8. Participatory Design

8.1 Introduction

Participatory design aims at including users in the design process so that users’ voice is reflected in the design of a technology they use [3, 9, 20]. Several methods of participatory design are listed in Table 8-1. The core method of participatory design includes workshops and design sessions in which users are encouraged to think creatively and propose their own ideas.Ethnography is also used in conjunction with participatory design to gain a deeper understanding of users. Beyond workshops, ongoing activities in which designers prepare prototypes and mockups and obtain feedback from users in a continuous manner are also crucial. To assist users who are not familiar with design practices, cards are often used as a medium of gathering and structuring data. In a more proactive approach, users are given design tools by which they can explore designs on their own.

In this chapter, I discuss the basic rationale for stakeholders’ participation in design beyond the ethnical issue of involving users in decisions that affect them and the practical issue of tapping into users’ extensive domain knowledge. Through this discussion I then argue that stakeholders’ learning is critical but challenging. I highlight the issue of power inherent in this learning. Then, I seek to expand the scope of participatory design, beyond involving stakeholders in design towards any kind of technological design that incorporate a social as well as technical system.

8.2 Why Participation?

Design is political [12]. Any design aims at a desired end—what ought to be rather than what is [21]. And it is somebody’s desired end. Designers of a technology are in the position to dictate what users can and cannot do. It is true that in any social interaction, we have expectation as to what others can and cannot do. Yet, technology design is particularly powerful in this capacity. While technology can enable what would otherwise be impossible, it can also limit people’s behavior. Stakeholders’ participation is therefore an ethnical issue.

Technological design is also complex [21]. It requires extensive knowledge of the domain. Designers, however, typically have little knowledge of the particular domain. They need to learn a lot. Ethnography is often used to immerse oneself in the users’ environment and gain a deeper understanding of the users and other stakeholders. User participation is proposed as a means to tap into users’ domain knowledge.

Furthermore, participatory design is called for because users need to have a sense of ownership in order to make better use of the technology. Workers who can exercise certain control over their work tend to be more motivated and develop more efficient and effective work practices. Technologies cannot produce any value on their own; it is users’ practices that deliver value. Some users may simply use a limited set of functionality and ignore the potential value of the technology while others can use it creatively [24]. User participation is an effective means to empower users.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshops</td>
<td>Users and designers work together to create a design, vision, policy or understanding of the current setting jointly in a focused manner.</td>
</tr>
<tr>
<td>Ethnography</td>
<td>Designers conduct an in-depth observational study of users in order to obtain a first-hand understanding of users’ situation.</td>
</tr>
<tr>
<td>Cooperative prototyping</td>
<td>Users experience potential technologies with a prototype and modify the prototype cooperatively with designers.</td>
</tr>
<tr>
<td>Mock-ups</td>
<td>Designers create mock-ups, often using cardboard, to stimulate users to think about the potential technology and new work practices.</td>
</tr>
<tr>
<td>Card sorting</td>
<td>Designers learn users’ information environment by having the users write down types of information on cards and group them into piles.</td>
</tr>
<tr>
<td>User design</td>
<td>Users are given a design tool to create a design on their own. The design tool needs to be easy enough for non-programmers to use.</td>
</tr>
</tbody>
</table>
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There is, however, a deeper reason for user participation. Design of a technology encompasses not only material artifacts but also people. Lives of the users will be affected by the technology. There could be unintended consequences to lives of many others who do not necessarily touch the technology. This situation requires us to conceive the technology within the socio-technical system, a system that encompasses technical and social conditions.

Designing a socio-technical system is different from designing a material artifact in isolation. Material artifacts behave according to laws such as Newton’s law. Artifacts are governed by the natural laws. Although natural laws are not explicit, information technologies are deterministic in that their behaviors are predicted by specified codes. Designing a social system is a completely different matter. Designers cannot dictate completely how humans behave. This is primarily because human behavior is governed not by laws but by rules. Rules are different laws in that we can always violate them. Although natural laws are always falsifiable and valid only under certain conditions as Thomas Kuhn showed, material artifacts do not violate the laws.

Rules are different from laws because people who follow the rules have a certain understanding of them. Let’s consider the following rule: Stop on a red light. When we follow this rule, we know that we are expected to follow it. In this sense, we have a reflexive understanding of the rule. Furthermore, we hold each other accountable for following the rule. When we start moving on a green light, we expect others to stop on their red light. Rules are always normative in that we get punished when we violate them. Not only might we be stopped by an officer, we are also seen by others to have violated the rule and considered reckless.

Because rules are reflexive, we cannot simply create a rule and expect people to follow blindly. For instance, in early days of American football, injuries became a concern. Then, a helmet was introduced to protect players from injuries, with an expectation that injuries will decrease. Yet, injuries increased as a result. With the protection, players started to play more aggressively and dangerously. This simple example shows the difficulty of designing human behavior. For professional players, it was important to show splashy plays. Without understanding this, we often fail to achieve an expected result. To design the whole socio-technical system, we need to take the reflexive understanding that people have rather than simply imposing constraints and procedures.

Only involving stakeholders in the design discussion is not enough. If we had asked football players how to reduce injuries, they would probably not have given any viable design. Stakeholders themselves tend to have too simplistic understandings. Most of stakeholders’ reflexive understanding of the socio-technical system is not a conscious thought that they can readily express. Nor can we design something that will work in the first attempt. There are always unanticipated consequences. Design is a constant trial and error, or reflective conversation in which we try something and see if it works. This involves iterative design through which learning accumulates. When we try one idea, it may not work. Then, we learn and try a different approach. Design needs to be constantly tested and validated.

Beyond simply involving stakeholders in the design decision making, design needs to be part of the stakeholders’ life. Stakeholders need to learn how to design the socio-technical system in which they find themselves. It is, however, not easy for stakeholders to learn to design. I will discuss this challenge in the next section. Furthermore, if we accept this notion of participation—beyond simply involving stakeholders in design, we need to expand the scope of participatory design. Typically, participatory design has been applied only to situations where there are a definite group of users. Any technical design, which almost always involves social design, needs to be participatory. Therefore, I discuss below participatory design in a research setting where researchers need to consider and deal with stakeholders’ reflexive actions.

8.3 Stakeholder’s Learning

8.3.1 Learning and Transformation

Users and other stakeholders need to learn and transform their own knowledge in order to start contributing to design. When asked what kind of a technology they want, users typically suggest what they have been using and possible improvements over some of the annoyances that they have been frustrated with. There are two problems with this situation. First, if these requirements are all realized, the development cost will be much larger than the budget. Even if the budget is abound, the system will be too enormous in size to
maintain. Some of the requests are only “good to have” while others are “must to have.” It is difficult for users themselves to distinguish these two. They need to learn to take a more holistic perspective. Second, such incremental changes do not justify costly technology development. Technology development is proposed to achieve a more significant improvement and change. Faced with this gap, stakeholders are required to transform their knowledge, break out of their familiar reality, and design a technology to achieve larger goals. In designing consumer products, designers cannot simply ask what kind of design stakeholders would want.

To make the situation even worse, stakeholders are typically busy with their own daily work and cannot easily find time to participate in design. In most cases they do not want to participate because they think technology development is somebody else’s job. They typically say to designers, “I tell you what we want, and you can then make it.” In a typical information system development, a client contracts with an IT vendor. Designers of the IT vendor will work with another client after they are done with their current one. In contrast, users will continue working as users and won’t do another information system design in so many years. Therefore, stakeholders face the first challenge of understanding that they need to design the system they will use.

The difficulty in learning is that a certain view of the world is ingrained in stakeholders. They take the world they know for granted and take it as the reality [2]. In participatory design, then stakeholders need to challenge their own worldview and obtain a new perspective. Yet, this process is not straightforward. Realizing that what one has thought to be the reality is not so grounded results in despair as Hegel put it. For designers who need to help stakeholders design, it is not enough to listen to them. It is often necessary to dispute what stakeholders request and convince them that something different would be better.

In information system development, most system designers understand that stakeholders’ participation is vital. If users do not feel a sense of ownership, the likelihood for them to resist the system increases. More than that, when testing the system with actual work situations, implementing the system in the workplace, and training all users, stakeholders’ participation is critical. Stakeholders who have a sense of ownership often create test procedures, implementation plan and training manuals themselves. When testing, they try to go beyond what is written in the instruction in order to test the features in various operational scenarios, giving feedback for quick fixes and in many cases considering changes in the work processes to better work with the system. Furthermore, when system development is delayed as most are, stakeholders typically blame designers. Stakeholders who design their own system try to work out the best solution together.

It is helpful to use Carlile’s distinction of transfer [5], translation and transformation, as show in Table 8-2. Although Carlile proposed this distinction in the context of knowledge sharing, it can be applied to information system design. There are various levels of design: features, work practices and goals. Features refer to what the information system does technically, e.g., producing a certain output given a certain input. Work practices encompass not only the features but also how people use them to accomplish their work. Goals are high-level objectives that underlie the work practices. For instance, an accounting slip that an accounting department receives and uses to manage their ledger is a feature. The accountants’ work practice includes looking at the items listed on the slip, approving them, and entering journal titles for each. The goal for this practice indicates that the accounts are responsible for the centralized accounting data and possess control of all the accounting activities of the organization. This is not the only goal that can be conceived. The organization may introduce a new information system to achieve an alternative goal: decentralized and real-time accounting for timely decision making. For this goal all members of the organization, not just accountants, are supposed to enter accounting data and take responsibility for them. Manual approval by accountants for all the purchases may no longer make sense although accountants still need to take some responsibility. Then, the work practices may need to be altered as well as the features.

Transfer refers to exchange of information out of fixed knowledge (Figure 8-1). In this case, stakeholders simply state what they want without entertaining the possibility of an alternative perspective. In accounting system development, users demanded a unique identification number for accounting slips, which they had been using in their existing system. Yet, when they learned that the packaged application did not offer the exact same number, they simply demand a modification. The requirement was simply transferred without being altered. Preservation of the same work practice was attempted.

Translation involves negotiation of meanings although the knowledge is fixed (Figure 8-2). Stakeholders are now ready to change their initial requirements of features and try to create new features. Yet, these new features tend to aim at the same goal. In the example of the accounting system, users proposed a tweak of the system, e.g., a combination of various fields to realize the equivalent of unique identification number.
Table 8-2 Transfer, Translation and Transformation of Design

<table>
<thead>
<tr>
<th>Created elements</th>
<th>Transfer</th>
<th>Translation</th>
<th>Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Created elements</td>
<td>Features</td>
<td>Work practices and features</td>
<td>Goals, work practices and features</td>
</tr>
<tr>
<td>Users’ actions</td>
<td>Users demand certain features, which are in most cases features of their existing system.</td>
<td>Users explore desired work practices by using available features to achieve a fixed goal.</td>
<td>Users redefine the goal and design features and work practices.</td>
</tr>
<tr>
<td>Designers’ actions</td>
<td>Designers propose an alternative feature, but users refuse it. Designers cannot easily persuade users.</td>
<td>Designers explain an alternative work practice but users are fixated on their goal.</td>
<td>Designers refine users’ ideas by working out technical details.</td>
</tr>
<tr>
<td>Boundary of users’ work</td>
<td>Users think that designing is not their responsibility but the designers’, in exchange of payment.</td>
<td>Users understand that they are responsible for design, in particular meeting the budget constraint.</td>
<td>Users understand that they are responsible for realizing the value of the technology for the organization.</td>
</tr>
<tr>
<td>Resulting design</td>
<td>Infeasible and costly</td>
<td>Complex and expensive</td>
<td>Simple and consistent</td>
</tr>
</tbody>
</table>

Therefore, users proposed different work practices although they tried to achieve the same goal. While the original requirement was translated into something different, the underlying meaning and the goal remained the same; i.e., achieving the unique identification number.

Transformation, on the other hand, involves change in the goal for which features are considered (Figure 8-3). The identification number had been used in the character-based terminals of the existing system while no equivalent number was exposed to users of the packaged application because users could simply search for slips by a number of fields and click on the result—users did not have to worry about numbers. The identification number was also needed to look up paper documents attached to slips such as invoices and receipts. Yet, as the new system was to store scanned documents, no number was needed to look up the documents. Therefore, the whole idea of the identification number could have been altered. In this case, an alternative goal was recognized, and as a result, work practices and features were altered.

It is not easy for stakeholders who have their own ingrained worldview to learn to design from a new
Figure 8-3  Transformation

Perspective. It is not enough to solicit stakeholders’ voices in design. In many ways what stakeholders suggest early on is not what they end up needing later. Many features are fixed at the level of transfer or translation. In information system development, stakeholders need to learn up to transformation within a limited time. Without this learning, designers often try to arrive at compromises. For instance, translation may be good enough because the tweaks can be low cost. Yet, design may not achieve the holistic goal.

8.3.2 Boundary Objects

Theorists have suggested that boundary objects play a crucial role in this transformation [1, 4, 5]. Boundary objects help represent stakeholders’ interests. One party’s concern cannot be clearly expressed in words. Yet, boundary objects translate the concern in a form that is readily understandable to other parties. For instance, a certain design diagram of product designers can represent a concern of production engineers. Product designers can readily understand what is an issue for production engineers. In the same way, boundary objects help users understand an alternative worldview.

In packaged application implementation, e.g., ERP, users play with a demo system before discussing detailed requirements, i.e., conference room pilot. Users often realize that although the package won’t be able to support a feature that they want, they can do the same with alternative features that are available in the package. After a while, users start to think of alternative technical implementations. In one project, users started to propose creating a virtual warehouse in order to simplify the work process. The same users initially did not have a concept of a virtual warehouse because warehouses for them are always physical ones. By playing with the system and exploring the features, they could start to think creatively.

When there is no fully functional system to use for the demo, low fidelity mockups could be useful [6]. Often mockups are made of paper without any computational capability. Furthermore, it is often more important for users to write design documents rather than simply to talk about designs. By specifying the detailed design, e.g., workflows and UI, users come to think of the whole system works. Yet, because it is not easy for untrained users to specify design, a paper-based toolkit is sometimes used [15, 23]. Users can design by moving stickers on a formatted sheet. Various stakeholders get together and specify a single design.

8.3.3 Power

Power is critical in relation to users’ learning. In traditional participatory design, users are portrayed as powerless. Situated learning theory suggests that access is crucial for learning [13]. As stakeholders are sequestered from design, their learning is inhibited. This situation seems to have changed over the last decade. Information technology has become a commodity. Users’ reliance on IT professionals’ expertise has been less critical. Competition has strengthened among IT vendors, who now have to compete on price. In this circumstance, stakeholders often have power over IT designers because designers come from an IT vendor that is contracted by the client. Consumers and customers have power as makers of purchasing decisions. In development of a large information system, somebody else may decide to purchase a system. For instance, top management or the IT department often decides to introduce a system. Yet, users eventually have a say to detailed designs. Many projects fail because of users’ resistance. Therefore, designers need to obtain agreement from users on detailed features.
Designers often feel powerless in interacting with stakeholders who do not want to participate and only dictate the design. Stakeholders demand features they believe are important. Designers bring several alternative designs but stakeholders simply reject all of them. While powerlessness hinders learning, power can also be consequential to learning. Powerful stakeholders simply transfer requirements without altering their perspective.

Designers on the other hand are not powerless. Stakeholders depend on them to detail the features. Precisely because stakeholders need to pay for the system, designers often suggest that they could simply listen to them but the system will be too costly. In typical information system development, stakeholders’ requests inflate and cost estimates blow the budget. By imposing pressure on stakeholders to reduce costs, designers can leverage their power.

Beyond learning, power is always an issue in information system development. Design is always a political process because design affects parties’ life [7, 14, 17]. New information systems often alter the power structure of an organization. A group that monopolized centralized information may lose its power because the system aggregates information for use by other departments. Alternatively, the headquarter may try to centralize information and control. Sales departments want to control inventories of products at factory warehouses while factories have managed these inventories. Because factories want to ship goods out of warehouses to recognize revenues, pushing them to sales’ costs, sales are frustrated because they receive some goods that they did not demand. From factories’ point of view, sales people who do not come to the warehouse cannot manage the inventories because the space is limited and much work is involved in maintaining the volume. Parties then try to influence the design by resorting to the power of their managers and building alliances.

This kind of conflict is observed in almost all the system development projects. Some projects can relatively efficiently resolve these conflicts if top management gives top-down directives. Yet, parties still try to maintain their power by manipulating details. Some group may refuse to use the system, dooming the project to failure. Unfortunately, there is no shortcut to this sticky problem. In order to resolve these conflicts, practitioners need to understand the political structure correctly and facilitate a dialog between groups.

8.4 Expanding the Scope of Participatory Design

8.4.1 Technology Design in Research

As we have seen above, participatory design is not just involving stakeholders in design. It is about designing the socio-technical system of which stakeholders’ reflexive agency is a part. Now I want to discuss technology design and development in a research setting, particularly in industry R&D. I claim that as any socio-technical system needs participatory design because stakeholders’ reflexive understandings are part of it, we need to think of participation in any R&D activities. Participatory design has been applied in research settings. The typical participatory design methods can be used in research settings. Particularly when researchers are developing a technology for end-users, understanding these users through observations and exploring design together in workshops is a crucial step. Often many technologies are developed in R&D that are ignorant of actual users’ situations.

Yet, researchers need to do more. In a typical research situation there is no definite group of stakeholders. Researchers are trying to design not a concrete product or service but technologies that have not existed before. Then, researchers need to consider such issues as the integration in the existing technical infrastructure, market adoption, business models, and regulatory and institutional arrangements in addition to the technical functionality, performance, feasibility, and reliability. Therefore, researchers must deal with the whole socio-technical system.

Before getting into the detail, we need to understand the current research environment, particularly in the industry research labs. Industry research labs have taken market demands into account. Inventions and innovations tend to take place where there is demand [10, 16, 18]. Nonetheless, researchers in industry labs could afford doing research whose connection to the corporation’s businesses were not obvious. Even if demand is taken into account, it is detached from the researchers’ research practices. In traditional R&D organizations, researchers have been doing only research, i.e., designing and conducting experiments, designing and implementing prototypes, and reading and writing papers. It was either before the research is
launched or by managers who do not do the research day to day that demand was considered.

In the current environment, more pressure is added to research labs to produce technologies relevant to the existing businesses and create new businesses for the corporations. This pressure has been transferred to individual researchers. When researchers have an idea they want to work on, they need to show the market potential. In many cases, marketing professionals and managers determine that there is no big enough market and decide not to fund it. Even if it is funded, after a year or two when the project is evaluated, it is either reduced or shelved due to unclear market potential. This situation creates two problems. First, research that addresses a concrete demand that already represents a large market tends to be incremental and does not ensure the long-term advantage of the organization. This kind of research cannot be distinguished clearly from product development in business groups. Second, researchers themselves are frustrated.

In these situations, researchers must be conscious about how the technologies they create will be used. They need to have a certain understanding of the technological, economic and social conditions in which the technologies are used.

8.4.2 Iterative Research Practices

In recent years, it has been witnessed that some researchers take a more proactive role in exploring market as well as science and technology—interacting constantly with users, potential clients, domain experts, competitors, partners, funding agencies, and investors. Researchers at Palo Alto Research Center, a Xerox Company (hereafter PARC) started a new research program in clean technology, particularly solar energy generation, in 2004. Researchers had no idea what to work on in solar. Nor did they know anybody in that domain. They slowly started exploring the domain. For instance, researchers formed a study group to read papers and books, invited prominent speakers and had meetings with some players in the domain. They also went to the largest conference in the domain, World Renewable Energy Congress and listened to as many talks as possible. They met several key figures in the domain and came back with a stack of business cards.

After successfully concluding the solar concentrator photovoltaic (CPV) research, researchers at PARC wanted to work on crystalline silicon panels. Yet, it was a huge area and they had no idea what specifically to work on. One idea was to start experimenting with new materials, methods or systems for PV panels. Instead, they explored the domain by talking to various domain experts in order to find something more realistic. When they were observing the manufacturing line, they encountered something familiar, a printer. As a research center of Xerox, they knew about printers better than anybody else. They learned that screen printers were used to deposit gridlines, metal lines to extract electricity from PV. The idea of improving this line came easily. They thought about printing taller and narrower lines. Because the line is put on top of the cell, the shadow it creates meant inefficiency. The taller line could produce smaller shadow and reflect some light on the cell. For this, they invented co-extrusion printing.

Yet, researchers did not start investing money in this research. They wanted to be careful. They decided to do two things. First, they hired a domain expert who had more than 30 years of experience in the solar research and business. They worked with this expert to explore new ideas and refined designs. This expert, a former executive of a large PV manufacturer, also guided the researchers in business decisions. He could quickly evaluate an idea and offer some tips based on his experience. Second, with this expert researchers went around and talked to several potential clients. They explained the technology’s performance, reliability, expected life time, and targeted price. Positive feedbacks brought them more confidence. Only after this validation did they start to invest in this research and developed the technology.

This case shows that researchers explored not only the technology but also the market demand, potential clients requirements and investment criteria, existing technological infrastructure, and business models. The kind of market understanding they developed was much more detailed than the casual market sizing that scientists typically do to justify their project. Business analysis revealed that simply developing the co-extrusion printers did not justify the investment. They quickly realized that the business would depend on selling ink, which shaped the research direction early on. The printer needed to be designed in such a way to operate within the existing technological infrastructure. More than anything, the need for this technology was validated. Co-extrusion printing had performance advantage large enough to make a difference in overall module efficiency. In addition, this printing used a non-contact method; the printhead does not touch the wafer. Because price per watt was the most critical factor for solar, PV manufacturers came to use very thin wafer. The non-contact method appealed because it won’t break the wafer.
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The researchers explored new research themes not by sitting in the lab and reading scientific articles but by interacting directly with the market. When researchers started biomedical research, another new domain for PARC, they thought that the inkjet printing technology could be used for DNA microarrays. The idea was excellent and an important technology, high-volume production disposable print heads, was developed. Yet, the technology had no outlet because DNA microarrays were not used in clinical settings but mostly in research, for which high volume production was not necessary. This lesson made the researchers more careful in picking a research theme.

In the biomedical case, researchers could identify domain experts who could guide them. They were connected to faculty members of Scripps Research Institute in San Diego and formed a joint research institute, Scripps-PARC Research Institute. PARC researchers asked Scripps researchers for a list of ten biggest problems in the field. PARC researchers explored these problems and found a few of them particularly interesting because they possessed capabilities to address them. One was, for instance, detection of cancer cells in blood. This problem was difficult and no viable solution had existed because cancer cells are so few in blood. PARC researchers realized that this problem was similar to document scanning. They thought about using laser to illuminate tagged cells and collect light with a sensor. Unlike document scanners, again based on the long history of research for Xerox, a challenge was to collect the light at high speed. One researcher came up with the idea of using a bundle of optical fiber to channel the light into a sensor. A novel detection system that was extremely fast and accurate was invested.

8.4.3 Iterative Exploration

Research is fundamentally uncertain. No matter how well researchers anticipate possible contingencies, accurate prediction of the future is not possible. The best approach appears to be an iterative one: Testing one’s understanding and adjusting the course of action frequently. While it is a standard practice to organize product development concurrently, a serial process appears to be more appropriate for uncertain research, i.e., tackling one thing at one time.

A group of researchers at PARC invented a new way to filter water. Traditionally membrane-based filtration or chemically processed sedimentation were used to remove particles out of water. Researchers who used to work on toner particles invented a novel approach that did not require a membrane and achieved high throughput. The idea is to move fluid through a curved channel. Particles move into either inside or outside of the channel, depending on the design, and form a band. A separator at the end can then remove the band. The innovation of this technology was the use of Dean’s vortex on top of centrifugal force. Even neutral buoyancy particles can be moved to a side through the vortex created in the channel. Because this technology does not require a membrane, less maintenance is required, little energy is used, and throughput is high.

After these researchers developed a design through experimentation and simulation for three months, all of them stopped the research and started doing market investigation. They wanted to know where this technology could be used. Filtration is quite versatile. It can be used not only in municipal water treatment but also in grey water, blood, desalination, and even wine production. It took them three months to have a good understanding of possible applications. After they identified possible applications and understood basic requirements for each, they went back to research to refine the technology for targeted applications.

The notion of real-options can be useful. Because the future cannot be fully determined, researchers justify a small investment to gain more information into the future. The idea is not to predict the future accurately. Researchers need to identify and address the most critical issue and adjust their commercialization scenario as they learn more. While technical risks require extensive research and therefore investment, it does not mean that researchers should dive deep doing the research and show the result only a year later. If they identify the most risky component of the technology and come up with the steps to address the risk, they can focus on it.

The risk can also be economic or social. For instance, user adoption is the biggest uncertainty in most cases. Not all good technologies will sell well. It is not possible to come to a determinate answer whether a particular technology will sell. Yet, a lot of risk can be reduced if one talks to potential clients and understands the economic ecosystem. The most critical issue may not be resolved with a small investment. In this case, researchers need to manage the risk rather than reduce it. They need to think of the smallest step to gain information for reducing the risk. For example, the researchers who invented the filtration technology were aware that the biggest market was lucrative but risk averse. They visited a water plant and
realized that it would take much longer to address this market. They changed a strategy and explored another market.

Through the iteration, researchers can also find unintended applications. The filtration researchers, for instance, discovered that produced water treatment, water used in oil extraction, was a critical problem that the technology could address. This application was not obvious without knowing the domain. Only by reaching out to stakeholders in the market could they identify that application. In this sense, market understanding also evolves as the technology evolves.

If researchers go through this learning, they often come to terminate or shelf their project by themselves. For instance, as researchers at PARC went through the iterative process, they could not resolve one of the critical issues related to the market structure. This led them to shelf the project and to propose a new research project building on what they learned. Similarly, in a solar concentrator project, researchers talked to potential clients before investing in the project. As they received a mixed feedback, they changed the commercialization strategy and quickly licensed the technology without significant investment. Again, this experience led them to propose a new project to avoid the problem they encountered in the previous project.

In sum, any technology development in research needs to be considered as design of a socio-technical system. Therefore, stakeholders’ reflexive understanding is part of the equation. Researchers cannot design a technology they conceive and put it out in the world. They need to iteratively inquire, test, and refine the technology. In such research, there is seldom a definite group of users to interact with. Researchers need to involve potential clients, partners, domain experts and competitors as well as dealing with regulatory and institutional factors.

8.4.4 Continuity and Discontinuity

It is often suggested that researchers in R&D should take risks and engage in disruptive research. In other words, discontinuity is encouraged. Yet, we also need to think about the socio-technical system in which research activities are embedded. As we saw above, PARC researchers moved into completely new domain such as clean technology and biomedical. It appears that they conducted discontinuous research. A closer look reveals that researchers carefully sought and constructed continuity in moving into discontinuous domains.

The challenge for researchers was a lack of credibility in the new domain. Their managers were not comfortable taking risks. People in the new domain also did not provide support readily. It was only through continuous means that researchers could overcome the challenge. For instance, as we saw, they looked for problems for which their existing capability could be leveraged: printing for solar, document scanning for cancer cell detection, and particle manipulation based on toner research for water filtration.

Researchers also relied on external domain experts. These experts played a crucial role not only to fill the gap in knowledge but also to legitimate the researchers. Managers could feel more comfortable if external domain experts could endorse the researchers’ ideas. Researchers could also gain access to networks that the experts had in the new domain. PARC institutionalized involvement of these experts by creating a new title called visiting technologists. Visiting technologists stay at PARC for a certain duration of time. Currently at PARC, most new research projects hire visiting technologists.

Participatory design in a broad sense needs to encompass the socio-technical system of research itself as well as that of the technology. Research needs to fit in the institutional environment. While discontinuity is encouraged in abstract and achieved in retrospect, the research process needs to be continuous.

8.5 Conclusion

In this chapter, I have tried to argue that participatory design is needed not only to incorporate users’ voices in design but also to conceive the whole socio-technical system of which stakeholders are part. The commonsense notion of design, rooted in artifact design, does not represent what this design really is. The critical issue of stakeholders’ learning was discussed. Then, I also tried to expand the scope of participatory design in the context of industry R&D.
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