PART TWO

DESIGN PROCESS

CHAPTERS

CHAPTER 2: DEFINING AND RESEARCHING THE PROBLEM

Chapter outline

- Developing a research plan
- Conducting the initial client interview
- Using print and electronic sources for research
- Analyzing competitive and model products
- Defining user needs
- Interviewing experts
- Iterating your research and writing it up

Even though your client has probably already defined the problem you'll be working on, you should take time to do research and come up with your own definition. There are two reasons for this: (1) The client may not have defined the problem correctly, and (2) Studying the problem gives you a better grasp of the project.

To understand the importance of correctly defining the problem, consider the project described in Chapter 1. What the client defined as the problem was actually a solution: an under-the-desk revolving file cabinet to help her organize her papers. After observing that she was visually oriented, however, the design team concluded that she would do better with a system that would allow her to see her papers at a glance. In other words, they defined the problem in "solution-independent" terms.

To appreciate the value of extensively researching the problem, consider a second scenario. A design team was charged with preventing a child with Down Syndrome from repeatedly chewing on her fingers, a behavior that was resulting in recurring infections. Although the mother had presented the problem clearly, team members felt they needed to make themselves experts to solve the problem in the best way. So they observed the child, talked to the child's physical therapist, and read studies on the behavior and development of Down Syndrome children.

Early in a design project, you can use the following methods to research a problem and develop expertise:

- interview the client
- gather background information using both print and online sources
- analyze competitive and model products
- define user needs by interviewing and observing users, and by developing user profiles and scenarios
- interview experts
- iterate your research process

2.1 DEVELOPING A RESEARCH PLAN

You need to plan your research carefully to understand all relevant aspects of the problem and gather information efficiently. The best way to develop a useful research plan is to spend a team meeting doing the following:

1. Generate a list of questions you need to answer to become experts on the design problem.
2. Group related questions into categories.
3. Identify likely sources to answer the questions.
4. Assign each team member questions to research.

Each of these steps is discussed below.

2.1.1 Generate a list of questions

Begin your research by formulating questions you need answered in order to understand the design problem thoroughly. To avoid overlooking any aspect, generate every possible question you can think of. You can weed out overlapping questions later.

Here is an example of questions generated by a team designing a device to enable people with severe arthritis to crochet with one hand:

Example 2.1: List of research questions

What is the extent of the arthritis? Is only one hand affected?

Does the disease affect other areas of the body?

Toward what age groups is the device targeted?

Are there other users and stakeholders, besides the arthritic person, that we need to consider?

What aspects of crocheting do the client, users, and other user groups want the device to improve?

How is crocheting normally done?

How often and for what length of time do users want to crochet?

How easy will it be for a person to adapt to such a device or learn to use it? Who, if anybody, will teach the person to use it?

What kinds of materials could we use and which are safe?

What devices already exist for arthritic individuals? What are the pros and cons of these devices?

What would be the ideal size of the device?

How durable does it have to be?

Should it have any specific safety features?

How large a space or area do people need to crochet?

If they don't use a commercial adaptive device, how do users currently address the problem? Does what they're doing work?

In what settings will the device be used?

Where could the device be placed when not in use?

What safety concerns do the user and others (relatives, physicians, physical therapists, etc.) have? Why?

What social and emotional factors do we need to consider?

What might limit the usability of the device for the user?

How easy must the device be to use?

How intuitive must using the device be?

How much learning/practice is required to use the device?

What's the best material to use for the crochet hook? What are the preferred dimensions of crochet hooks used for a similar purpose?

What other products exist for people with the use of only one hand?

Would the user typically use different sizes of crochet hooks? Can users coordinate both hands?

How much should the hook cost?

Will it be mass-produced or custom-made?

What kinds of arthritis cause the loss of use of one hand? How does the arthritis cause this condition?

2.1.2 Group related questions into categories

That long list of questions is useful but difficult to work with, so the team grouped related questions into the following categories:

Example 2.2: Categorized list of questions

- Causes and extent of the disability

  What is the extent of the arthritis? Is only one hand affected?

  Does the disease affect other areas of the body?

  What social and emotional factors do we need to consider?

  Can users coordinate both hands?

  What kinds of arthritis cause the loss of use of one hand? How does the arthritis cause this condition?

- User groups

  Toward what age groups is the device targeted?

  Are there other users and stakeholders, besides the arthritic person, that we need to consider?

- Competitive and model products

  What devices already exist for arthritic individuals? What are the pros and cons of these devices?

  If they don't use a commercial adaptive device, how do users currently address the problem? Does what they're doing work?

  What's the best material to use for a crochet hook?

  What are the preferred dimensions of crochet hooks used for a similar purpose?

  What other products exist for people with the use of only one hand?

- Safety

  What kinds of materials are safe to use?

  What safety concerns do the user and others (relatives, physicians, physical therapists, etc.) have? Why?

- Ease of use

  How is crocheting normally done?

  What aspects of crocheting would the client, users, and other user groups want the device to improve?

  How easy would it be for a person to adapt to such a device or to learn to use it? Who, if anybody, will teach the person to use it?

  What might limit the usability of the device for the user?

  How easy must the device be to use?

  How intuitive must using the device be?

  How much learning/practice is required to use the device?

- Conditions of use

  How often and for what length of time would they want to crochet?

  What would be the ideal size of the device?

How durable does it have to be?

How large a space or area do people need to crochet?

In what settings will the device be used?

Where could the device be placed when not in use?

Would the user typically use different sizes of crochet hooks?

- Client constraints

  How much should it cost?

  Will it be mass-produced or custom-made?

2.1.3 Identify likely sources to answer the questions

You will need to consult a variety of sources to answer these questions. The sources that the crochet team decided to consult appear in parentheses after each category of research questions below. For some sources, the team was intentionally vague until members obtained specific names and titles.

Example 2.3: List of potential sources

- Causes and extent of the disability (client, physical therapists, medical textbooks)
- User groups (client)
- Competitive and model products (client; physical therapists; users; salespeople at craft shops; websites of manufacturers, retailers, the U.S. Patent Office, and crocheters).
- Safety (salespeople at craft shops, physical therapists, users, physicians, materials science professors)
- Ease of use (users, client, crocheters, physical therapists)
- Conditions of use (users, crocheters)
- Client constraints (client)

2.1.4 Assign research questions to team members

You may assign questions based on categories or sources. For instance, if an entire category of questions can be answered by consulting medical textbooks and databases, you might assign that category to a single team member. In other cases, you may need to consult a single source to answer questions in several categories. Your client, for instance, can usually answer a wide range of questions, so you might assign one or two team members to write interview guides containing questions from multiple categories. The next section of this chapter explains how to write interview guides that you can use to gather information from clients, users, and experts.

Finally, you should document team members' research assignments in a Responsibility Allocation Matrix (RAM) chart, which is discussed in Chapter 16.

2.2 CONDUCTING THE INITIAL CLIENT INTERVIEW

The initial client interview serves to help you begin to define the design problem and learn about user needs and other requirements. To gain as much as possible from this interview and to establish a good working relationship with your client, you should prepare carefully and follow the guidelines below.

2.2.1 Make an appointment

Before you call the client, list times that one or more members can be present. Be flexible: Your client is probably very busy, so you will need to accommodate yourselves to his/her schedule. Tell your client that the interview will take about an hour. You may finish early, but that's better than not scheduling enough time.

2.2.2 Assign roles

If more than one team member will attend the interview, decide who will ask the questions and who will take notes. Even if you tape record the interview, you should still have a note-taker in case there's a mechanical problem with the recorder. Also, be sure to get the client's permission to tape record.

2.2.3 Gather information about the project

Gather information that will allow you to ask relevant and useful questions. You can do this in several ways:

- Based on information you receive beforehand (for instance, a client's written description of the project), brainstorm a list of needs for various user groups.
- If the client is affiliated with a company or other organization, research it on the Internet or through other sources.
- Research competitive products.
- If you know that previous EDC teams have worked on the project, review their reports. Your instructors can help you gain access to those reports.

2.2.4 Write the interview guide

An interview guide will help you thoroughly understand what the client wants the design to achieve, who the users and other stakeholders are, what they need, and what constraints affect your design.

Although your questions will depend on the nature of your project, the Sample Interview Guide below gives you some helpful generic questions that you should adapt to meet the needs of your project.

After the interview, a team member should draft a concise, well-organized summary for team review and records. In spring quarter, you will send this summary to your client after your instructors review it.

Your team should then meet to decide your next steps on the project, based on the information gathered at the interview.

Example 2.4: Sample interview guide

(Note: You will need to adapt these generic questions to suit your specific client and project.)

Begin your guide by introducing your team and briefly explaining what you will provide for your client: (1) a written report and final oral presentation that explain your design concept, research, and recommended next steps, and (2) a prototype that shows key functions of your design but is not necessarily a fully functional product.

1. Questions about the client (these are particularly important when your client represents a business or other organization):
    - What does your organization do?
    - Who is served by your organization?
    - What is your position in the organization?
2. Questions about the problem:
    - What is the problem that you would like us to solve?
    - Why is this a problem?
    - Have you or others taken steps to solve this problem? If so, what were the results, and were they positive or negative?
    - If the problem involves improving an existing product or system: What do you like about the current product/system and why? What don't you like about it and why?
3. Questions about users and other stakeholders:
    - Who will be the end users of this design? (NOTE: Encourage your client to give you specific demographics: age range, gender, level of experience, geographic area, etc.)
    - Can you give us the names of users and their contact information so we can interview them later in the project?
    - What other individuals or groups will interact with or have an interest in this design? For example, does someone have to clean, manufacture, or sell it?
4. Questions about requirements, features, constraints, and other designs:
    - What requirements do you have for the design? Why are they important to you?

- Are there any specific features you think the design should have? Why are those features important to you?
- Are there any constraints on the design that we must take into account?
- Are there designs currently on the market that we should look at? (NOTE: If you have already researched similar designs, you might want to show the client pictures of them to solicit likes and dislikes.)
- Have previous designers worked on this problem for you? What designs did they develop? What were the strengths and weaknesses of those designs? May we have access to the designers' final prototypes?

5. Questions about research:
   - Can you suggest experts or other people we should talk to regarding the project?
   - Can you suggest relevant books, articles, and websites?
6. Questions about the follow-up:
   - How often would you like to receive email progress updates?
7. Wrapping up the interview: End on a positive note by thanking the client and expressing enthusiasm about the project.

2.2.5 Write a summary of findings from the client interview

After the interview, you should summarize what you learned from the interview in a brief, well-organized report. This report serves four functions:

It provides team members who could not be at the interview with crucial information they need in order to participate actively on the project.

It provides your instructors with an understanding of the project so that they can better advise you on your research and design process.

It offers you an opportunity to share the summary with your client to verify that you understand the problem correctly and did not misinterpret any information from the meeting.

It serves as a permanent record of your research and should be included in your project notebook.

In writing the report, you will need to organize your findings so that readers can easily find the key information they are looking for. Despite having a well-organized list of interview questions, you may find that your client at times threw out information helter-skelter. That means that you can't just type up your notes in the order in which you wrote them down. Instead, you'll need to organize them into logical categories. These categories will probably not be the same as the categories you used to organize your questions in the interview script.

For an example of one team's summary of their first client meeting, see Appendix A.

2.3 USING PRINT AND ELECTRONIC SOURCES FOR RESEARCH

All EDC projects require you to do research—not just direct meetings with clients and users, but also research from print and electronic sources.

Print sources include textbooks, handbooks, specialized encyclopedias, scientific journals, trade magazines, newspapers, catalogues, pamphlets, and government publications. There are two reasons to consult print sources: (1) Often, the information you need is available only in print. (2) Print sources often provide greater detail than do websites and interviews. Print sources are especially useful for getting background information and technical information. For example, if you want background information about a medical condition, it's better to use a textbook or an authoritative encyclopedia than a source like Wikipedia or How Stuff Works, which are fine for personal reference but aren't considered authoritative sources for a serious report.

However, many electronic resources are highly respectable. Electronic sources include websites, library catalogs, indexes to periodicals, CD-ROMs, networked databases and electronic magazines, newspapers, and journals. Northwestern subscribes to a huge number of electronic resources that can be accessed through the NU library website: http://er.library.northwestern.edu. Many of these indexes could lead you to excellent information about medical conditions. In addition, a website such as that of the Center for Disease Control is very credible. Below is a list of online sources that EDC students have found particularly useful.

2.3.1 Useful online sources for EDC projects

Patent information

These sources offer a wealth of information about competitive and model products that will be useful in many of your spring quarter projects.

- Patent and Trademark Office
  http://www.uspto.gov/
- Delphion
  http://www.delphion.com/simple

Federal regulatory agencies

Particularly useful for projects involving consumer safety issues are:

- U.S. Consumer Product Safety Commission: http://www.cpsc.gov/search.html
- National Highway Traffic Safety Administrations: http://www.nhtsa.dot.gov/

Suppliers of materials and parts

Useful in selecting materials and components for your spring quarter prototypes are:

- Thomas Register of American Manufacturers http://www.thomasregister.com
- McMaster-Carr Supply Company http://www.mcmaster.com

2.3.2 Guidelines for working with print and electronic sources

No matter what kind of source you use, you must evaluate it for credibility.

For print sources consider:

- The author's credentials.
- The date of publication. Make sure information isn't outdated.
- Whether articles appeared in a refereed journal (one in which all articles must be judged by experts before being accepted for publication).

For websites consider:

- What organization sponsors the site and whether that organization has credibility. A team designing a device to help prevent hamstring injuries was wise in researching the physiology of such injuries on the site of the American Academy of Orthopaedic Surgeons (AAOS) rather than on a site operated by a company that sells athletic training videos.
- When the site was last updated. The longer ago the site was updated, the less reliable it is as a source.
- What the credentials are of an author whose information appears on a site.
- How well information on a site is documented.
- Whether the site has an obvious bias that makes its objectivity and reliability suspect.

A team working on a project to design a wheelchair ramp for a local church was investigating the pros and cons of portable and permanent ramps. They

found a website for a company that described itself in this way: "Low cost modular ramps: we provide affordable, easily accessible ramps for wheelchairs, scooters and power chairs. Compare us to wood & concrete ramps for the least expensive ramp system." A page on the site includes the following information that reads in its entirety:

Example 2.5: Website that lacks credibility

Modular Ramps vs. Wood and Concrete Ramps

Wood rots and wet wood is slippery.
Carpenters and home improvement contractors have limited skills in ramp design.
Wood and concrete require footings and excavation of your property.
Finding and hiring a contractor takes much longer.
Wood and concrete are PERMANENT structures
Such permanent ramps are considered home modifications and are not reimbursable as Durable Medical Equipment (DME).
Permanent ramps devalue the resale value of your home.
Permits are required for permanent ramps.

The team wisely decided not to use the information because the sponsor of the website sells portable aluminum ramps and therefore is likely to be biased against permanent ones. In addition, no references are provided to support the validity of the claims about the downsides of permanent ramps.

Keep records of all your sources so you can reference them in your reports and proposals. These references, including full bibliographic information for each source, give your written work credibility. All reports that reference sources should include citations and a reference list (see Chapter 25).

2.4 ANALYZING COMPETITIVE AND MODEL PRODUCTS

Much of what you will be searching for as you begin your research are existing products that fulfill the same or similar functions as needed in your design. Analyzing existing products allows you to identify strengths and weaknesses of previous solutions to your design problem and helps you understand why and how well these products work.

A competitive product is one that is geared to your users and their intended application, regardless of the technology it employs. For example, several teams recently designed a utensil that would enable stroke survivors with the use of only one hand to cut food when they dine in restaurants. Using the Internet, the teams found pictures of and specifications for several existing products—a wide-bladed knife, a t-handle rocker, a saw-shaped knife, and others—intended for the same user group and purpose. The most valuable

competitive product is usually the one that your design is intended to replace. This may include a previous EDC project.

A model product is one that performs functions similar to the product you are designing but is intended for different users and applications. For example, the teams who worked on the food-cutting utensil analyzed manual rotary fabric cutters used by quilters and pruning shears used by gardeners to gather ideas about cutting for their design. You also can study model products for subsystems of your design. For example, if you are designing a coffee pot that shuts off automatically, you may want to analyze the auto-shutoff system in electric irons and alarm clocks to determine if these technologies apply to your product.

2.4.1 Analyzing competitive products

Begin by analyzing the product you've been asked to redesign or others that address the same user needs. To start your analysis:

- Obtain the product and/or detailed pictures. Here are some examples:
  - Several teams were designing an improved device to hold wheelchairs steady while players batted during wheelchair softball games. The teams examined the current device to see how it worked, what it was made of, and how it was constructed. They also took photos from several angles and made a dimensioned drawing for further analysis.
  - The teams working on the food-cutting utensil were not able to obtain the actual competitive products, but they found detailed photos and specifications on the websites of various retailers and manufacturers as well as dimensioned drawings from the U.S. Patent Office website.
  - A team redesigning a crowded office space photographed the office from several angles, measured the dimensions of each cubicle and furnishing, and made a detailed, dimensioned drawing of the office.
- Analyze the key features to find out why they were used and how well they function. Here are examples of this analysis from the three projects listed above:
  - The wheelchair softball teams learned several things from their examination of the existing device: 1) It consisted of plywood and two-by-fours that had been nailed together. From this, the team deduced that the device needed to be inexpensive and easy for the players to build. 2) The dimensions were such that the wheelchair could be stabilized but not held completely still. From this, the team inferred that batters probably wanted some degree of chair movement while they swung. 3) The device was duct-taped at a few points, indicating that it had broken during use. As a result of this observation, the team decided that durability

should be an important requirement. Of course, the team verified these and many other inferences and decisions with their client and users, but the key point is that they might not have even thought to ask about these things had they not analyzed the product first.

- The office redesign team was very glad they took photos and made dimensioned drawings of the office, because later in the project they could refer to them when deciding on the dimensions of their own design alternatives.
- The food-cutting utensil team learned a great deal about the advantages and disadvantages of competitive products by analyzing the photos and specifications they found on websites. The following example provides the team's analysis of two competitive products; it comes from a short report summarizing the results of their research:

Example 2.6: Analysis of two competitive products

The Rocker is designed to be used in a rocking motion to cut the food rather than the "dragging" method used by most knives. Certain models of the Rocker are collapsible, making it easy to transport to restaurants and other dining locations. It simply folds into its ergonomic handle, as in a penknife, to make it easy and safe to carry. A key disadvantage of this design is that it requires a large amount of upper leverage to be effective, which is hard for older people to achieve, especially while sitting down in a dining setting.

The Saw is designed so that the handle of the knife is perpendicular to the blade for maximum leverage and ease in cutting. Like a saw cutting a piece of wood, this model uses the dragging motion to cut the piece of food. It is designed to transfer the cutting power from the arm to the center of the blade with minimal effort. The grip is large, comfortable, and fits naturally in the hand. Though this design may seem effective, it has two major flaws. First, it needs a strong stabilization device to keep the food from sliding along with the knife. And it requires a long blade to be effective, which is inconvenient for someone who wants to travel with the utensil.

The team's analysis of competitive products helped them to focus on key problems they would have to solve, such as: How would they stabilize the food if their design used a conventional sawing motion? What kind of device would minimize the upper arm strength needed to cut food? What are the most comfortable kinds of grips for various cutting devices? How would they make the device portable? In addition, the analysis gave them ideas for designing the subsystems of their product, such as a penknife design to retract the blade.

Because you will use the results of your competitive products analysis to make design decisions, you must take care to be accurate. The team redesigning the crowded office space paid dearly for inaccuracy when members

learned fairly late in the design process that they had mismeasured the size of the desks. As a result, the cubicles they had designed would be too small to accommodate the desks, so they had to go back to the drawing board and lost valuable time.

2.4.2 Analyzing model products

Look for model products that use technologies to perform functions similar to those of your product. Analyze these model products by asking "how?" A team designing a bicycle headlight that would quickly attach to and detach from handlebars of any diameter got ideas by analyzing vise-grip pliers, bungee cords, test tube clamps and other products. The team asked, "How do these devices perform an attaching or clamping function? Are any of these methods useful for our design?" This type of analysis will help you develop specifications for your design and give you ideas for technologies and materials you can use.

You can also analyze model products later in the design process. One team working on the food-cutting utensil decided to focus on a scissors-like design. The team's members wanted to make the scissors grips comfortable to hold, so they went to a store that sold a variety of scissors, held the scissors themselves, and analyzed the features that added to or detracted from comfort. They even bought the most comfortable pair of scissors and used the grips to build a mockup to test with stroke patients.

2.5 DEFINING USER NEEDS

The success of a design depends on its ability to meet user needs. An innovative design will address unmet needs, and meet more needs or meet needs better than existing designs do. Therefore, identifying users and understanding their needs are crucial elements of the design process.

If you have followed the process outlined thus far for interviewing the client, using print and online resources to do research, and analyzing competitive and model products, you already will have learned a good deal about users and their needs. This section of the textbook focuses on how to benefit from user interviews, user observations, and user profiles and scenarios.

2.5.1 Interviewing users about their needs

Keep in mind that an interview is more than a conversation. It is scripted dialog that has been carefully written to ensure completeness and consistency in user interviews, and to allow you to compare your findings and synthesize your information.

You will get the most useful, in-depth responses by interviewing users in person, or, if that's not possible, by phone. One-on-one interviews provide the opportunity for users to delve into the "why" behind their answers. Although having users fill out surveys is less time-consuming, the results tend to be spotty and superficial because people aren't as eager to reply to emails or take the time to write out their answers when you aren't there to encourage their responses. A team that redesigned a crowded office space tried to save time by dropping off surveys for the employees to fill out on their own. The team received only a few responses, and those contained unhelpful comments such as, "It's hard to move around in here," which the team already knew. As a result, team members ended up doing one-on-one interviews that yielded detailed explanations of problems and possible solutions.

Often, you will combine your interview with a user observation, which is explained in the following section.

1. Find users to interview. These include end-users as well as those who will manufacture, maintain, service, or sell the product. To find users to interview:
    - Ask your client to put you in touch with users of current versions of the product.
    - Ask your instructors how to get in touch with users.
    - Ask family members and friends who fit your user profile if they're willing to be interviewed.
2. Make an appointment. To improve your chances of securing an interview:
    - Get an early start in scheduling interviews: Some contacts can meet with you on short notice, but others require a lead-time of one to two weeks.
    - State who referred you. People are more willing to meet with you when someone they know and respect has referred them. When saying who referred you, use proper titles (e.g., Mr., Ms., Professor, Dean).
    - Motivate people to say "yes." People are more willing to help when they understand the importance of their participation. Therefore, identify yourself as an NU engineering student and explain the nature of your project and the purpose of the interview.
    - Ask for a response by a certain time. People tend to work better when given a deadline, so politely indicate the date by which you need to conduct the interview.
    - Know when to follow up. When making initial contact—whether by phone, voice mail or email— state that you will follow up in a few days.
    - Use professional language. When contacting a potential interviewee by phone, be businesslike rather than too familiar or conversational. If you're communicating by email, double-check your grammar and spelling. When addressing individuals other than students or peers,

use proper titles (e.g., Mr., Ms., Professor, Dean). If you're unsure of a person's title, do a little research or ask the individual how he or she prefers to be addressed.

3. Write an interview guide, Your guide should include the following:
   - A brief, introductory explanation of your project and the purpose of the interview. You might say something like, "We are working on a new design for a child car seat and would like to learn about your experiences with the car seat you own," or "We want to find out your thoughts about a product we are designing: a deck that would fit over a bathtub to create more usable space in a bathroom."
   - Demographic questions. Ask for information relevant to your users and project. For instance, a team designing an improved child car seat asked parents how many children they had and how many car seats they had owned in order to establish the parents' level of experience with the product.
   - Questions about existing products. Begin with easy questions such as, "What features do you like about your current child car seat?" "Why do you like those features?" "What features do you dislike?" "Why do you dislike them?" Then move on to questions that require more thought, such as those about aspects of the product you want to improve on: "How do you get your child from the car seat to the stroller?" "How difficult or easy is that transition?"
   - Questions about opportunities and requirements for your design. Again, begin with easy-to-answer questions: "What advantages would you find in a car seat that converts to a stroller?" "What concerns would you have about such a product?" Then move on to more probing, difficult questions: "What do you think is the most convenient way to unfold the seat into a stroller?" Make sure to ask questions that your users are capable of answering, rather than those that require expertise.

NOTE: When appropriate, ask questions that users can respond to using numerical ratings or rankings so you can more easily compare and tabulate responses. To determine the most and least important requirements for their design, the convertible car seat team might ask users to rank requirements in numerical order:

Rank the following requirements for a convertible car-seat/ stroller in order of importance to you, with a ranking of 5 being the most important and a 1 being the least important:
___Safety ___Cost ___Appearance ___Ease of Use ___Size/Weight

Alternatively, team members might decide that because some requirements are of equal importance, they should ask users to rate each requirement:

Rate each of the following requirements on a scale of 1 to 6, with 6 being extremely important and 1 being unimportant:						
Safety	1	2	3	4	5	6
Cost	1	2	3	4	5	6
Appearance	1	2	3	4	5	6
East of Use	1	2	3	4	5	6
Size/Weight	1	2	3	4	5	6

Make sure that your questions are worded in an unambiguous way. For instance, don't ask, "On a scale of 1 to 5, with 5 being best, how do you rate your current stroller?" because you will have no way of knowing what criteria your interviewee is using for the rating. Instead, ask, "On a scale of 1 to 5, with 5 being best, how do you rate your current stroller in its ease of folding and unfolding?" Similarly, when you ask questions that may have varying interpretations, be sure to follow up with clarifying questions. For instance, it may be useful to ask a broad question like, "How versatile is your current stroller?" because your interviewee may interpret the question in an unexpected way that yields valuable information for you. You may have meant that to be a question about the range of height and weight in children that the stroller can accommodate, while your interviewee interpreted the question to be about the varying weather and other conditions in which the stroller can be used, something you didn't think to ask but are now glad to have learned. Just be sure to include a clarifying question like, "What range of height and weight in children has your stroller been able to accommodate?"

4. Decide on a method of recording answers to questions. Options include writing them in a notebook (or below the questions in the interview guide) and tape-recording them. If you do the latter, also take notes in case your recorder malfunctions. Also be sure you obtain interviewees' permission to tape-record their answers.
5. Arrive on time – or early – for the interview!
6. Follow the guide during the interview, but be prepared to capture unexpected information. Designate someone on your team to ask questions and another to take notes in order to make this easier.
7. Follow up with a thank you. Expressing appreciation at the end of an interview is generally sufficient, but following up with a phone call or email is good professional practice and may prompt your interviewee to provide additional feedback.
8. Organize the information you've obtained. Because you will probably interview several users, you will need to sort responses into categories and tabulate the results. Consider this example. A team was designing the front passenger seat of an automobile to make it fold down so the seat-

back could be used to organize belongings and hold items for school and recreation. They asked car-owners what components they would like in such a product and then organized the results in this table (Shiao, Chen, Lee, & Srinivasan, 2003):

Example 2.7: Table summarizing user preferences

Component	# of people who want it
Kleenex holder	22
CD pouch	20
Lap desk	19
Trash receptacle	19
Insulated food pouches with cold packs	17
Pouch for ice scraper	13
One large pouch	11
Cell phone mount	11
Several small pouches	8
Expandable file / accordion folder	7
Hooks	7
Removable mirror	6
Dry erase board	6
Notepad / Post-it notes	5
Pencil pouch	5
Clipboard	1

Another team designing a patio chair for people with back problems might have devised the following template to organize comments from users about their likes and dislikes regarding existing chairs:

Example 2.8: Template for table to organize user comments

	Likes	Dislikes
User A : Getting in chair		
: Sitting		
: Getting out		
: Other		
User B : Getting in chair		
: Sitting		
: Getting out		
: Other		

Some information from user interviews may not lend itself to tabular organization. In that case, summarize the information in a series of brief, well-organized paragraphs and lists.

9. Write a memo to your team and instructors summarizing the interview results. Use main categories to group the findings most relevant to your project. Also include tables or graphs used to summarize data succinctly.

2.5.2 Observing users

Observation is another key method for understanding users and their needs. To design a better patio chair for people with back problems, watch those people getting in and out of patio chairs currently on the market: Where do they place their hands and how do they position their body as they lower themselves into the chair? Do they show signs of difficulty in performing these actions? Once they're seated, how do they move themselves into a comfortable position? How do they position their hands and body when getting out of the chair? Do they seem to have trouble doing so? By carefully observing your subjects' body language and facial expressions, you can discover things they themselves are unaware of.

You'll probably observe users early on using competitive products, and later interacting with the mockups you have built. For instance, although the patio chair team would not want to risk having a person with a back problem try to sit in their mockup of the chair, they could learn a great deal by watching a user grip mockups of the armrests in preparation for sitting down.

Prepare yourself mentally for the environment in which you will observe, whether it be a hospital, office, home, etc. This may be your first experience doing this kind of thing, and that may lead you to take a passive approach. However, you will be much better served to go in with a confident, professional attitude. In the long run, that approach is much more likely to put users at ease and make them willing to serve as subjects.

Finally, be sure to record user observations carefully. Bring the tools you need with you—camera, tape measure, graph paper, etc. Also, don't trust your memory; record the information as the observation is proceeding, and take time immediately after you leave to discuss the observations with your teammates, making further notes as you do.

To get the most out of your user observations:

1. Decide what kinds of observations will help you in your project. In other words, don't observe for the sake of observing. Ideally, observations should be done with the actual products and in the actual settings in which they are normally used.
2. Schedule observation time when necessary. Some projects don't require a specific time, such as anonymously observing people in line at Burger King. Other observations, including those that you want to videotape, require advance planning to make sure your users are available.
3. Prepare for the observation by writing a "task breakdown" or "task analysis." Amy Schwartz (Human Factors Director at IDEO Product Design)

describes this as a list of steps required to perform the task or process you will observe. This list helps you to be a more attentive observer. The following example provides a task breakdown for the patio chair project.

Example 2.9: Task breakdown

The user:

a. approaches chair
b. positions body in preparation for sitting
c. extends arm(s) to grasp chair arm(s)
d. lowers body
e. readjusts hands on the chair arms
f. swivels body
g. raises legs to rest on the bottom portion of chair
h. moves body back
i. finds comfortable position

4. Write a user observation plan. This should include:
   - Times at which each observation began and ended. The duration of the session can reveal a lot about the quality of the results.
   - A brief introduction of yourselves, the project, and the purpose of the observation. In explaining the purpose, tell users you are watching what they do to learn how to improve the design (unless you are observing anonymously) and that they are not being tested, the product is. Explain that if they can't do or find something, chances are the design is at fault. This will put them at ease so they perform the task more naturally.
   - Questions to get relevant demographic information. Avoid unnecessary or overly personal questions. For instance, there's no need to ask about gender when you can learn that simply through observation, and you may want to avoid questions about age when you are dealing with older users.
   - Tasks you would like users to perform.
   - Questions about those actions and other issues relevant to the project.
   - Measurements and other quantitative information you wish to record (and tools you will use to make those measurements)
   - Tools you will use to record what happens at the observation:
     a. Paper and pencil for simple actions involving one user at a time.
     b. Video recorder to capture and review subtle details.
     c. Digital camera for use in visual documentation and preparing a report, poster, or proposal.
     d. Tape recorder to supplement handwritten notes and capture users' comments.

e. Sketchpad or graph paper for making drawings.

f. Tape measure for recording accurate dimensions.

Note: Use photo and video recording only if your team has obtained the user(s)' consent first. Take care that the users do not feel pressured to consent. Photos or videos taken to record information should have identifying tags that say who took the photo, describe the action or object represented in the photo, and include appropriate references to human subjects (i.e. references that accord with the users' requests). Even if users have allowed you to make a photo or video record, this does NOT necessarily mean that they wish to be identified in the photo or video record. Be sure to find out if participants want you to use their names or wish to preserve their anonymity. In certain cases, you may need to use Photoshop or video editing programs to block out a user's identifying features.

For an example of a team's observation plan, see Appendix B.

5. After completing your observations, summarize the results.

- Provide an overview of key aspects of the session. Your team's record of user observations or testing should include basic elements to help your reader understand the conditions under which you conducted this research. It is especially important to provide readers with a detailed context for user testing, because the results of those tests will likely provide the basis for your team's decision to pursue one design strategy over another. Basic elements of the overview include the following:
  - Date, location, and key persons in attendance
  - Conditions of observations. For instance, were you at practice for an athletic event? In a clinical setting? At the user's home? Recognize that the context imposes certain limitations on what you can learn from that set of data (e.g., conditions in a clinic are likely to be significantly different from conditions in a user's home). Explain those limitations in your summary.
  - User groups and sub-groups. Take note of differences among users and their habits or responses to your design ideas. Sometimes unique characteristics of a certain user may dictate his or her response to a design and point up issues that your team may not have anticipated. For example, athletes who use wheelchairs may include both users with paraplegia and users who have had limbs amputated. These users will likely have varying levels of abdominal and back strength or control of those muscles, and may thus interact with designs quite differently.
- Create a table of observations, opportunities, and follow-up. In the first column, note key observations; if they are complex, use a separate sheet of paper for each step in the process. In the second column, list the design opportunities suggested by the observations. In the third column, list the directions the team would take to follow up on

those opportunities. Below is a portion of the observations table compiled by the patio chair team:

Example 2.10: Portion of an observation results table

Observations	Opportunities	Follow-up
User grips chair arms tightly	Prevent users from cutting or chafing their hands	Put padding on chair arms
User initially pulls self forward by grasping the middle of the chair arms	Make it easier to grab the middle of the chair arms	Include pegs or other kinds of grips at the middle of the chair arms
User displays discomfort when pulling self forward and away from the chair back	Have the chair back provide support as the user pulls forward	Include a spring at the base of the chair back to allow it to move forward with the user

- Organize measurements and other quantitative data in a table or other easy-to-read format.
- Provide captions and photo credits for photos. Be sure that user anonymity is preserved by editing and cropping photos as necessary. Captions can point out significant details as appropriate.

For an example of a team's summary of findings from the user observation, see Appendix C.

2.5.3 Creating user profiles and scenarios

To develop a good design, you need to ask yourself, "What are these users like and how will they use this design?" You can learn a lot about users even when you aren't observing them if you can imagine what it's like to be in their situation. A powerful way to answer these questions is to engage in a special kind of role-play: that is, by generating user profiles and scenarios. A user profile is an imaginary but detailed portrait of a typical user for your design. It's like a snapshot that will help you think of your user as a real person and an individual. Here are two profiles for a curbside mailbox designed to be theft-proof, vandal-proof, and crash-proof.

Example 2.11: User profiles

Claire is 69 and has lived in her home in the country for more than 40 years. She likes to do everything for herself, but lately she's been having problems with mobility. For the last few months, she's been walking with a cane and doesn't get out much. Instead, she does more mail-order shopping. Every morning she walks down to the mailbox at the front of her property to leave letters for the mail carrier, and walks back in the afternoon to pick up her mail, which usually includes

> catalogues and packages. Claire is becoming increasingly nervous about leaving her mail at the mailbox because of some recent mail thefts in the neighborhood.
>
> Mickey is 7, and one of his daily chores is to retrieve the mail from the curbside mailbox. Because his mother has told him he can't go into the street, he has a hard time reaching into the front of the mailbox to get the mail.

These user profiles provide a more detailed picture of your users than words like "old people" and "children."

If a user profile is like a snapshot, then a scenario is like a short video clip. It imagines these users using the design. Here is a scenario created for the curbside mailbox:

Example 2.12: Scenario

> When Kim arrived at work at Dr. Brady's office Monday morning, she needed to retrieve the mail that had been delivered on Saturday. The office is on Route 73, a busy road. At 9 a.m., commuters whiz by at 65 miles an hour. Kim walks down to the mailbox at the curbside and waits 45 seconds for a break in the traffic before stepping into the street to get the mail from the box. She unhooks the mailbox door and digs out six medical supply catalogues, 15 bills, and five advertising circulars. By the time she gathers all this, traffic whizzes by again. Oops! Kim drops an envelope, and it's soon run over by a Ford Bronco. She scrambles out of the way of the traffic, but neglects to refasten the mailbox door, and the flap protrudes into the street. Kim begins to lean over to relatch it when a Chrysler minivan zooms by, trying to make the light at the corner. He clips the mailbox flap, tearing it off its hinges. "Jeez," Kim says, "we have to fix this thing again. It's the third time this year."

Why concoct such an elaborate story? Because it lets you visualize a potentially real situation and the challenges that go along with it. You can practically see Kim, nerves on edge, cursing the traffic and the mailbox, trying to keep hold of her catalogues, retrieve her fallen bill, and get the mailbox latched before it's ripped from its hinges. What would make her job easier and safer? How can she avoid the traffic problem?

Envisioning the problems of Kim, Claire, and Mickey helps you develop requirements and specifications for your design (see Chapter 3).

2.6 INTERVIEWING EXPERTS

Experts can give you the information you need for your project and teach you about technologies that may be critical to your design. They can also tell you what users want, who your competitors are, what shortcomings plague existing products, what regulations are imposed by governmental agencies, and many other facts that influence your overall design.

Like client and user interviews, an expert interview uses scripted questions that flow logically from one topic to another. Although you may not follow your guide word-for-word, it will serve as your overall map for the interview.

2.6.1 Guidelines for interviewing experts

As you might suspect, several of these guidelines are the same as those used in the interview guidelines described earlier in this chapter.

Before the interview

1. Define your objectives. Early in your project, experts can provide background information and a better understanding of current designs. For example, an EDC team designing a product to melt ice blockages in drain pipes met with a plumber early in the process to get a sense of how common this problem is and how plumbers solve it. Later in the process, experts might offer information about alternative technologies or help in analyzing a new design. Because an interview shouldn't last more than an hour, limit your objectives to what can be covered in that block of time.
2. Identify experts by using these resources:
    - Your client. In addition to technical expertise, he or she may be able to put you in touch with other experts in the field.
    - Your instructors. They can provide you with background information and technical expertise.
    - Other NU professors. For technical questions, there's probably a professor at Northwestern who has the answer.
    - Family and friends. EDC students frequently find that parents, relatives, and family friends have the answers to their questions.
    - Salespeople and product consultants. People who sell products similar to the one you're designing can provide a wealth of information as well as help you select materials and components for your prototype.
3. Make an appointment. To improve your chances of securing an interview, review the guidelines for making appointments earlier in this chapter.
4. Gather information and create sketches. If the objective of the interview is to generate requirements and specifications, or to identify problems with current designs, you will ask better questions and get more useful responses by analyzing a few current designs. Later, when you're trying

to solve a difficult technical problem, make drawings or mockups of your current design.

5. Generate a list of questions for the interview. You will want to ask different kinds of questions depending on the objectives of your interview.
    a. At the start of your project, you need to find out about previous design solutions. Some generic questions for background interviewing are:
        – Who are the users and stakeholders of the product?
        – If we change X aspect of the product, what are the consequences?
        – What modifications of the product have been tried before?
        – Why are there problems with the product?
    b. Another objective for interviewing an expert is to define the design requirements by asking about competitive products, so make a point of bringing a competitive product (or a sketch of it). Some generic questions for interviewing about products, devices, systems, or spaces are:
        – What is the rationale for feature A?
        – What are the problems with this feature?
        – How does feature A work?
        – What are the advantages of design X over Y and vice versa?
        – What are the strengths of this design?
        – What are the weaknesses of this design?
        – What is the best-designed component you've seen?
    c. Later in the project, you will have specific questions about the feasibility of your design concept and about materials and components for your prototype. Generic questions for interviewing about the features of your design concept and prototype are the following:
        – Are there problems with feature A?
        – What are some solutions to these problems or alternative features to consider?
        – What materials and components should we consider for feature A?
        – What are the pros and cons of each material and component?
        – How can we test feature A?
        – What are we missing in this design concept?

At the interview

1. Arrive on time.

2. Introduce yourself, your project, and its purpose. Even if you mentioned these things in your initial email or telephone conversation, it's good to do so again.
3. Speak clearly and be sure the expert understands your question.
4. Listen carefully. If you don't understand an answer, don't be afraid to ask for clarification; you may have to ask "Why?" more than once to get the information you need.
5. Record the answers. Options include writing them in a notebook (or below the questions in the interview guide) and tape-recording them. If you do the latter, also take notes in case your recorder malfunctions. Also be sure you obtain interviewees' permission in advance to tape-record their answers.
6. Keep returning to the guide. If the answers start to wander, bring the conversation back to its purpose.
7. Be flexible. If an answer triggers a question not in the guide, go ahead and ask it.
8. Don't argue. Experts may make incorrect statements or state opinions as facts. Don't call them on these; instead, probe more deeply to understand why they hold their opinion. Putting them on the defensive may make them less willing to share their knowledge with you.
9. Follow up with a thank you. Expressing appreciation at the end of an interview is generally sufficient, but following up with a phone call or email is good professional practice and may prompt your interviewee to provide additional feedback

For an example of a team's guide for interviewing an expert, see Appendix D.

After the interview

1. Organize the information. Despite having a well-organized interview guide, you may find that the expert at times threw out information helter-skelter, and you'll have to sort it into categories.
2. Determine which information is relevant to your project and use it appropriately. A team designing a device to prevent paint from freezing learned from an electrical engineering professor that even for paints listed as not flammable there is a fire risk in inserting an electrical heating device into the can. Despite that information, the team developed one alternative that included a battery-operated heating element inserted in the can of paint. The expert's information should have led them to rule out this alternative.
3. Determine what additional information you now need and how to get it. The expert might not have been able to answer all your questions, may have suggested new ones, or may have been able to give only part of an answer.
4. Write a memo summarizing the interview results for your teammates and instructors. The summary should include the main categories of informa-

tion you got (#1 above), the most relevant information (#2 above), and the new questions you now have to answer (#3 above).

For an example of a team's summary of findings from their expert interview, see Appendix E.

2.7 ITERATING YOUR RESEARCH AND WRITING IT UP

In this chapter, we have emphasized doing research to make yourself an expert in the early stages of the project. However, as discussed in Chapter 1, design is an iterative, recursive process. Therefore, you will find that you need to do research at later stages of the project, too. One team found this out while designing a paper-shredding device for developmentally disabled youths enrolled in a vocational training program. After the team decided on their design concept and its components, they still needed to interview a materials science professor to find out about plastics, research the McMaster-Carr catalogue to find out about the specifications of various electronic components, and interview an electrical engineering professor to learn about circuitry. At each new stage in the interview process, they needed to return to the techniques outlined in this chapter, and then to re-evaluate their research summaries and project definition in light of their new research findings. Even though they may have written excellent summaries of their research earlier, they needed to revise those summaries as they went along.

Design is a continuous process of analysis and synthesis. Early in your research, you analyze what you learn about the client's wishes, the users' needs, important background information, and previously tried solutions. You decide what is most relevant to your design problem and then summarize it for yourself. But, as you accumulate more information from additional sources, you have to synthesize that information in your notes. Sometimes this synthesis takes the form of a short report, such as a memo to your instructors. Sometimes it's a table comparing information about other solutions on the market.

As you continue to gather information, you need to continue to highlight important information, eliminate irrelevant information, and apply what you learn to your design problem. Consider how your team will act on this new information, and why your client should care about it. A team designing a highchair footrest for children with Down Syndrome and cerebral palsy did extensive research online about those two medical conditions. They learned that many children with cerebral palsy exhibit spastic movements in their legs that can be quite intense. Therefore, the team made sure that their footrest would be able to withstand the force of these repeated impacts. As they learned more about their users' needs, they continued to refine the requirements for their design.

A key point of thinking in design—whether you're doing the design itself or writing up your research results—is to synthesize your researched information. Bring together information from sources in a way that makes sense to your teammates and to others who will be reading your reports. Organize your research so that it supports the decisions that lead to your design and backs up your claims about your design's effectiveness The amount of research and the kind of research you do are crucial to good design, but so are the ways in which you think about that research and write it up for others to understand what you've done.

2.8 REFERENCES

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