

DESIGN
THINKING

One of my rules in consulting is simple: never solve the problem I am asked to solve. Why such a counterintuitive rule? Because, invariably, the problem I am asked to solve is not the real, fundamental, root problem. It is usually a symptom. Just as in Chapter 5, where the solution to accidents and errors was to determine the real, underlying cause of the events, in design, the secret to success is to understand what the real problem is.

It is amazing how often people solve the problem before them without bothering to question it. In my classes of graduate students in both engineering and business, I like to give them a problem to solve on the first day of class and then listen the next week to their wonderful solutions. They have masterful analyses, drawings, and illustrations. The MBA students show spreadsheets in which they have analyzed the demographics of the potential customer base. They show lots of numbers: costs, sales, margins, and profits. The engineers show detailed drawings and specifications. It is all well done, brilliantly presented.

When all the presentations are over, I congratulate them, but ask: "How do you know you solved the correct problem?" They are puzzled. Engineers and business people are trained to solve

problems. Why would anyone ever give them the wrong problem? “Where do you think the problems come from?” I ask. The real world is not like the university. In the university, professors make up artificial problems. In the real world, the problems do not come in nice, neat packages. They have to be discovered. It is all too easy to see only the surface problems and never dig deeper to address the real issues.

Solving the Correct Problem

Engineers and businesspeople are trained to solve problems. Designers are trained to discover the real problems. A brilliant solution to the wrong problem can be worse than no solution at all: solve the correct problem.

Good designers never start by trying to solve the problem given to them: they start by trying to understand what the real issues are. As a result, rather than converge upon a solution, they diverge, studying people and what they are trying to accomplish, generating idea after idea after idea. It drives managers crazy. Managers want to see progress: designers seem to be going backward when they are given a precise problem and instead of getting to work, they ignore it and generate new issues to consider, new directions to explore. And not just one, but many. What is going on?

The key emphasis of this book is the importance of developing products that fit the needs and capabilities of people. Design can be driven by many different concerns. Sometimes it is driven by technology, sometimes by competitive pressures or by aesthetics. Some designs explore the limits of technological possibilities; some explore the range of imagination, of society, of art or fashion. Engineering design tends to emphasize reliability, cost, and efficiency. The focus of this book, and of the discipline called human-centered design, is to ensure that the result fits human desires, needs, and capabilities. After all, why do we make products? We make them for people to use.

Designers have developed a number of techniques to avoid being captured by too facile a solution. They take the original problem

as a suggestion, not as a final statement, then think broadly about what the issues underlying this problem statement might really be (as was done through the “Five Whys” approach to getting at the root cause, described in Chapter 5). Most important of all is that the process be iterative and expansive. Designers resist the temptation to jump immediately to a solution for the stated problem. Instead, they first spend time determining what basic, fundamental (root) issue needs to be addressed. They don’t try to search for a solution until they have determined the real problem, and even then, instead of solving that problem, they stop to consider a wide range of potential solutions. Only then will they finally converge upon their proposal. This process is called *design thinking*.

Design thinking is not an exclusive property of designers—all great innovators have practiced this, even if unknowingly, regardless of whether they were artists or poets, writers or scientists, engineers or businesspeople. But because designers pride themselves on their ability to innovate, to find creative solutions to fundamental problems, design thinking has become the hallmark of the modern design firm. Two of the powerful tools of design thinking are human-centered design and the double-diamond diverge-converge model of design.

Human-centered design (HCD) is the process of ensuring that people’s needs are met, that the resulting product is understandable and usable, that it accomplishes the desired tasks, and that the experience of use is positive and enjoyable. Effective design needs to satisfy a large number of constraints and concerns, including shape and form, cost and efficiency, reliability and effectiveness, understandability and usability, the pleasure of the appearance, the pride of ownership, and the joy of actual use. HCD is a procedure for addressing these requirements, but with an emphasis on two things: solving the right problem, and doing so in a way that meets human needs and capabilities.

Over time, the many different people and industries that have been involved in design have settled upon a common set of methods for doing HCD. Everyone has his or her own favorite method,

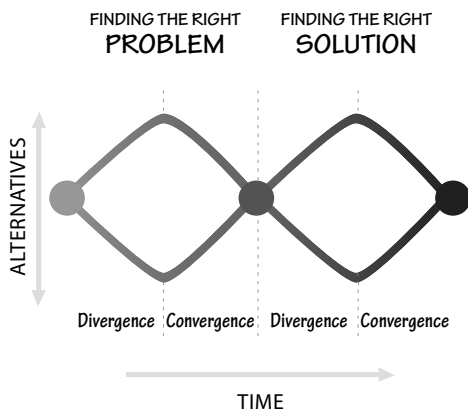
but all are variants on the common theme: iterate through the four stages of observation, generation, prototyping, and testing. But even before this, there is one overriding principle: solve the right problem.

These two components of design—finding the right problem and meeting human needs and capabilities—give rise to two phases of the design process. The first phase is to find the right problem, the second is to find the right solution. Both phases use the HCD process. This double-phase approach to design led the British Design Council to describe it as a “double diamond.” So that is where we start the story.

The Double-Diamond Model of Design

Designers often start by questioning the problem given to them: they expand the scope of the problem, diverging to examine all the fundamental issues that underlie it. Then they converge upon a single problem statement. During the solution phase of their studies, they first expand the space of possible solutions, the divergence phase. Finally, they converge upon a proposed solution (Figure 6.1). This double diverge-converge pattern was first introduced in 2005 by the British Design Council, which called it the *double-diamond design process model*. The Design Council divided the design process into four stages: “discover” and “define”—for the divergence and convergence phases of finding the right problem,

FIGURE 6.1. The Double-Diamond Model of Design. Start with an idea, and through the initial design research, expand the thinking to explore the fundamental issues. Only then is it time to converge upon the real, underlying problem. Similarly, use design research tools to explore a wide variety of solutions before converging upon one. (Slightly modified from the work of the British Design Council, 2005.)



and “develop” and “deliver”—for the divergence and convergence phases of finding the right solution.

The double diverge-converge process is quite effective at freeing designers from unnecessary restrictions to the problem and solution spaces. But you can sympathize with a product manager who, having given the designers a problem to solve, finds them questioning the assignment and insisting on traveling all over the world to seek deeper understanding. Even when the designers start focusing upon the problem, they do not seem to make progress, but instead develop a wide variety of ideas and thoughts, many only half-formed, many clearly impractical. All this can be rather unsettling to the product manager who, concerned about meeting the schedule, wants to see immediate convergence. To add to the frustration of the product manager, as the designers start to converge upon a solution, they may realize that they have inappropriately formulated the problem, so the entire process must be repeated (although it can go more quickly this time).

This repeated divergence and convergence is important in properly determining the right problem to be solved and then the best way to solve it. It looks chaotic and ill-structured, but it actually follows well-established principles and procedures. How does the product manager keep the entire team on schedule despite the apparent random and divergent methods of designers? Encourage their free exploration, but hold them to the schedule (and budget) constraints. There is nothing like a firm deadline to get creative minds to reach convergence.

The Human-Centered Design Process

The double-diamond describes the two phases of design: finding the right problem and fulfilling human needs. But how are these actually done? This is where the human-centered design process comes into play: it takes place within the double-diamond diverge-converge process.

There are four different activities in the human-centered design process (Figure 6.2):

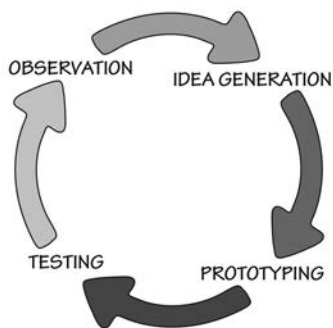


FIGURE 6.2. The Iterative Cycle of Human-Centered Design. Make observations on the intended target population, generate ideas, produce prototypes and test them. Repeat until satisfied. This is often called the *spiral method* (rather than the circle depicted here), to emphasize that each iteration through the stages makes progress.

1. Observation
2. Idea generation (ideation)
3. Prototyping
4. Testing

These four activities are iterated; that is, they are repeated over and over, with each cycle yielding more insights and getting closer to the desired solution. Now let us examine each activity separately.

OBSERVATION

The initial research to understand the nature of the problem itself is part of the discipline of design research. Note that this is research about the customer and the people

who will use the products under consideration. It is not the kind of research that scientists do in their laboratories, trying to find new laws of nature. The design researcher will go to the potential customers, observing their activities, attempting to understand their interests, motives, and true needs. The problem definition for the product design will come from this deep understanding of the goals the people are trying to accomplish and the impediments they experience. One of its most critical techniques is to observe the would-be customers in their natural environment, in their normal lives, wherever the product or service being designed will actually be used. Watch them in their homes, schools, and offices. Watch them commute, at parties, at mealtime, and with friends at the local bar. Follow them into the shower if necessary, because it is essential to understand the real situations that they encounter, not some pure isolated experience. This technique is called *applied ethnography*, a method adapted from the field of anthropology. Applied ethnography differs from the slower, more methodical, research-oriented practice of academic anthropologists because the goals are different.

For one, design researchers have the goal of determining human needs that can be addressed through new products. For another, product cycles are driven by schedule and budget, both of which require more rapid assessment than is typical in academic studies that might go on for years.

It's important that the people being observed match those of the intended audience. Note that traditional measures of people, such as age, education, and income, are not always important: what matters most are the activities to be performed. Even when we look at widely different cultures, the activities are often surprisingly similar. As a result, the studies can focus upon the activities and how they get done, while being sensitive to how the local environment and culture might modify those activities. In some cases, such as the products widely used in business, the activity dominates. Thus, automobiles, computers, and phones are pretty standardized across the world because their designs reflect the activities being supported.

In some cases, detailed analyses of the intended group are necessary. Japanese teenage girls are quite different from Japanese women, and in turn, very different from German teenage girls. If a product is intended for subcultures like these, the exact population must be studied. Another way of putting it is that different products serve different needs. Some products are also symbols of status or group membership. Here, although they perform useful functions, they are also fashion statements. This is where teenagers in one culture differ from those of another, and even from younger children and older adults of the same culture. Design researchers must carefully adjust the focus of their observations to the intended market and people for whom the product is intended.

Will the product be used in some country other than where it is being designed? There is only one way to find out: go there (and always include natives in the team). Don't take a shortcut and stay home, talking to students or visitors from that country while remaining in your own: what you will learn is seldom an accurate reflection of the target population or of the ways in which the proposed product will actually be used. There is no substitute for

direct observation of and interaction with the people who will be using the product.

Design research supports both diamonds of the design process. The first diamond, finding the right problem, requires a deep understanding of the true needs of people. Once the problem has been defined, finding an appropriate solution again requires deep understanding of the intended population, how those people perform their activities, their capabilities and prior experience, and what cultural issues might be impacted.

DESIGN RESEARCH VERSUS MARKET RESEARCH

Design and marketing are two important parts of the product development group. The two fields are complementary, but each has a different focus. Design wants to know what people really need and how they actually will use the product or service under consideration. Marketing wants to know what people will buy, which includes learning how they make their purchasing decisions. These different aims lead the two groups to develop different methods of inquiry. Designers tend to use qualitative observational methods by which they can study people in depth, understanding how they do their activities and the environmental factors that come into play. These methods are very time consuming, so designers typically only examine small numbers of people, often numbering in the tens.

Marketing is concerned with customers. Who might possibly purchase the item? What factors might entice them to consider and purchase a product? Marketing traditionally uses large-scale, quantitative studies, with heavy reliance on focus groups, surveys, and questionnaires. In marketing, it is not uncommon to converse with hundreds of people in focus groups, and to question tens of thousands of people by means of questionnaires and surveys.

The advent of the Internet and the ability to assess huge amounts of data have given rise to new methods of formal, quantitative market analysis. “Big data,” it is called, or sometimes “market analytics.” For popular websites, A/B testing is possible in which two potential variants of an offering are tested by giving

some randomly selected fraction of visitors (perhaps 10 percent) one set of web pages (the A set); and another randomly selected set of visitors, the other alternative (the B set). In a few hours, hundreds of thousands of visitors may have been exposed to each test set, making it easy to see which yields better results. Moreover, the website can capture a wealth of information about people and their behavior: age, income, home and work addresses, previous purchases, and other websites visited. The virtues of the use of big data for market research are frequently touted. The deficiencies are seldom noted, except for concerns about invasions of personal privacy. In addition to privacy issues, the real problem is that numerical correlations say nothing of people's real needs, of their desires, and of the reasons for their activities. As a result, these numerical data can give a false impression of people. But the use of big data and market analytics is seductive: no travel, little expense, and huge numbers, sexy charts, and impressive statistics, all very persuasive to the executive team trying to decide which new products to develop. After all, what would you trust—neatly presented, colorful charts, statistics, and significance levels based on millions of observations, or the subjective impressions of a motley crew of design researchers who worked, slept, and ate in remote villages, with minimal sanitary facilities and poor infrastructure?

The different methods have different goals and produce very different results. Designers complain that the methods used by marketing don't get at real behavior: what people say they do and want does not correspond with their actual behavior or desires. People in marketing complain that although design research methods yield deep insights, the small number of people observed is a concern. Designers counter with the observation that traditional marketing methods provide shallow insight into a large number of people.

The debate is not useful. All groups are necessary. Customer research is a tradeoff: deep insights on real needs from a tiny set of people, versus broad, reliable purchasing data from a wide range and large number of people. We need both. Designers understand what people really need. Marketing understands what

people actually buy. These are not the same things, which is why both approaches are required: marketing and design researchers should work together in complementary teams.

What are the requirements for a successful product? First, if nobody buys the product, then all else is irrelevant. The product design has to provide support for all the factors people use in making purchase decisions. Second, once the product has been purchased and is put into use, it must support real needs so that people can use, understand, and take pleasure from it. The design specifications must include both factors: marketing and design, buying and using.

IDEA GENERATION

Once the design requirements are determined, the next step for a design team is to generate potential solutions. This process is called *idea generation*, or *ideation*. This exercise might be done for both of the double diamonds: during the phase of finding the correct problem, then during the problem solution phase.

This is the fun part of design: it is where creativity is critical. There are many ways of generating ideas: many of these methods fall under the heading of “brainstorming.” Whatever the method used, two major rules are usually followed:

- **Generate numerous ideas.** It is dangerous to become fixated upon one or two ideas too early in the process.
- **Be creative without regard for constraints.** Avoid criticizing ideas, whether your own or those of others. Even crazy ideas, often obviously wrong, can contain creative insights that can later be extracted and put to good use in the final idea selection. Avoid premature dismissal of ideas.

I like to add a third rule:

- **Question everything.** I am particularly fond of “stupid” questions. A stupid question asks about things so fundamental that everyone assumes the answer is obvious. But when the question is taken seriously, it often turns out to be profound: the obvious often is not ob-

vious at all. What we assume to be obvious is simply the way things have always been done, but now that it is questioned, we don't actually know the reasons. Quite often the solution to problems is discovered through stupid questions, through questioning the obvious.

PROTOTYPING

The only way to really know whether an idea is reasonable is to test it. Build a quick prototype or mock-up of each potential solution. In the early stages of this process, the mock-ups can be pencil sketches, foam and cardboard models, or simple images made with simple drawing tools. I have made mock-ups with spreadsheets, PowerPoint slides, and with sketches on index cards or sticky notes. Sometimes ideas are best conveyed by skits, especially if you're developing services or automated systems that are difficult to prototype.

One popular prototype technique is called "Wizard of Oz," after the wizard in L. Frank Baum's classic book (and the classic movie) *The Wonderful Wizard of Oz*. The wizard was actually just an ordinary person but, through the use of smoke and mirrors, he managed to appear mysterious and omnipotent. In other words, it was all a fake: the wizard had no special powers.

The Wizard of Oz method can be used to mimic a huge, powerful system long before it can be built. It can be remarkably effective in the early stages of product development. I once used this method to test a system for making airline reservations that had been designed by a research group at the Xerox Corporation's Palo Alto Research Center (today it is simply the Palo Alto Research Center, or PARC). We brought people into my laboratory in San Diego one at a time, seated them in a small, isolated room, and had them type their travel requirements into a computer. They thought they were interacting with an automated travel assistance program, but in fact, one of my graduate students was sitting in an adjacent room, reading the typed queries and typing back responses (looking up real travel schedules where appropriate). This simulation taught us a lot about the requirements for such a system. We learned, for example, that people's sentences were very different from the ones

we had designed the system to handle. Example: One of the people we tested requested a round-trip ticket between San Diego and San Francisco. After the system had determined the desired flight to San Francisco, it asked, “When would you like to return?” The person responded, “I would like to leave on the following Tuesday, but I have to be back before my first class at 9 AM.” We soon learned that it wasn’t sufficient to understand the sentences: we also had to do problem-solving, using considerable knowledge about such things as airport and meeting locations, traffic patterns, delays for getting baggage and rental cars, and of course, parking—more than our system was capable of doing. Our initial goal was to understand language. The studies demonstrated that the goal was too limited: we needed to understand human activities.

Prototyping during the problem specification phase is done mainly to ensure that the problem is well understood. If the target population is already using something related to the new product, that can be considered a prototype. During the problem solution phase of design, then real prototypes of the proposed solution are invoked.

TESTING

Gather a small group of people who correspond as closely as possible to the target population—those for whom the product is intended. Have them use the prototypes as nearly as possible to the way they would actually use them. If the device is normally used by one person, test one person at a time. If it is normally used by a group, test a group. The only exception is that even if the normal usage is by a single person, it is useful to ask a pair of people to use it together, one person operating the prototype, the other guiding the actions and interpreting the results (aloud). Using pairs in this way causes them to discuss their ideas, hypotheses, and frustrations openly and naturally. The research team should be observing, either by sitting behind those being tested (so as not to distract them) or by watching through video in another room (but having the video camera visible and after describing the procedure). Video recordings of the tests are often quite valuable, both for later showings to team members who could not be present and for review.

When the study is over, get more detailed information about the people's thought processes by retracing their steps, reminding them of their actions, and questioning them. Sometimes it helps to show them video recordings of their activities as reminders.

How many people should be studied? Opinions vary, but my associate, Jakob Nielsen, has long championed the number five: five people studied individually. Then, study the results, refine them, and do another iteration, testing five different people. Five is usually enough to give major findings. And if you really want to test many more people, it is far more effective to do one test of five, use the results to improve the system, and then keep iterating the test-design cycle until you have tested the desired number of people. This gives multiple iterations of improvement, rather than just one.

Like prototyping, testing is done in the problem specification phase to ensure that the problem is well understood, then done again in the problem solution phase to ensure that the new design meets the needs and abilities of those who will use it.

ITERATION

The role of iteration in human-centered design is to enable continual refinement and enhancement. The goal is rapid prototyping and testing, or in the words of David Kelly, Stanford professor and cofounder of the design firm IDEO, "Fail frequently, fail fast."

Many rational executives (and government officials) never quite understand this aspect of the design process. Why would you want to fail? They seem to think that all that is necessary is to determine the requirements, then build to those requirements. Tests, they believe, are only necessary to ensure that the requirements are met. It is this philosophy that leads to so many unusable systems. Deliberate tests and modifications make things better. Failures are to be encouraged—actually, they shouldn't be called failures: they should be thought of as learning experiences. If everything works perfectly, little is learned. Learning occurs when there are difficulties.

The hardest part of design is getting the requirements right, which means ensuring that the right problem is being solved, as

well as that the solution is appropriate. Requirements made in the abstract are invariably wrong. Requirements produced by asking people what they need are invariably wrong. Requirements are developed by watching people in their natural environment.

When people are asked what they need, they primarily think of the everyday problems they face, seldom noticing larger failures, larger needs. They don't question the major methods they use. Moreover, even if they carefully explain how they do their tasks and then agree that you got it right when you present it back to them, when you watch them, they will often deviate from their own description. "Why?" you ask. "Oh, I had to do this one differently," they might reply; "this was a special case." It turns out that most cases are "special." Any system that does not allow for special cases will fail.

Getting the requirements right involves repeated study and testing: iteration. Observe and study: decide what the problem might be, and use the results of tests to determine which parts of the design work, which don't. Then iterate through all four processes once again. Collect more design research if necessary, create more ideas, develop the prototypes, and test them.

With each cycle, the tests and observations can be more targeted and more efficient. With each cycle of the iteration, the ideas become clearer, the specifications better defined, and the prototypes closer approximations to the target, the actual product. After the first few iterations, it is time to start converging upon a solution. The several different prototype ideas can be collapsed into one.

When does the process end? That is up to the product manager, who needs to deliver the highest-possible quality while meeting the schedule. In product development, schedule and cost provide very strong constraints, so it is up to the design team to meet these requirements while getting to an acceptable, high-quality design. No matter how much time the design team has been allocated, the final results only seem to appear in the last twenty-four hours before the deadline. (It's like writing: no matter how much time you are given, it's finished only hours before the deadline.)