PROTOTYPING: FACING UNCERTAINTY THROUGH SMALL WINS

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ABSTRACT

Design is a learning process in which new knowledge is constructed and used to shape the environment in ways that did not previously exist. Because design is about creating that which does not yet exist, when individuals engage in the design process, they face uncertainty about final outcomes. Drawing on psychological research, this paper presents a grounded theory to explain how the practice of low-fidelity prototyping allows practitioners to remain committed to the design process despite uncertainty about final outcomes. When enacting the low-fidelity prototyping practice, practitioners break larger tasks into modest size tasks. Modest size tasks allow practitioners to take frequent action. By taking frequent action on manageable tasks, practitioners experience small wins by observing their impact and attributing success to their actions. Through a series of small wins, they attribute the positive effects to self-action and reduce anxiety of failure and increase a sense of perceived control. This sense of perceived control allows them to remain committed to the design process despite the uncertainty of the outcomes.

Keywords: Design Work, Low-fidelity, Prototyping, Human Behavior

1   INTRODUCTION

Design is a learning process in which new knowledge is constructed and used to shape the environment in ways that did not previously exist. When individuals engage in the design activity, they experience uncertainty, or a state of being in doubt, because the final outcomes are not yet known. For some, this uncertainty is overwhelming and they become paralyzed by infinite possibilities to pursue and unable to act. For others, they face the uncertainty and realize unique solutions not yet identified by others. What differentiates between individuals who are overwhelmed by uncertainty versus individuals who tackle the uncertainty? Individuals who tackle the uncertainty rely on design processes that allow them to control the uncertainty by constructing new knowledge. As they follow their design processes, new knowledge is created, and uncertainty is reduced.
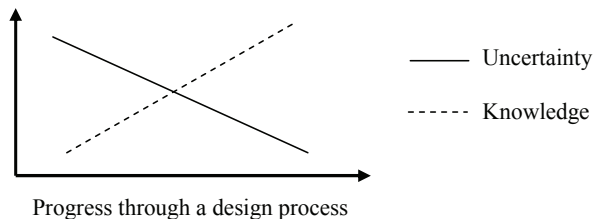

Progress through a design process

Figure 1. Uncertainty reduces as individuals progress towards a final solution.

Psychological research suggests that peoples' experience of uncertainty depends on their perception of their ability to control the uncertain conditions. When individuals are in uncertain conditions which promote high control, they experience more intrinsic motivation, greater interest, less pressure and tension, more creativity, more cognitive flexibility, better conceptual learning, a more positive emotional tone, higher self-esteem, more trust, and greater persistence [1] [2]. In these environments, they are more likely to be proactive and take action in the face of setback [2]. In contrast, when

people function in uncertain environments that promote low control, they are less likely to experience these positive outcomes and take fewer actions in the face of setbacks [3].

Drawing on behavioral research and empirical data, this paper presents a grounded theory to explain how enacting a specific design practice, low-fidelity prototyping, allow individuals to experience high control and remain committed to realizing a final outcome rather than be overwhelmed by the uncertainty inherent within the process.

Low-fidelity prototyping is the practice of quickly making a low-fidelity physical or virtual manifestations of concepts to test their viability and communicate ideas to other. This paper proposes a framework for how design practitioners use low-fidelity prototyping as a way of managing uncertainty and remain committed to the design process. When individuals practice low-fidelity prototyping, individual take small, visible actions. These small, visible actions wins result in feelings of perceived control. This control results in continued commitment to the design process despite uncertainty about final outcomes.

2 METHODS

The framework I present in this paper is grounded in an eighteen-month ethnographic study of 35 member team in a large software firm, "Big Tech," and in pertinent behavioral science. Big Tech's product development efforts are multi-national and the firm's products and services are sold throughout the developed world. This study focused on the "Green Team," a team charged with working with a diverse set of teams throughout the company to apply a design process which emphasized the use of focused, low-fidelity prototyping as a way of quickly realizing ideas.

The Green Team initially formed in September 2004 due to senior management concerns about product usability and development time. For the first three months, I observed the members of the corporate strategy team researching and preparing for the development of the team. A design consultancy firm specializing in design processes taught a six-member team through active hands-on coaching with the expected outcome of innovation, a process I call participant innovation. The hands on nature of participant innovation stood in contrast to an innovation consulting engagement typically delivered by traditional management consulting firms in which consultants either present power point decks on process or manage work independently of the client so the client is less actively involved in learning new skills.

After this initial three-month trial and training period, the board officially approved the creation of the team to use the design process to positively impact the company's revenue generating products, processes and services. I spent the remaining 15 months of my study observing the Team develop its 35 member team, solicit projects upon which to apply their design process, and coach internal teams through their prototyping based design process to drive innovation throughout Big Tech.

2.1 Research Design

As is typical with grounded theory, I initiated this study with open data collection, rather than specific hypotheses about what was to be found [4]. After initial data collection, I searched for emerging patterns and followed the most interesting and promising patterns [5]. I collected data from the time the team was introduced to the design process and observed them applying the process to over 15 products and services. Primarily, case studies are conducted retroactively, relying on reflection. The advantage to this research approach is the ability to collect real-time longitudinal data; the disadvantage is that biased is introduced through participant observation [6].

I observed the Team one day a week over the 18-month period (September 2004-March 2006), writing detailed transcripts of conversations I heard and interactions I observed between the Team's members, its clients, partners, and stakeholders. A typical visit entailed informal and formal conversations with team members as well as observation of formal and informal meetings throughout the day. I watched the team work on projects at different stages of development and asked questions about how and why they were doing various work practices. Throughout the observation, I cultivated relationships with all team members – discussing the development of the team and adoption of the design process. I was welcomed to observe all meetings throughout the 18-month period except for three meetings pertaining to employee compensation; moreover, the company provided me with space in the Team office area, allowing me to observe the naturally occurring team interactions and day-to-day activity. The office area had an open office plan making it easy to observe most interactions between members, partners, stakeholders, and clients and the outcomes that resulted from their work.

I began this study with a broad research question: "What is the psychological experience of practicing design?" I chose qualitative methods to explore this question because I did not want to unnecessarily constrain my emergent framework by precisely identifying and operationalizing variables before data collection began. Following guidelines for inductive research [7], I wrote descriptive accounts of my observations until major themes emerged such as control and uncertainty. Following guidelines for developing well-grounded theory [7], I clustered these phenomena into larger conceptual categories. Simultaneously, I read pertinent literature to understand existing theory and to uncover related phenomena. Moving between inductive and deductive thinking, I began to develop my emerging conceptual framework, linking the work practices to the observed phenomena. This iterative process allowed me to develop initial inferences about the psychological experience of enacting design work practices. I continued to validate my theory against the data by reviewing all relevant data and compiling evidence and evaluating the strength of my evidence to inform whether I should modify or abandon my inferences based on insubstantial evidence. Following Strauss and Corbin's [7] guidelines, I flip-flopped between data and theory to construct an evidence-supported theory of how people experience control in the face of uncertainty through the enactment of the low-fidelity prototyping practice.

2.2 Data Sources

Throughout the study, I used qualitative methods to gather data from multiple sources to inform my inferences about the practitioner's experience of prototyping. By gathering data from multiple sources, I had multiple measures of the same phenomenon, avoiding the potential problem of construct validity within a single case [8]. The framework was strongly supported by the convergence of multiple, independent observations. These sources can be divided into six categories: observed meetings, observed strategic off-sites, observed client service engagements, semi structured interviews, team generated materials, externally generated materials. When my data collection ended, I had accumulated 360 research hours observing the day-to-day activity of the team, 64 hours observing strategic off sites, 20 hours observing client service engagements, and 40 hours of in-depth interviews.

3   DESIGN PRACTICE: LOW-FIDELITY PROTOTYPING

Design researchers have identified prototyping, or making physical or virtual representations of ideas, as a critical activity in a design process [9]. Prototyping allows individuals to explore and evaluate possible ideas with colleagues, clients, and users and thereby create new knowledge about the most appropriate solution for the identified problem at hand [10] [11]. Researchers distinguish between low- and high-fidelity prototyping according to how easily the prototype can be distinguished from the final product [27]. Low-fidelity prototyping, related to the sketching technique, emphasizes exploring and evaluating possible ideas quickly by creating physical and virtual representations of ideas. Researchers describe low-fidelity prototyping as a low cost tool for thinking [24] and design reasoning at the early stage of the design [25] [27] where as high-fidelity prototyping is a more costly tool used in the later stage of design to test the integration of parts and reason about the final decisions of the design. With low-fidelity prototyping, individuals construct new knowledge quickly by showing prototypes to users rather than spending time in isolation of users building elaborate prototypes that may or may not suit the users' needs or work in the way in which they were intended [26]. In this way, individuals quickly gain insights about the form and function of their ideas through hands on experiential learning. These insights are used to inform the next steps of their design process. Due to this research, much is understood about the role of low-fidelity prototyping in helping individuals and teams make decisions about future directions throughout the development process. However, few studies consider the individual's psychological experience of rapidly realizing insights through low-fidelity prototyping.

Consistent with the research on prototyping [25] [26], Green Team members described the usefulness of low-fidelity prototyping in getting feedback from users and using this information to inform the next steps in their process. One team member described low-fidelity prototyping as the source of innovation in their design process because it drove the fast and detached iteration of ideas based on informed empathy with users. Most of the Green Team's low-fidelity prototyping activity occurred quickly and embodied rough approximations of the form and function of an idea. Even though many
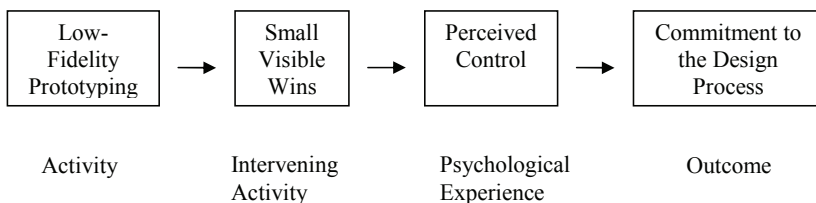
of the products and services they were designing were highly technical, they initial relied on low-fidelity prototypes made out of simple materials such as paper and Microsoft Office software to quickly communicate their ideas and illicit feedback from users. For example, when designing the user interface for a group software program, members of the Green Team, drew ideas on pieces of paper and showed the papers to potential users to get their quick feedback. Rather than spending time coding and designing the interfaces with technically sophisticated software, the team members relied on pen and paper to get feedback. When talking with the potential users, they were able to modify the designs in real time and get feedback on the modified designs. After two hours of talking with users about the low fidelity prototypes she presented, Karen, the Green Team lead on this project, reported having a better sense of the prototypes she should build next. She also reported a sense of relief that given how much she was planning to revise the ideas presented, she was glad she only spent a few hours developing these low-fidelity prototypes as opposed to spending several days creating high-fidelity prototypes. She was less upset that her ideas were not considered perfect because she had invested a limited amount of time building them. As it was with many projects, as the project progressed, prototypes became increasingly high-fidelity, resembling the final product in form and function, however she still aimed to develop them in such a way that they could easily be modified based on user feedback. Her confidence in the details of the designs paralleled the fidelity of the prototypes.

The Green Team's handbook outlined specific guidelines for low-fidelity prototyping: "Do them fast. Create many iterations. Test many different ideas. Provide only essential details. Reduce emotional detachment. Allow quicker iterations." They taught their colleagues within Big Tech, that everyone was capable of prototyping. Because they believed that low-fidelity prototyping could be completed by anyone and in any medium, the team frequently asked clients and users to prototype solutions as a way to communicate their ideas. In the example described above, Karen, the Green Team member showing the paper prototypes to potential users, offered pen and paper during the feedback session so that users could also build their own designs during the feedback session. Programming experience was not necessary – simply ideas to communicate high level ideas about a future design.

In this section, I described the prototyping practice and specifically how the Green Team conceived of low-fidelity prototyping as a practice for quickly realizing ideas and getting feedback from others to inform the next iteration of prototypes. In the next section, I propose a framework for how low-fidelity prototyping also serves to commit practitioners to the design process in the face of uncertainty. I use the longitudinal data collected when observing the Green Team to develop the conceptual framework.

4   FRAMEWORK

Drawing on psychological research, I present a grounded theory to explain how the practice of low-fidelity prototyping allows practitioners to remain committed to the design process despite uncertainty about final outcomes. I propose that when enacting the prototyping practice, practitioners break the larger tasks of the project at hand into modest size tasks. These modest size tasks allow practitioners to take frequent action. By taking frequent action on manageable tasks, practitioners experience small wins when they observe their impact and attribute success to their actions. Through a series of small wins, they attribute the positive effects to self-action and reduce anxiety of failure and increase a sense of perceived control. This control gives them increased confidence to take action in the face of uncertain outcomes and they commit to the design process. See Figure 2.

Low-Fidelity Prototyping		Small Visible Wins		Perceived Control		Commitment to the Design Process
Activity		Intervening Activity		Psychological Experience		Outcome

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Figure 2. Framework for Low-Fidelity Prototyping as a Practice for Facing Uncertainty

The mechanism described above is informed by psychologists', Weick's theory of small wins [13] and Bandura's theory of self efficacy [14]. According to Weick's theory, individuals are more likely to take action on a series of modest size tasks that produce small visible wins than on a large task that exceeds bounded rationality and induces dysfunctional arousal. By breaking a large problem into smaller tasks, individuals perceive existing skills as sufficient to deal with the demands of the small pieces. Rewards for each success are considerable, yet the cost of failure is perceived as small [13]. According to Bandura's theory, individuals perceive control by being persuaded of their ability and are more likely to put forth greater effort and commitment to a given task than they are to self-doubt[14]. Individuals are prone to adopt beliefs and practices that provide an increased sense of control [12].

When prototyping, Green Team members were persuaded of their ability to induce change because they broke large ambiguous problems into a series of discrete doable tasks. Rather than being overwhelmed by a broad and ambiguous assignment such as improving the work experience for administrators, the Team used the prototyping practice to take small steps towards tackling the assignment. They began by observing five administrators and co-creating low-fidelity prototypes to understand their basic needs - a doable step along the path to developing a solution. By gathering information quickly, Team members reported greater certainty about the problem and increased perception of control. Consistent with Bandura's theory of self-efficacy, when an individual's understanding of the context increases, so does his expectation about his ability to accomplish the task, thereby increasing his perceived sense of control [14]. After developing an initial understanding through simple low-fidelity prototypes, the team regrouped to discuss their accomplishments and outstanding questions and returned to the field to gather more in-depth data from a larger group of administrators. In this way, the team initialized a seemingly large task of improving administrators' work experience with a sequence of discrete observations that persuaded them of their ability to make progress rather than being overwhelmed by the breadth and ambiguity of the original task. Through the low-fidelity prototyping practice, Team members were able to understand and believe they could accomplish broad ambiguous assignments by breaking them down in to discrete tasks, promoting goal-directed behavior.

Modest size tasks promoted frequent action increasing the perception that the Team members were inducing change, key to the design process. For example, the low-fidelity prototyping practice required Team members to make physical or virtual manifestations of ideas generated. Once prototypes were created, Green Team members returned to users to validate their ideas. When enacting the low-fidelity prototyping practice, Team members were always tackling modest size tasks to progress their work.

The low-fidelity prototyping practice encouraged frequent action through modest size tasks. The Green Team prototyping mantra was "build to learn" as opposed to "discuss to learn." This attitude of action prevented Green Team members from ruminating about not getting the solution "right" because they were distracted by the task of building rather than contemplating the effectiveness of their idea. In a conference room, members of a Green Team discussed a future direction for a way to communicate a new service offering to Big Tech. At first, they didn't know which direction to pursue. After ten minutes of discussion and contemplating 20 difference ideas, the group began hypothesizing which idea would be most effective. One member interrupted the discussion and challenged his colleagues to build low-fidelity prototypes and test their hypotheses by showing the prototypes to their workmates who were eating lunch in the cafeteria downstairs. The team broke into smaller groups and began building low-fidelity prototypes of their new ideas. After twenty minutes of prototyping, the small groups were testing their ideas in the cafeteria. They reported back to the group and began working on a new set of prototypes informed by their discussions in the cafeteria. They reported feeling like they were making rapid progress on a project and were more engaged when testing their ideas rather than when they sat isolated as a group talking about the ideas. Research suggests that when an individual ruminates, mulling his decisions over and over trying to analyze what will work, rather than acts, he may experience feelings of helplessness and lack of control. Alternatively, when an individual acts with the belief that he can effectively induce positive change, he will experience feelings of hope and control [2].

By taking regular actions on small manageable tasks, Green Team members were more likely to experience small wins, accomplishments they could attribute to their own actions. When prototyping,

team members built rough physical artifacts to represent their ideas and by doing so, they were able to immediately realize the viability of their ideas. In a meeting to design an online community for engineers to exchange ideas, a Team member described her idea of making a website that allowed engineers to realize the overlapping projects on which they had worked. As she described her idea, she drew the layout of the web page in her notebook. Upon seeing this low-fidelity prototype, her co-worker suggested they ask the developer to mock up a digital, interactive version. By creating a low-fidelity prototype, she accelerated the project's development. Both Team members envisioned the idea existing in the future once they created the initial physical artifact. This modest size task of making a quick sketch of an idea, rather than developing the entire idea a high fidelity prototype online, produced visible results leading to a sense of perceived control. The Team member later revealed that she was working on making low fidelity prototypes of her ideas more frequently so as to push her ideas more quickly along. Consistent with Weick's theory of small wins [13], regular action increased the likelihood that the Team members would experience small wins.

By taking frequent action on small manageable tasks, Green Team members observed their impact and attributed success to their actions. For example, when giving feedback on prototypes, users recognized their ability to impact other's lives, validating their ability to act. Research suggests that individuals prefer achievements that are validated, recognized, and valued by others to solitary achievements [15]. Users consistently offered constructive positive feedback rather than negative feedback because they acknowledged the Team's efforts to improve their situation. In this way, the team's confidence in their ability to act was sustained. In an empirical study, given a similar level of performance, subjects who received constructive criticism maintained or increased a perception of control whereas individuals who received disparaging criticism lowered their perceived sense of control. Individuals who received constructive criticism set higher goals for themselves in subsequent task [16]. In this way, the prototyping practice allowed Team members to observe their impact and attribute success to their actions.

The series of small wins also allowed Green Team members to more easily dismiss failures. According to Weick's theory of small wins, when a larger problem is broken down into a series of small wins, rewards for each success are considerable, yet the cost of failure is perceived as small. [13]. The more action an individual takes, the more likely he will experience success. The low-fidelity prototyping practice guided small repetitive actions, leading participants to experience small successes more readily and dismiss failures easily. Through low-fidelity prototyping, practitioners aimed to create 10 prototypes for every idea, reducing the importance of any one prototype and taking small successful steps towards a final goal. Participants reported feeling they were making progress towards a solution with each prototype created, regardless of quality. By accomplishing a task that was initially measured by quantity rather than quality, they gained confidence in their ability to achieve an outcome. When presenting his prototypes, a team member described how he made progress over the weekend by creating 20 prototypes even though he didn't suspect that any of the prototypes would lead to viable solutions. According to the Green Team's process handbook, prototyping "reduces failure in the development process by making mistakes early." The pressure to produce the perfect prototype was reduced by the sheer number that would be produced. By making explicit the connection between their beliefs and their behavior, participants experienced an increase sense of control through prototyping.

Low-fidelity prototyping also served to increase an individual's perception of control by encouraging team members to tackle difficult problems through small wins, thereby reducing anxiety about the unknown. If problems are perceived as too massive, individuals are less likely to take innovative action because bounded rationality is exceeded and dysfunctional levels of arousal are induced [13] . By reformulating the problem into a series of concrete, distinct outcomes of moderate importance, individuals are more likely to take action because they clearly perceive their action impacting the outcome. The Team members believed that they could effectively induce positive change with each prototype they created. A Team member described prototyping as a "pillar" of the team's process, leading to the team's rapid progress in the development of an online tool. "We did in a mini-cycle that usually, you know, takes years for [Big Tech]." Low-fidelity prototyping was a critical tool for the team's success because it reduced anxiety about the unknown and gave the team and others a sense that they were making progress at a faster rate than the typical Big Tech development process.

Low-fidelity prototyping normalized failure. In a weekly meeting, a team member announced, "If you aren't failing, you aren't doing [the design process]." According to the Green Team's process

handbook, prototyping "reduces failure in the development process by making mistakes early." The pressure to produce the perfect prototype is reduced by the sheer number that will be produced. Also, when breaking the problem down into smaller pieces, the participant's existing skills are perceived as sufficient to deal with the modest demands of the small piece of the problem [13]. By making explicit the connection between their beliefs and their behavior, participants experienced an increase sense of control through prototyping.

Green Team members perceived control in the unpredictable process of innovation. Consistent with Bandura's theory of self-efficacy [14], Green Team members perceived control when they took action, experienced the impact of their action, and attributed the impact of their action to their behavior. Bandura's theory posits that individuals who are persuaded of their ability are more likely to put forth greater effort and commitment to a given task than they are to self-doubt. Further, timing matters. Giving and communicating confidence in the early stages of skill development makes a notable impact on the development of perceived control because individuals can easily credit themselves for the positive effect immediately after the action has been taken [17]. My data suggest that low-fidelity prototyping offered opportunities for participants to take frequent visible action, observe their impact, and immediately attribute success to their actions taken. With greater perceived control, an individual's devotion to the process was initiated and sustained. During a two-hour brainstorm and prototyping session about how the work practices could impact the organization, Team members encouraged each other to express as many ideas as possible and build off one another's ideas, enhancing the perception that as a team, they could achieve multiple outcomes. They wrote their ideas on large pieces of paper tacked to the wall, filling approximately five sheets of paper and created low fidelity prototypes. The team generated so many ideas and decided as a group that they couldn't possibly pursue all of them. After the brainstorm, a team member noted, "Building on each other's ideas produces the best ideas." By generating so many ideas, they were able to consider the breadth and depth of their ability to make a change. Rather than focus on all of the things about the organization that were unchangeable, the work practice focused the participant's attention on all of the actions that they were able to take to change the organization.

The Green Team members initiated and sustained their commitment to the design process because it allowed them to feel in control when facing the uncertainty inherent in design work. They experience a feeling of control in what is otherwise considered a low control situation. Research finds that the perception of one's achievements is paramount to the actual impact [14] [18]. People who feel more in control, experience more intrinsic motivation, exhibit greater interest and persistence, and are more likely to be proactive and take action in the face of setbacks [19].

5   DISCUSSION

This paper offers an explanation for how individuals manage the uncertainty inherent when designing – or creating new knowledge and shaping the environment in new ways. This paper proposes that individuals who engage in low-fidelity prototyping activity, quickly breaking large tasks into modest size tasks. By completing these modest size tasks, practitioners quickly produced visible results that were validated by others leading to a sense of perceived control. As a result, design practitioners experienced increased confidence and motivation to act. With each modest accomplishment, individuals attributed success to their use of the design process – specifically low-fidelity prototyping activity. Enacting the work practices triggers perceived control and commitment to the design process in face of uncertainty.

This lens is unique in the design literature supports a growing stream of research that considers studying the psychological experience of enacting design practices in a work context [21]. When design practices are viewed in an organizational context from the perspective of the practitioners, questions are raised about what the work practices accomplish and additional outcomes are realized – such as commitment to the design process in the face of uncertainty. This study suggests that when enacting the low-fidelity prototyping work practice, user feedback and decision making may not be the sole effectiveness outcome. While low-fideility prototyping may not always be resource efficient, as it may demand costly resources to enact, it may be effective at accomplishing other organizational objectives such as commitment to a design process and giving control in a highly ambiguous situation. Identifying outcomes beyond the traditional effectiveness outcomes is consistent with Sutton and Hargadon's [21] study of brainstorming that found six additional consequences of practicing

brainstorming not previously examined in the experimental literature. In addition to the expected outcome of generating ideas, brainstorming supported the organization's memory of solutions, provided skill variety, supported an attitude of wisdom in and outside the session, created a status auction that maintained a focus on designing products, and impressed clients and generated income. Together, our research contributes to a growing body of work that explores how psychological outcomes are supported at work [22] and also highlights the importance of studying work practices in an organizational context, rather than in a laboratory setting. Finally, it extends research on the prototyping practice beyond a consideration the role of prototyping in eliciting user feedback and in decision making. By extending the research on this design critical activity, low-fidelity prototyping, we can better understand the design process at large.

5.1   Implications for Design Management

My research suggests ways in which individuals can manage design work in uncertain conditions. The design process, like other innovation processes, does not systematically result in marketplace innovation, and when it does, this feedback comes long after the design process has been enacted. Although employees may initially be persuaded to pursue an innovation process because of successful implementation of the process in other organizations and interest in doing "something new," this motivation may not be sustainable. Over time, employees may express uncertainty about the effectiveness of the innovation process if they do not benefit from the day-to-day enactment of their work practices. As first intimated by Hackman and his colleagues' work on job redesign [23], managers may actively design employee work experiences by using behavioral science theory to evoke cognitive, emotional, and behavioral reactions from employees. Applied to this research, managers may adopt and design work practices, such as low-fidelity prototyping, to which employees are committed so they experience intermediate benefits before formal outcomes are realized. Low-fidelity prototyping serves as one example of a work practice that delivers immediate feedback to employees tackling challenges with great uncertainty.

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