User-Centered Innovation: The Interplay between User-Research and Design Innovation
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Abstract:
User information is an important source of user-centered innovation. Through the investigation of 47 user-centered case studies collected from leading design consulting firms, this study aims to establish the relationship between user-research and design innovation, to identify the research characteristics and analytic models critical to each innovation situation, and to discuss where, why, and how the research and analysis should be done so that information is gathered efficiently and is available to the team at the right time in the multi-disciplinary design process. This study suggests new approaches to user-research planning, an alternative mental model of design innovation, and a different way of describing user-research in relation to design innovation. The investigation reveals how user-research should be planned, conducted and tailored for each innovation situation.

0. Overview
User information is an important source of new user-centered product ideas (of what should be designed), which has the potential to redirect a company’s technology capabilities toward an entirely revolutionary innovation.

While a new idea is a thought about something new or unique, and making that idea real is an invention, innovation is an invention that has a socioeconomic effect; innovation changes the way people live. As Alan Williams (1999, p.14) stated ‘While creativity is finding, thinking up, and making new things, innovation is doing and using new things.’

Having recognized the primary importance of understanding how people interact with design, many user-research methods are borrowed from the social sciences: sociology, anthropology, and psychology both to measure how people perceive, understand, remember, and learn in design evaluation process (Preece, 1993), and to understand, credibly explain and perhaps predict human behavior in the pre-design process (Karat, 1997). While understanding current human behaviors is a goal of social science research, design requires the application of such understanding, turning it into innovation. Thus, designers struggle with the methodological implications of conducting user-research to support early phases of design.

This study aims to better understand the relationship between user-research and design innovation and identify where, why, and how the research and analysis should be done so that information is gathered efficiently and is available to the team at the right time in the multi-disciplinary design process.

1. Innovation
Innovation is critical to companies’ long-term growth and renewal. Recognition of the challenge of adopting new technologies into business growth is pervasive. The Industrial Research Institute (IRI) conducts an annual survey of its members. In 1998, ‘making innovation happen’ was rated the top challenge facing technology leaders. The IRI annual survey also indicated that its counterparts in Australia, Brazil, Korea, Europe, and Japan also rated ‘making innovation happen’ at either the top or near the top of the list of the biggest problems facing their technology leaders (Leifer, 2000).

The relationship between business growth and innovation is widely understood by executives today as has been written by a number of consultants and business scholars such as Richard Foster (1986), James M. Utterback (1994), Clayton Christensen (1997), and Richard Leifer (2000). These authors agree that incremental innovation can keep the company competitive with current platforms, but only radical innovation can provide a platform for the long term growth that corporate leaders seek.
Scholars have long distinguished between what Christensen (1997) calls sustaining and disruptive technological innovations, although not always in those words. For example, James March (1991) made a distinction between exploitation of existing technology and exploration of new technology. Leifer (2000) places innovations into two categories: incremental and radical innovation. In addition, he further distinguishes 3 types of radical innovation with respect to alignment with the firm’s established lines of business: 1) Innovation within the technology/market domains of existing business units, 2) Innovation in the ‘white space’ between a firm’s existing businesses, 3) Innovation outside a firm’s current strategic context.

Along the same line in relation to design, John Heskett (1997) proposed four design innovation strategies to be decided by the organization in any given situation. The strategies include: no change, incremental detail change, radical redefinition of basic concepts, and fundamental innovation. According to Heskett, design projects usually begin with business objectives, which fall into one of the four innovative strategies, based on market situation, a company’s willingness to spend and capability to innovate.

2. User-Research and User-Centered Design

Key to innovative design is an understanding of the user. It is an important source of new product ideas (of what should be designed), which has the potential to redirect a company’s technology capabilities toward an entirely revolutionary innovation. In the past, directions for design development were based on marketing research, which limits innovation to its evolutionary form. Because traditional marketing research builds upon opinions of current experience and already present technologies, it is generally unhelpful for design that is not tied to a familiar consumer paradigm. Recently, a few forward thinking companies started deriving their design directions from user-research, which helps uncover unarticulated or emerging user needs. User-research methods in design are borrowed from the social sciences: sociology, anthropology, and psychology both to measure how people perceive, understand, remember, and learn in the design evaluation process (Preece, 1993), and to understand, credibly explain and perhaps predict human behavior in the pre-design process (Karat, 1997).

Within the history of behavioral research in design, user-research has been classified according to information resources, human senses (Rubin & Elder, 1980), and research applicability (Aldersey-Williams, Bound, and Coleman, 1999). Liz Sanders (1992) proposed five categories of product development research methodology: observation, classification, conversation, description, and participation. The five categories are a mix of data gathering techniques, user’s participation, and analytical model. Later, Jay Melican (2000), in his doctoral dissertation at the Institute of Design, proposed dimensions of classification including: analytical approach (conceptual vs. procedural), degree of abstraction (raw vs. abstract), degree of generalization (individual, social/organization, cultural), model of collection (observing, listening/discussing, participating), media of delivery (verbal, visual, tactile), and position of privilege (privileges the subject, privileges the researcher).

Particularly for the classification of the analysis areas, Beyer and Holtzblatt (1998) proposed five analytic models including: flow model, sequence model, artifact model, cultural model, and physical model. The five analytic models are also related to Spradley's (1980) nine major dimensions of social situation, Pena’s (1969) framework for information gathering, Owen’s (1989) Structured Planning, AEIOU framework for observation, which was developed by the Doblin Group, a consulting office in Chicago and Chayutashakij’s (2001) analysis matrix.

One of the objectives of this study is to understand how different types of user-research are conducted and applied in each innovation situation. It is necessary to develop user-research classification in a way that is meaningful to this study. Based on the previous approaches (discussed above) and expert interviews, two sets of semantic scales were developed in order to discuss research characteristics and analytical models critical to each innovation situation. The two semantic scales are further discussed in 4.2 and 4.3.
3. Research Methodology

The understanding of user-research and innovation relations and how user-research can be managed comes primarily from in-depth analyses of 47 user-centered case studies.

During the field research, in-depth interviews were conducted with key individuals in 24 leading design research and consulting firms over a period of 3 months. The interviewees included researchers, project managers, directors and CEOs. The cases include consumer products, communication devices, web interfaces, furniture, hi-tech digital solutions, product platform strategy, and strategic design. The participants in this study were all intensely interested in finding ways to conduct and use user-research effectively. All cases were self-reported as successful and favorites of the interviewees.

Each interview was recorded and later transcribed. The interview data composed the information database from which findings were derived. Recognizing patterns of user-research used in different innovation situations, the ‘Design Innovation Model’ was developed as a framework to better understand the user-research characteristics and analytic models critical to each situation. The characteristics of user-research and the analytic models used in all the innovation situations are then compared on the semantic scales, and discussed regarding where, why, and how the research and analysis should be done so that information is gathered efficiently and is available to the team at the right time in the multi-disciplinary design process.

4. Results and Discussion

The relation of user-research and innovation is discussed in 3 aspects: user-research roles, user-research characteristics, and research analytic models critical for each innovation situation.

4.1 The Role of User-Research in each Innovation Situation

There has been no investigation establishing the relations between innovation and user-research used in design. From literature review, immersion, observation, case studies, expert interview, and intensive analysis, the user-research usage pattern is highly associated with 4 major innovation situations combining variation on technology and market. According to the finding, the ‘Design Innovation Model’ was developed as a framework to further explain the relationship between user-research and design innovation.

The 4 quadrants of the ‘Design Innovation Model’ represent 4 design innovation situations including: Situation I-new technology for new market, Situation II-new technology for known market, Situation III-known technology for new market and Situation IV-known technology for known market.

Also through intense research, two major concerns of design innovation were found. The diagonal dot line on the ‘Design Innovation Model’ separates 2 major concerns: A-usability concern (above the dot line) and B-symbolic concern (below the dot line).

This section will discuss the nature of each innovation situation on the ‘Design Innovation Model’ and its relations to previous approaches including Heskett’s innovation strategies: fundamental innovation, radical redefinition, and incremental innovation (excluding the imitation strategy, where design goal setting is not applied), the classifications proposed by Christensen (1997) and Leifer’s (2000) discrimination of innovation: incremental and 3 types of radical innovation with respect to alignment with the firm’s established lines of business.
4.1.1 Situation I: New Technology for New Market

This situation is what Christensen calls ‘Disruptive Innovation’ and what Heskett calls ‘Fundamental Innovation’. It is very close to Leifer’s ‘Radical Innovation outside a firm’s current strategic context’. Innovation in this category opens new and entirely unfamiliar markets. It embodies the highest organizational uncertainty. Christensen points out when this kind of innovation occurs, incumbents reject the new technology; where markets do exist for such innovative products, they tend to be small and offer slim margins. The firms need to recognize the need for a different approach to operation within the market.

According to the finding, the critical objective of the user-research in this situation is to match the unarticulated needs of users with technology possibilities. It is essential to understand the users’ experience holistically by encompassing psychological, physiological, cultural and social forces. User information is critical to various kinds of decision making in this situation including project mission, strategic product platform, and experience strategy.

4.1.2 Situation II: New Technology for Known Market

This situation is very close to Leifer’s ‘Radical Innovation within the market domains of existing business units.’ It is also ‘Disruptive Innovation’ by Christensen’s definition and may fall into what Heskett calls ‘Radical Redefinition’. These kinds of projects aim to replace existing technologies for essentially the same customers and markets. This type of innovation strengthens a firm’s position with familiar markets. A project idea that aims to serve current customers has its own market demand and is ready for commercialization. Thus, a constructive relationship between the business unit and the project can be established as it evolves and organizational uncertainty is reduced. The infrastructure for contacting customers, understanding markets, and delivering the innovation are assumed to be well understood.

The important role of user-research is to help increase understanding of potential users, uncover unmet needs and restructure the product process by identifying opportunities for new functionality of what the product can do, and what features are needed to meet the expectations of users.

4.1.3 Situation III: Known Technology for New Market

This type of innovation would fall into Heskett’s ‘Radical Redefinition’ and would fall into ‘Continuing Innovation’ as described by Christensen, while it is discussed by Leifer as ‘radical innovation in the white space between a firm’s existing businesses’. Radical innovation products that fall into the white spaces between existing businesses end up in either a new business unit or an existing one that is prepared to expand its scope.

Geoffrey Moore (1999) describes how companies who create technological products frequently have great success with the first two groups of adopters on the adoption curve (Innovators, Early Adopters) and fail to cross the chasm to mainstream buyers (the Early Majority and so on). Moore urged that mainstream markets require a very different approach from that of the innovators and early adopters. He also suggested that marketing professionals create profiles and target specific segments of the population rather than trying to invest right into the mainstream.

In this situation, user-research is essential to innovation diffusion and in identifying the potential group of users who would be a link from early adopter to early majority. User-research plays an important role in the decision on re-branding and repositioning which are related to visual communication and design language to communicate the new technology to the new market.

Searching for a new market, user-research may be used in combination with (or prior to) marketing research. User-researches can deepen research, allowing it to uncover unarticulated or emerging user needs. After these needs and solutions are identified, market researchers can quantify the opportunity with forecasting, competitive positioning, pricing, and analysis of demographics.
4.1.4 Situation IV: Known Technology for Known Market

This situation is what Leifer calls ‘Incremental Innovation’ and What Heskett calls ‘Incremental Detail Change’. It is what Christensen calls ‘Continuing Technology Innovation’. This type of innovation helps sustain an organization's existing customer base by improving the performance, capacity, reliability, or value of an existing product technology. It usually emphasizes feature improvements in existing products or services and is dependent on exploitation competencies. Although incremental detail change diminishes the focus and capacity of the companies to engage in truly breakthrough innovation, many firms seek incremental improvement to existing products and technologies while under pressure to maximize short-term financial performance.

According to intensive analysis finding, it is important to note that there are 2 major aspects of innovation with known technology for known market: 1) usability (functionality) development, and 2) formal and design language development. Each aspect has a different inquiry base and requires different user-research analysis and synthesis approaches. Thus, the role of user-research is separately discussed further as IV-A and IV-B.

**Situation IV-A: Usability Development**

The user-research supporting incremental usability development (also usually called R&D) seeks an understanding of the change process, investigates the claims of action research in promoting change. The research must provide the direction for: How the product or service might be improved or made more effective. In what way could it be better than the present or previous situation? How might the design deal with some problem? Researchers might observe if the users reinvent or redesign the product to serve their own purposes. This type of research identifies problems to eliminate and finds the unmet need of users to be fulfilled in the future by design.

In this situation, the goal is to make the product and service more efficient. If the research is not done along with iterative design, usability testing is usually employed to validate the final design solution, especially ergonomically. Besides ‘usability testing’ which is commonly known, other forms of evaluative research for usability development include preference testing, concept validation, ergonomic analysis, and human factor analysis.

**Situation IV-A: Visual Communication and Formal Design Language Development**

In this situation, user-research is critical in better understanding intangible attributes of the product or service, and influencers in the user’s culture. Researchers need to concentrate on understanding more about users’ beliefs, and attitudes toward a product, service, or situation in order to uncover the motivations and expectations behind behaviors that users display. In this situation, user information is very important to decision making on branding and brand identity in relation to look and feel of the product, visual communication, packaging, retail environment, etc.

It is important to note that, according to the finding, user-research findings are used in supporting both immediate and long-term design strategy. The projects that start from Situation I-New Technology for New Market would later need to be redefined through the same processes used for cases in Situation II- New Technology for Known Market and/or Situation III- Known Technology for New Market and Situation IV-Known Technology for Known Market. Likewise, projects that start from Situation II and III would need to be worked on more in detail as cases in Situation IV, either by a design consulting firm or by the corporation.

4.2. The Characteristics of User-Research Supporting Each Innovation Situation

The research characteristics semantic is developed from Jay Melican’s (2000) dimensions of user-research classification diagram in combination with other dimensions suggested by Aldersey-Williams, Bound, and Coleman (1999), and Sanders (1992). In addition, the scales related to design support (the point in the design process that the user-research is used) and the research direction (generative vs. evaluative) are added as they are reported as significant by most interviewees.
The characteristics of user-research conducted and used in all the innovation situations are compared on the semantic scales below in relation to design support, research direction, research structure, analytical perspective, degree of generalization, mode of collection, media of delivery.

4.2.1 Design Support

User-research needs to be done early as a pre-design process support, at the strategic level, for Innovation Situation I- New Technology for New Market, as it is critical for identifying the project mission by matching the unarticulated needs of users with technology possibilities. For Situation II and III, user-research should also be done as early in the process as possible to identify the emerging needs for new technology and/or functionality and the potential market for the technology. Later in the design process, user-research also informs the direction of design iteratively. In contrast, user-research supporting Innovation Situation IV usually is employed in the design process after the decision of ‘what to design’ has been made. Participatory design and iterative design play an important role in product and software development. And in many cases, ‘usability testing’ is employed for post-design evaluation.

4.2.2 Research Direction

User-research supporting Innovation Situation I, II and III are generative, while for Innovation Situation IV, especially usability development, user-research has been used more evaluatively to ensure that the product works functionally. Besides ‘usability testing’ which is commonly known, other forms of evaluative research for Innovation Situation IV include preference testing, concept validation, and ergonomic analysis.

4.2.3 Research Structure

Research structure for Innovation Situation I has to be open enough to capture the user’s experience holistically, as there are not many hypotheses as in other research situations. Because the technique stresses observation over inquiry, relatively little information is gathered through response to questions.

For Innovation Situation II, in order to identify emerging needs, observers may ask a few very open-ended questions, such as ‘why are you doing that?’ They often carry a list of questions to prompt their observation, for example, ‘what problem is the user encountering?’

The important questions for research in Situation III might include: What does the product, service or technology mean to users? What circumstances prompt people to use the product or service? Does the customer turn to the offering when and in the way the company expected? If not, there may be an opportunity to explore. By interacting with the user’s environment: how could the new technology product or service fit into the user’s system?

In contrast, research questions for Situation IV may be prepared and developed based on many hypotheses for usability testing, preference testing, and ergonomic analysis.
4.2.3 Research Perspective

In innovation where usability and functionality is a main concern (Situation Type A), user-research is usually done with a procedural perspective. The researchers may be most interested in studying user’s actions, reactions, and interactions in a particular physical setting. The researchers learn about the user’s physical and cognitive limitations and capabilities, and then come to understand how setting, tool, or other artifact can be best constructed to adapt to those capabilities.

While in Situation Type B, where symbolic meaning is a major concern, user-research is conducted with focus on a conceptual end. Researchers need to concentrate on understanding more about users’ beliefs and attitudes toward a product, service, or situation in order to uncover the motivations and expectations behind behaviors that users display.

4.2.5 Degree of Generalization

Research focused on the behavior of an individual supporting innovation for known market (Situation II and IV) should inform an understanding of behaviors typical to any social or organizational groups to which that individual belongs. For innovation for new market (Situation I and III), it is important to put together the studies of many users associated with the same community. Insights about user behaviors maybe generalized to describe cultural norms.

4.2.6 Mode of collection

Although there is no perfect singular mode of collection for each innovation situation and triangulate approaches are highly recommended for data collecting for all innovation situations, it is important to note that some modes of collection hold greater potential benefit and are suitable for one type of innovation situation more than the others.

According to the finding, traditional participatory research, focus group, survey, and customer interviews are employed for user-research supporting innovation with known technology (Situation III and IV), but they are rarely used for user-research supporting innovation with new technology (Situation I and II). Most researchers believe those techniques rarely lead to a truly novel product concept because users are so accustomed to current conditions and do not think to ask for a new solution even if they have real needs that could be addressed. Thus immersion and observation are often employed, and believed to hold the greatest potential benefit for addressing the problems with the new technological capacity that is not tied to a familiar consumer paradigm, leaving consumers with no foundation on which to formulate their opinions. For user-research supporting innovation with new technology (Situation I and II), real life context is better than the artificial setting of a laboratory. People being observed should carry out normal routines in their normal environment.

For innovation with known technology, prototyping is an interesting technique used iteratively in the data gathering process either during design or for the evaluation of design solutions. The higher the level of innovation in a design solution, the harder it is to understand how design should look, function, and be used. The prototyping is important for classifying the concept of the new product or service for the design team, communicates the concept within and beyond the team, and stimulates reaction among potential users.

4.2.7 Media of Delivery

Although many design consulting firms found that engaging team members and clients in field user-research, or letting them have action learning experience in the real context is one of the most effective ways to deliver user information, it is also important to discuss other media of delivery in relation to innovation situations.

The media of delivery is likely to reflect the mode in which the data is collected. For example, if the data is collected through video observation, the findings would likely be delivered in visual form. Researchers should keep in mind that the analytic mode and the analytic perspective of user-research effect data gathering techniques. This can be planned out for research across Innovation Situation I, II, III, and IV.
In innovation type A where the concern is on functionality or usability, user information is most commonly presented in verbal and diagrammatic formats mixed with visual media, including video or photographic imagery. In the case of known technology (IV-A), user data is also given in the form of tactile presentation, which might involve the use of prototypes constructed by subjects (Sanders, 1992). For innovation with symbolic meaning, where design language is critical, user information comes essentially in visual form and deliverables are usually enhanced with the inclusion of artifacts collected in the research process. Researchers may collect artifacts that users buy or create in relation to their artifact model, physical model, and cultural model.

### 4.3 Analytic Models


The seven analytic models used in this study are flow model, activity model, sequence model, ergonomics model, artifact model, physical model, and cultural model. The essentialness of the analytic models are compared on the semantic scales ranging from ‘not related’ on the left end, to ‘related’ in the middle and to ‘critical’ on the right end.

**Figure 3: Analytic Models Comparison on Semantic Differential**

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<thead>
<tr>
<th>Semantic Scales</th>
<th>Analytic Models</th>
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<tbody>
<tr>
<td>not related</td>
<td>I New Tech</td>
</tr>
<tr>
<td>related</td>
<td>II New Tech</td>
</tr>
<tr>
<td>critical</td>
<td>III Known Tech</td>
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<td></td>
<td>IV-A Usability</td>
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<td></td>
<td>IV-B Design</td>
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**4.3.1 Flow Model**

The analysis of flow model helps better understand the interaction between key stakeholders. It helps explain people’s roles and helps define how people communicate to get a job done. A good example is the use of social network analysis in alternative work place design. As the understanding of flow model could lead to the restructuring of the flow process and could help identify opportunities for new functionality of what a product should do, it is critical to innovation with new technology (Situation I and II), while not as important to innovation with known technology (Situation III and IV).

**4.3.2 Activity Model**

Activity model helps better understand recognizable patterns of activities people do in everyday life and/or around the design system. As activity model could lead to the restructuring of consumer segmentation, it is critical to innovation type B. Interestingly, activity model is usually assumed to be well understood for innovation type A. Thus the research is more focused on the task sequence level of detail rather than on the everyday-life activity level.

**4.3.3 Sequence Model**

The analysis of sequence model helps better understand work task order over time and the steps people take for a purpose. While the understanding of sequence model is critical for Innovation Situation II and IV-A as it uncovers the unmet needs and problems procedurally. It is not very important for Innovation Situation I, II, and IV-B.
4.3.4 Ergonomics Model

Ergonomics model takes into account the physical, cognitive, social, organizational, environmental, and other relevant factors, and makes them compatible with the needs, abilities, and limitations of people. It is critical to usability development (Situation IV-A), while not important to other innovation situations.

4.3.5 Artifact Model

The analysis of artifact model helps better understand how people create, use, and modify things for their purposes. Understanding the artifact model is critical for innovation type B, but is not as important to innovation type A. The scope of artifact analysis for innovation type A and B are also different. While research supporting innovation type B takes into account all range of objects that people use in everyday life, the research supporting innovation type A focuses more on the existing objects used in the system.

4.3.6 Physical Model

The analysis of physical model helps better understand the physical context of the potential user and the product or service. The understanding of physical model is important to all innovation situations. It helps define both the constraints imposed by the physical environment and the structure people create within those constraints for their purposes.

4.3.7 Cultural Model

The cultural model helps define expectations, desires, values, and the whole approach people take in their context. As it provides an in-depth understanding of potential user groups and the way to communicate to them, the cultural analytic model is critical to innovation with symbolic meaning concern (Situation I, III, IV-B), while it is not as important to innovation with usability concern (Situation II, IV-A).

Comparing innovation type A and B, user-research supporting Innovation Situation II and III are very different in terms of analytic models and usually are separated into different projects. In contrast, user-research supporting Innovation Situation IV-A and IV-B are intertwined. As design is a visual medium and it communicates symbolically and practically, the direction of design with known technology for known market needs to be informed by both research approaches.

Comparing Situation I, II, III and IV, although the sequential model is critical to user-research supporting Innovation Situation II and IV-A, the 2 research types have different scopes, approaches and employ a very different set of data collection techniques. On the other hand, user-research supporting Innovation Situation III and IV-B are the same. In both Situations, user-research focuses on the analysis of activity model, artifact model, physical model, and cultural model. As reported in many B type case studies (with symbolic meaning concerns), research can be done once for Innovation Situation III, or even for Situation I, and the findings can be used throughout the design process till the end of Innovation Situation IV-B.

5. Applications and Contributions

Findings of this study are relevant to the community of practicing user-centered designers and researchers. It suggests new approaches to user-research planning, an alternative mental model of design innovation, and a different way of describing user-research in relation to design innovation. ‘Design Innovation Model’ could be used by a multi-disciplinary team early in the goal setting process. Once the decision on design innovation strategy (situation) is made and is communicated clearly to all team members, the findings about user-research characteristics and analytical models could be used as a user-research planning guideline for both individual innovation situations and across innovation situations.
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Bibliography