories:

> **First, the participant in a usability test may be different from the future user (e.g. shorthaired male engineers are used to test a new hair dryer). Second, a prototype is available that is not yet fully operational (e.g. hair dryer has only a power setting but the temperature controls have not been implemented yet). Third, the task given may not be representative or sufficiently complex (e.g. appliance is used to dry a wig rather than the user's own hair). Fourth, the testing environment may differ physically from the future usage context (e.g. hair drying takes place in a lab rather than in the user's home).** [Sauer, 2010]

Houde defines fidelity like Sauer does as the "closeness to the eventual design," but also introduces a new term, "resolution" meaning the "amount of detail" a prototype exhibits [Houde, 1997]. Houde emphasizes, however, that the degree of resolution of a prototype is not directly related to what stage of development it is in, nor how finalized the design is.

“Reduced fidelity prototypes [are often used]… because they are cheaper, faster to build and more utilizable in earlier stages in the product development cycle than fully operational prototypes. However, there are concerns that this may be achieved at the cost of a less accurate picture of actual user behaviour” [Sauer, 2010]. Some studies, on the other hand, conclude that “reduced fidelity prototypes provide equivalent [usability and effectiveness] to fully operational products” [Sauer, 2010]. Even if the user feedback from a set of low- and high-fidelity prototypes is similar, other factors can influence their development into two final products that vary greatly in success.

2. AESTHETIC APPEAL

The aesthetic appeal of a prototype is not directly related to its fidelity, its resolution, or what stage of development it is in. A well-done drawing of a product, for example, can be very aesthetically pleasing, even though it only conveys one perspective of information to the customer. An almost fully functional prototype can convey most information about a product to a customer, yet be aesthetically unappealing if fabricated without care and attention. The results from one of Sauer’s studies showed a “clear preference of users for the more aesthetic appliance because of higher attractiveness ratings and higher perceived usability… [This, however, was] not paralleled by better objective usability of that appliance” [Sauer, 2009]. Sauer concluded that the simple beauty of a design could cause a user’s perception of an item’s usability to increase even when its actual usability did not. Consequently care and attention to aesthetic detail should be carefully incorporated into prototype design.

3. PROTOTYPES AS FILTERS

What elements of a product a designer decides to address and not address in a prototype are fundamental in determining the feedback that customers will provide. Within the design space, an engineer can focus on prototyping one or more particular aspects rather than the entire product. Lim explains what he coins the *fundamental prototyping principle*: "What matters is not identifying or satisfying requirements using prototypes but finding the manifestation that in its simplest form, filters the qualities in which designers are interested, without distorting the understand of the whole" [Lim, 2008]. By screening out other aspects of a design, a designer can filter the user feedback and narrow it to extract more precise knowledge about the elements selected as the focus of a prototype.

4. MATERIAL, RESOLUTION, AND SCOPE

Lim introduces the concept of prototype anatomy, and defines it to include three considerations: material, resolution and scope. Two of these factors, resolution and scope, we have met already in other studies and research. Lim considers the resolution of a prototype's details to correspond to the concept of fidelity, which was discussed in length above. Scope can be defined as "what the prototype covers (which can be understood as a level of inclusiveness—that is, whether the prototype covers only one aspect of the design idea or several aspects of the design idea)" [Lim, 2008]. Scope is related to the aforementioned idea of filtering a prototype to receive feedback on specific design parts. Material is the only completely new factor to be introduced as impacting user feedback in prototypes. The selection of paper, cardboard, foamware, or any other material is obviously a decision unique to each design and prototype. One characteristic that Schrage argues all prototyping materials should have in common, however, is lack of color. He quotes GVO's Michael Barry that "The minute you lay in color… you finalize it… You send a cue that it's finished" [Schrage, 1999]. Prototyping by its very nature is not intended to be the final product.

5. NOVICE VERSUS EXPERT

The way in which a user interacts with a prototype and the type of feedback that emerges can vary depending on user competence. Sauer argues that "for most products, [this is] the user attribute of the highest importance" [Sauer, 2010]. The competence level of exposed users is shaped by their prior knowledge, skills and abilities. In most studies, user competence, if taken into consideration, is divided into two categories: novice and expert. How this distinction is made and where the dividing line is drawn is unclear, but "whether a user is to be considered a novice or an expert… represents an important dichotomous distinction in user selection" [Sauer, 2010]. While some research shows no difference between the feedback received from novices and that received from experts, other studies have found user competence to impact the nature of responses. Sauer has found that "the consultation of experts may be advantageous because they provide a more complete listing of possible usability problems than novices" [Sauer, 2010]. Novices, on the other hand, are quick to identify the most obvious and severe problems with a prototype. One might conclude that an adequate representation from both groups could build on these strengths and compensate for weaknesses of a homogenous group.

6. ATTITUDE, STATE, AND PERSONALITY

A user's attitude, state and personality are all factors that can subconsciously impact the way in which a user responds to a prototype. Although in some cases the influence is more obvious than in others, these factors can never be completely controlled or removed. Sauer provides us with an example of how each factor might come into play:

> **[1] *User attitude*—if a product is to be designed for environmentally friendly use, environmentally concerned users may benefit more from enhanced system feedback on energy consumption as they are keen to reduce resource usage**
>
> **[2] *User state*—the effectiveness with which an alarm clock is operated is influenced by the state of fatigue of the user, that is, the typical situation of a not yet fully awake user trying to operate an alarm clock in the dark needs to be modeled when testing different design options**
>
> **[3] *User personality*—users scoring high on the personality factor conscientiousness may identify more usability problems because they approach the testing procedure more thoroughly.** [Sauer, 2010]

In testing situations for which attitude, state, or personality seem relevant to the feedback on a prototype, it might be worth monitoring these factors and taking them into consideration when implementing responses for the final product.

V. THE CHOICE BETWEEN INVOLVED AND MORE INVOLVED

Once a product developer has decided to involve users in the design process, there are different degrees of interaction to consider. Schrage divides involvement into two levels: customized choice and co-design. Customization has grown to be more than a tailored solution specific to a users needs. Delivering prototypes that meet a customer's specifications and requirements is no longer enough. User needs are dynamic throughout the design process, changing with every iteration of a prototype. "Customization isn't choosing from a menu; it's the ability to test any recipe" [Schrage, 1999].

One step beyond customized choice, integrating users even further in the design process, is co-design. Rather than being presented with prototypes to generate feedback for, customers invited to co-design are involved in every development decision that a designer makes. Although not always the optimal route, co-design can be beneficial if the users are knowledgeable in the product field themselves or if the product is specifically being designed for a particular customer.

The selection between customized choice and co-design often depends on the designer's and/or customer's purpose and desire. Schrage argues, however, that the decision can also reflect a company's culture:

> **An innovator that believes customers most value customized choice at reasonable cost will manage its prototypes to optimize most-choice/best-price options; customers will select from a broad menu of options to customize their product. Another innovator that believes its customers value the ability to co-design will invite active customer collaboration on the proposed product. Both firms offer genuinely customized products. But ordering a meal is not the same thing as being invited into the kitchen. The value propositions and business models are fundamentally different, and the prototypes themselves reflect fundamentally different design sensibilities even if the ultimate products are quite similar.** [Schrage, 1999]

As implied above, the selection of either customized choice or co-design may or may not have a direct impact on the final product. Consequently the level of user interaction and its relationship to the success of a future product likely varies from case to case.

VI. BENEFITS OF SOLICITING USER FEEDBACK ON PROTOTYPES

People often find it difficult to articulate what they want. This is likely a result of the fact that they do not *know* what they want. Whether a person suffers from indecision, or is simply unaware of what options there are to choose from, knowing what one wants is a state that occurs naturally upon being presented with the perfect solution. Users, as people themselves, undergo the exact same process: they are unable to formulate a vision of what they want in their minds—but they know it when they see it. This is where prototypes can be important. In this context, Schrage discusses the phrase "demand articulation", a term coined by Japanese management scientist Fumio Kodama to mean "the process whereby consumers of innovation discover—rather than know—what new products and services they need" [Schrage, 1999].

Even in the case that end users do know what their requirements are, how these requirements are articulated can be problematic. "Customers may have a difficult time in separating what they want a system to do from how they want the tasks to be performed" [Rudd, 1996]. What versus how a prototype performs is only one discontinuity in the communication between customer and designer. "Engineers generally ask what the product does," says Carnegie Mellon design professor Dan Droz [Schrage, 1999]. "Many industrial designers ask 'What is the product?'" This "looks-like" approach versus "works-like" approach to design is another gap that can be bridged with user-interactive prototyping.

Extending the idea of knowing what you want when you see it, one could conclude that users then "also know it when they create it" [Schrage, 1999]. The fine line between incorporating user feedback and co-designing a product will be discussed in more detail further on, but there is one advantage worth mentioning at this point. "Clients who would be all too quick to toss a development group's hard-won prototype in the garbage are far more reluctant to do so with a prototype that they themselves have helped develop" [Schrage, 1999]. Significant customer involvement in the development of a design can prevent situations from happening in which a client says, "You've given us what we asked for, but now that we've seen it, it's not what we want." The opportunity to avoid such scenarios, which are frustrating for both the designer and the user, should be taken advantage of.

Perhaps one of the most important benefits of exposing a prototype rather than the final product to a user, is that it invites ideas and creativity. Something that gives an impression of being "unfinished" is much more welcoming to criticism, feedback, and suggestions for improvement than a polished piece is. "Roughness encourages questions" [Schrage, 1999]. Simply seeing, feeling, and playing with a prototype can generate new ideas that haven't been previously considered. "Even by accident, new prototyping media can create new interactions between people that in turn create new value… the value of prototypes resides less in the models themselves than in the interactions—the conversations, arguments, consultations, collaborations—they invite" [Schrage, 1999]. Schrage highlights the role of a prototype as a tool to explore possibilities and potential. The symbiotic relationship that forms between a prototype and a user, each one feeding off of the other, is invaluable is the product development process:

> **Prototypes and simulations can do more than answer questions; they can also raise questions that had never been asked before. Playing**

with a prototype can stimulate innovative questions as surely as it can suggest innovative answers. The best and most powerful models are provocative, and the unexpected questions that a model raises are sometimes far more important that the explicit questions it was designed to answer. [Schrage 1999]

VII. PRECAUTIONS WHEN SOLICITING USER FEEDBACK ON PROTOTYPES

As advantageous as exposing future users to a prototype can be, there are also significant precautions that product designers should bear in mind when doing so. First, although a user interaction with a prototype can encourage new ideas as aforementioned, it also runs the risk of exposed users becoming wedded to the first idea or iteration. Once a concept is expressed as a physical object, it can create tunnel vision among customers who see it—they become "fixated to one idea" [Yang]. Not only does this hinder creativity that could possibly lead to a superior future product, but it can also cause misunderstandings between user and designer. How a prototype looks and works can easily become engrained into a customer's memory. If, then, the final product does not look or work as the customer expected based on his/her knowledge and interaction with the prototype, the ultimate success can be negatively impacted. This adverse reaction to a new and unfamiliar solution can arise even if the final product is "superior" and the user likes it more, simply due to the exposed user's feeling of commitment to the prototype. In order to avoid these situations, a designer must make it "clear to the users that there is no commitment to reproducing the prototype in the target system, but rather to incorporating the good ideas derived from the exploration in its definitive specification" [Floyd]. Even if this understanding exists, Floyd cautions that if "essential changes of some features of the prototype [are] made during implementation of the final product without the explicit consent of the user, serious problems regarding its acceptance must be expected" [Floyd]. Presumably such restrictive precautions would only be necessary for cases in which the product was co-designed or specifically designed for a particular user.

When a particular solution to a problem is observed, that solution may become a standard that stymies further creativity. This is the exact opposite result from that which a prototype is intended to stimulate. However, one can readily understand why *a* solution can seem like *the* solution, when a user interacts with a functioning prototype. This correlates somewhat to the concept "if it's not broken, why fix it?" Schrage comments on the Mark Twain quotation, "'if you've got a hammer, the whole world looks like a nail.' A prototype, like a hammer, can also suggest a complete perspective on the world" [Schrage, 1999]. This phenomenon of narrowing vision can become increasingly prominent the more a prototype resembles a finished product. "By offering a credible model of reality, [a prototype becomes] a mirror of reality" [Schrage, 1999]. Once it is interpreted as "the real thing," a prototype can cease to be perceived as a vehicle for creative change and further innovation.

Another variable that a designer should always be prepared to face when implementing user testing is conflicting feedback. What should an engineer do when users have opposing suggestions? Or if one user loves the same element of a prototype that another user hates? This type of delicate situation requires an approach with caution. A lesson might be learned from the design of GM's Caprice:

> **A focus group strongly objected to the proposed redesign of the Caprice exterior. GM design vice president Charles M. Jordan rejected the focus group's reaction. "We decided to not do anything**

about it," he said. "We believed in the design... All the car guys liked the design." Caprice sales in 1991 were half as expected, and in 1995 the model was discontinued. [Schrage, 1999]

While here the feedback conflicted between the exposed users and the design team, one might be able to draw from this scenario and relate it to user versus user feedback conflict. In any case, GM's experience with the design of the Caprice suggests an advantage to weighing customer feedback more heavily than design team desires.

VIII. LEARNING FROM SUCCESS

There is no guaranteed recipe for maximizing the impact of user feedback from prototypes. No combination of the discussed factors, or careful balance of ambition and caution will consistently reap the most benefits of implementing user feedback for every product. One particular scenario, however, stands out and appears to have struck perfection in reality.

Microsoft... had sent out roughly 400,000 beta-version copies of the system [Win95] to thousands of beta sites worldwide... "beta sites" are organizations and individuals willing to help track bugs and flaws—and suggest product enhancements—in exchange for receiving the software in advance, influencing its development, and getting help with any problems that might arise. Beta sites are typically lead customers. As a rule, betas tend to be sophisticated corporate connoisseurs of software. The value of their time and technical contributions far exceeds that of naïve users... A conservative estimate of the cost in time, training, upgrading, monitoring, and maintenance of testing a single Win5 beta for several months is over $3,000... Microsoft's global community of betas effectively subsidized the final stage of Win95 development to the tune of, conservatively, $900 million. When one adds the value of customer involvement during earlier prototype phases and of beta sites' suggestions, Microsoft probably reaped well over $1 billion worth of value from its customers and developers before it sold a single copy of Win95...

Without question, this subsidy enabled Microsoft to produce a far better product for far less money in far less time than it otherwise could have. [Schrage, 1999]

Microsoft's situation may appear to have been a unique and lucky one, but the lesson that should be extracted from this story is to seek out such opportunities in one's own realm of product design and development.

IX. TO PROTOTYPE OR NOT TO PROTOTYPE

To prototype or not to prototype – this really is no longer the question. Product developers have already widely accepted the answer to be "yes." Studies have shown that it is beneficial to include prototyping as a step in the product design path. Schrage notes a study where "prototyping produced a [40 percent more efficient] product of equivalent performance with [45 percent] less effort. The productivity of the prototype-driven design, measured in user satisfaction per man-hour, was superior" to the design that did not employ prototyping.

The question that we are really looking to answer, however, is what impact user testing and feedback on a prototype have on the outcome of the corresponding final product. Schrage argues that "there seems to be little doubt that collaborative prototyping with customers and suppliers can yield competitive benefits." Other experts share this opinion:

Spec-driven cultures draw heavily from market-research data before concepts are moved in the prototyping cycle. In prototyping cultures, prototypes are typically used to elicit market feedback well before final versions of the product are tested. David Kelly of IDEO argues

that innovation cultures need to "move from spec-driven prototypes to prototype-driven specs" to become more effective. [Schrage, 1999]

Despite the general sentiment in favor of user feedback on prototypes, there has yet to be published experimentation to validate many of the claims made on its behalf. An appropriate study to execute might be to compare the "success" of the final products of two identical prototypes, one of which was developed using feedback from user testing, and one of which was developed without user testing. Another adaptation of the above study could involve comparing the "success" of two final products that originated from the same need and design concept, one of which was co-developed with users, and one of which was developed solely by engineers.

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