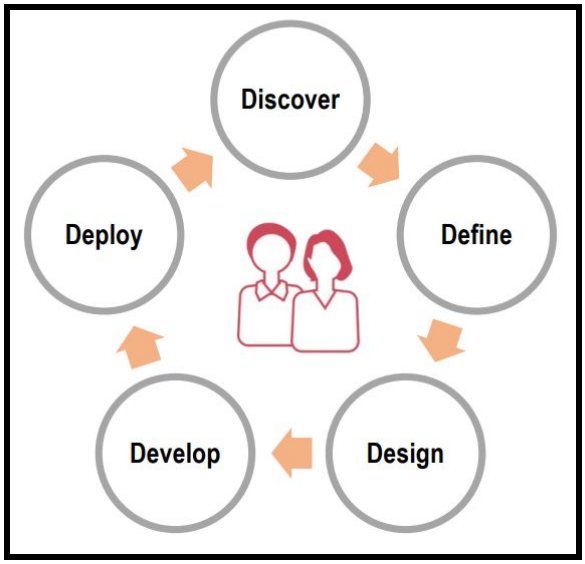
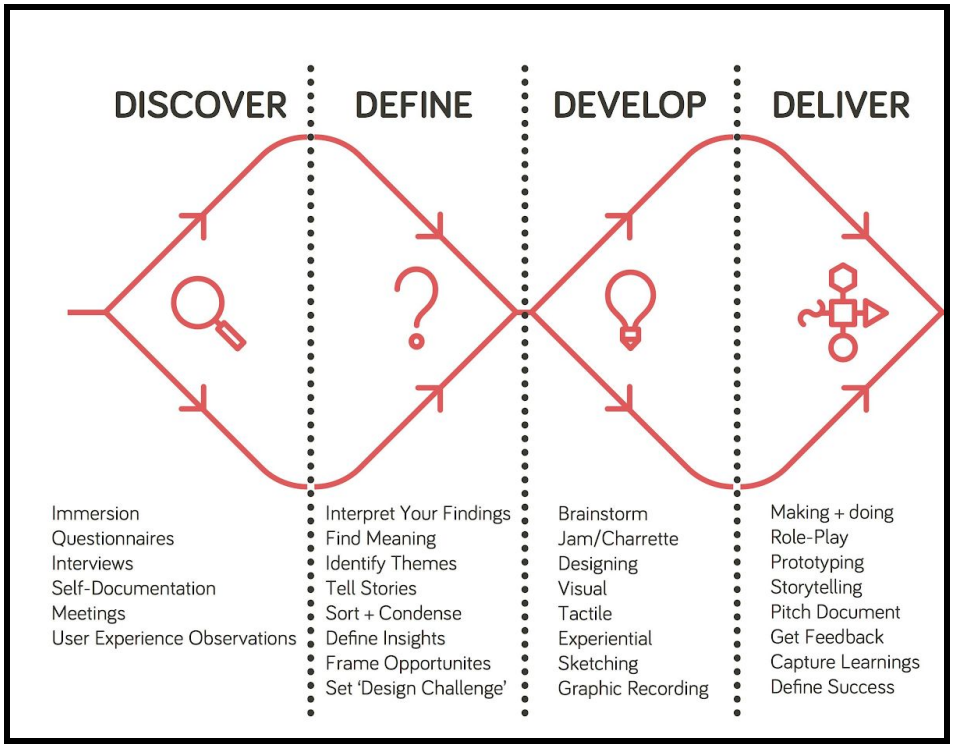
Lecture Notes:

- **Human Centered Design Process - 5 D's:**



- **Double Diamond Process Model:**



- **Keyhole Impact:**
- The **keyhole impact** is when people perceive only small portions of available information. Furthermore, everyone has their own **point of view (POV)** which is shaped by their life experiences. For these reasons, the design perspective may not match the user perspective.

E.g. Consider the FedEx logo below. There's an arrow between the E and the x, but many people can't see it.

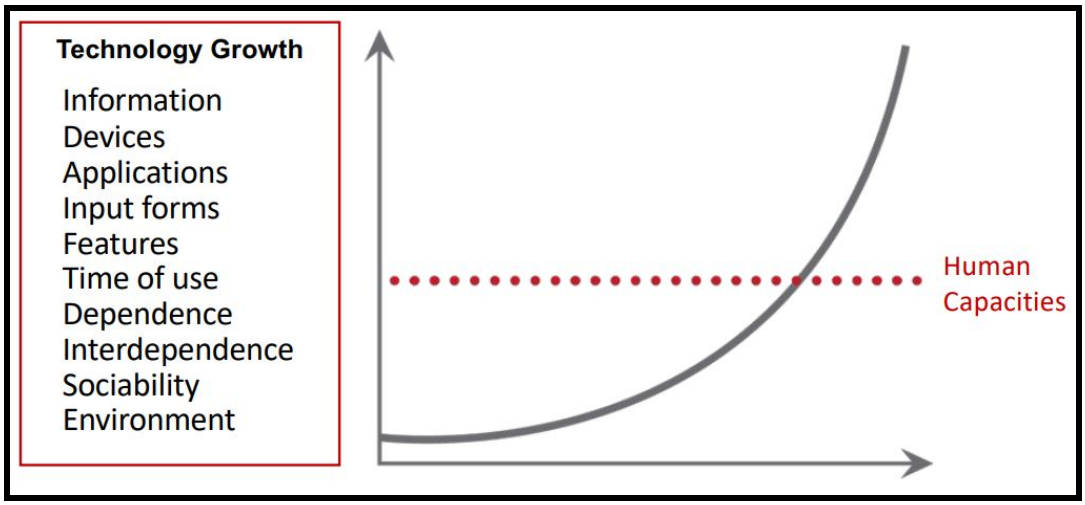
As designers, we must remember that we are not the user.

- **History of User Experience:**

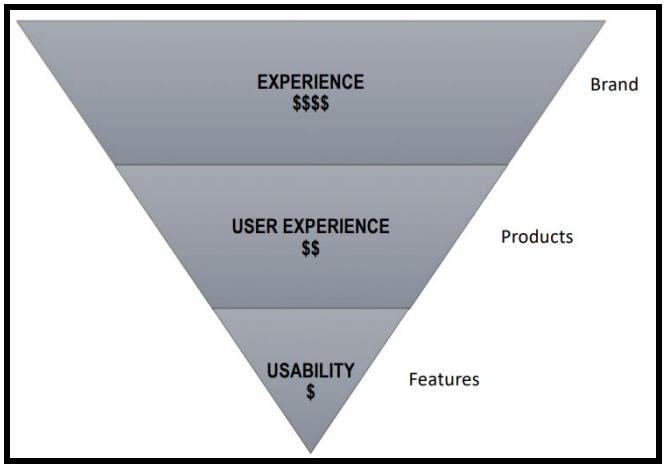
Year	**Type of User Experience**
1857	Ergonomics
1940's	Human Factors
1980's	Human Computer Interaction/Human Centered Design
1982	Customer Experience
1990's	Usability
1993's	User Experience
1960-Present	Design Thinking

- **Technology Impact:**

While technology has grown at an increasing rate, human capacities have not changed. Humans have limited resources. While our eyes have 10 million cells used to receive information and our ears have 100 thousand cells used to receive information, our brain can only process a tiny fraction of that information. It filters out a lot of unnecessary information.



- **Experience Value Chain:**



- **Note:** It's easier and less expensive to change stuff in the design phase than it is once the product is on the market. Furthermore, once the product is on the market and people have negative experiences with it, even if you do change the product, it may be too late. Some users may not consider using products from that brand again.
- **Customer Experience:**
- It is everything that people see, hear & touch.
- Cycle of customer experience:

- **Note:** More people share negative reviews than positive reviews. This is why having good customer/user experience is crucial.
- **Design Thinking:**
    1. **Empathize:** Learn about the audience for whom you are designing, by observation and interview.
       I.e. Who is my user? and What matters to this person?
    2. **Define:** Create a point of view that is based on user needs and insights.
       I.e. What are their needs?
    3. **Ideate:** Brainstorm and come up with as many creative solutions as possible. Wild ideas are encouraged.
    4. **Prototype:** Build a representation of one or more of your ideas to show others. Remember that a prototype is just a rough draft.
    5. **Test:** Share your prototyped idea with the original user and ask for feedback.

- **Strategic Goals and Methods of UX Research:**

Stage	Discover	Define	Design	Develop	Deploy
Goals	- Reduce risk of novel products. - Support decisions in high risk products. - Assess customers' priorities.	- Confirm audience fit. - Define UX success **KPIs (Key Performance Indicator)**. - Validate high level concepts. - Prioritize features.	- Iterate detailed design. Measure design impact using qualitative & quantitative KPIs for high risk projects	- Avoid launch surprises. - Assess launch support needs. - Prepare call centres for launch	- Monitor impact. - Expose weaknesses. - Identify opportunities.
Methods	- Stakeholder interviews - Business objectives - Call centre reports - Community forums - Field studies - User interviews - User surveys - Focus groups - Current product testing - Heuristic evaluation - Competitive Analysis - Task analysis - User needs & goals - Analytics & weblogs - Usability benchmarks - Eye tracking - Diary/camera studies - Card sorting - Click tests - Concept testing - Desirability studies - Customer journeys	- User stories - User profiles - User tasks - Personas - Current scenarios - Task analysis - Success metrics - Guerilla usability - Card sorting - Tree tests - New user journeys	- Brainstorm concepts - Select metaphors - Future scenarios - Functionality, screen flows, fields, navigation, site maps - Low-fi prototypes - Guerilla testing - High-fi prototypes - Formal usability studies - Design guidelines - Detailed design specs for devs - Participatory design - First click tests - Eye tracking - Benchmark testing - Car sorting - Unmoderated - Remote studies	- Work close with devs - A/B Testing - Monitor design changes w/o UX input - Heuristic reviews of developing product - Check success metrics in lab - Confirm bus objectives - Formal usability testing (experiments) - Design guidelines updates - Debrief process & lessons learned	- Monitor weblogs - Monitor call centres - Conduct user surveys - Monitor social media - Field studies of use - Future features list - Focus groups w users - User Interviews - Click stream analysis - True intent studies - Intercept surveys

- **Problem space:**
- **Problem space** refers to the entire range of components that exist in the process of finding a solution to a problem. This range starts with "defining the problem," then proceeds to the intermediate stage of "identifying and testing possible solutions" and ends with the final stage of "choosing and implementing a solution". Plus, it includes all of the smaller steps that exist between these identified stages.
- **Dark Patterns:**
- A **dark pattern** is a user interface that has been carefully crafted to trick users into doing things.

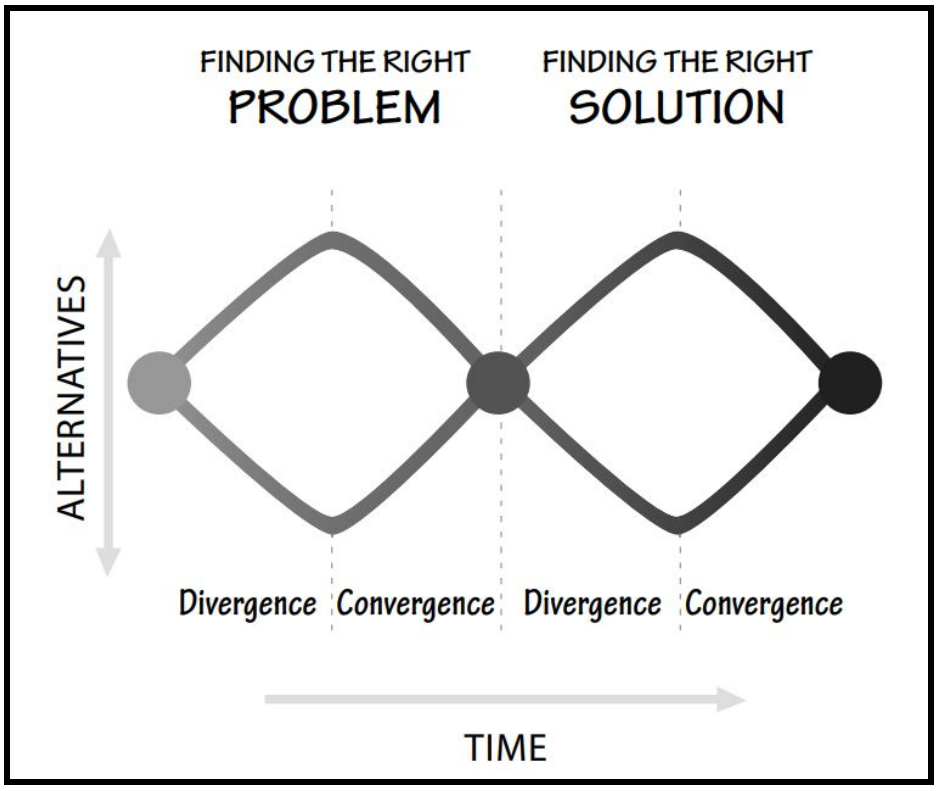
Textbook Notes:

- **Solving the right 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. A brilliant solution to the wrong problem can be worse than no solution at all. Hence, we should solve the correct problem. 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 while 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.

- The key emphasis 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.
- The focus of the discipline called human-centered design is to ensure that the result fits human desires, needs, and capabilities.
- 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. 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, 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.
- There are many various methods for doing HCD, but all are variants on the common theme:
    1. Iterate through the four stages of observation.
    2. Generation
    3. Prototyping
    4. 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."
- **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.

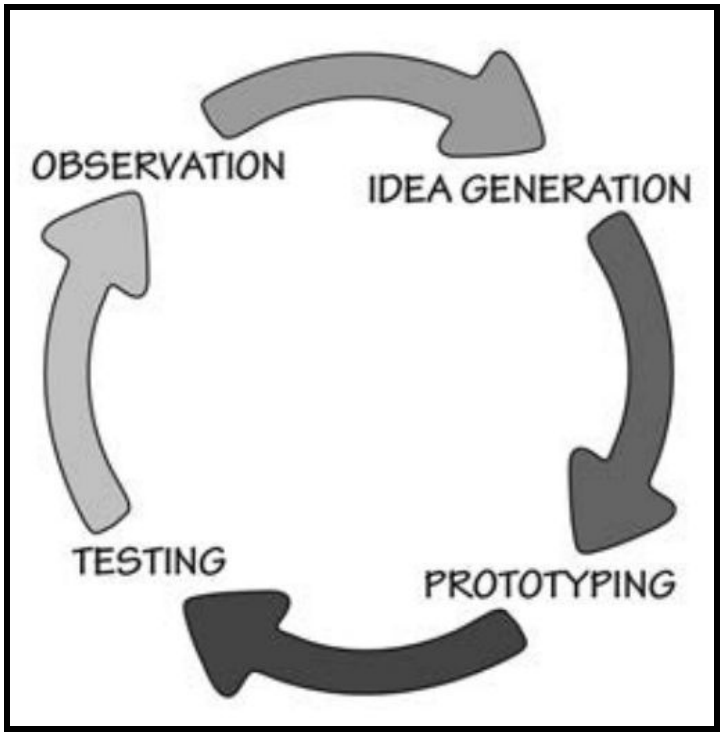
- This double diverge-converge pattern was first introduced in 2005 by the British Design Council, which called it the double-diamond design process model. The Design Council divided the design process into four stages: “discover” and “define” for the divergence and convergence phases of finding the right problem,and “develop” and “deliver” for the divergence and convergence phases of finding the right solution.
- The Double-Diamond Model of Design:



- The double diverge-converge process is quite effective at freeing designers from unnecessary restrictions to the problem and solution spaces.
- 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.
- **The Human-Centered Design Process:**
- The double-diamond describes the two phases of design:
    1. Finding the right problem.
    2. Fulfilling human needs.

  These 2 phases are done using human-centered design (HCD). HCD takes place within the double-diamond diverge-converge process.
- There are four different activities in the human-centered design process:
    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.



- In the **Iterative Cycle of Human-Centered Design**, we make observations on the intended target population, generate ideas, produce prototypes, test them and we repeat until we're satisfied. This is often called the **spiral method**, to emphasize that each iteration through the stages makes progress.
- **Observation step:**
- 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. 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.
- There is no substitute for direct observation of and interaction with the people who will be using the product. Sometimes, you may need to travel to different countries for direct observation.
- 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. It is called **Big Data** 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 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.
- 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.
- **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, three major rules are usually followed:
    1. **Generate numerous ideas.** It is dangerous to become fixated upon one or two ideas too early in the process.
    2. **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.
    3. **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 obvious 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. 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**. 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.
- E.g.
  The author 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. 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, which was 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 or by watching through video in another room. 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.
- The ideal number of people testing the product is 5. First, study five people 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 **"Fail frequently, fail fast."**
- Many executives and government officials believe that tests 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. 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 because oftentimes, they have special cases.
- 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 and 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 the cycle ends 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.
- **ACTIVITY-CENTERED VERSUS HUMAN-CENTERED DESIGN:**
- The intense focus on individuals is one of the hallmarks of human-centered design, ensuring that products do fit real needs, that they are usable and understandable.
- However, sometimes the product is intended for people all across the world. Many manufacturers make essentially the same product for everyone. Some of these products include:
    - Automobiles
    - Cameras
    - Telephones
    - Computers/Laptops

  - Tablets
  - TV sets
  - Refrigerators

  Note: While many of these products may have regional differences, for the most part, they are the same.

  Note: Even products specifically designed for one culture, such as rice cookers, get adopted by other cultures elsewhere.
- In order to accommodate all of these very different, very disparate people, we need to focus on activities, not the individual person. This is called **activity-centered design**. Let the activity define the product and its structure. Let the conceptual model of the product be built around the conceptual model of the activity. This works because people's activities across the world tend to be similar. Moreover, although people are unwilling to learn systems that appear to have arbitrary, incomprehensible requirements. They are quite willing to learn things that appear to be essential to the activity.
- **Note:** Consider activity-centered design an enhancement of HCD. After all, the activities are done by and for people. Activity-centered approaches are human-centered approaches, far better suited for large, nonhomogeneous populations.
- **DIFFERENCES BETWEEN TASKS AND ACTIVITIES:**
- There is a difference between a task and an activity. An **activity** is a high-level structure while a **task** is a lower-level component of an activity.
  E.g. An activity could be "Go shopping" while a task could be "Drive to the supermarket."
- An **activity** is a collected set of tasks, but all performed together toward a common high-level goal. A **task** is an organized, cohesive set of operations directed toward a single, low-level goal. Products have to provide support for both activities and the various tasks that are involved. Well-designed devices will package together the various tasks that are required to support an activity, making them work seamlessly with one another, making sure the work done for one does not interfere with the requirements for another.
- Activities are hierarchical, so a high-level activity will have under it numerous lower-level ones. In turn, low-level activities spawn tasks that are eventually executed by basic operations.
- The American psychologists Charles Carver and Michael Scheier suggest that goals have three fundamental levels that control activities:
  1. **Be-goals** are at the highest, most abstract level and govern a person's being. They determine why people act, are fundamental and long lasting, and determine one's self-image.
  2. The next level down is the **do-goal**, which determines the plans and actions to be performed for an activity.
  3. The lowest level of this hierarchy is the **motor-goal**, which specifies just how the actions are performed. This is more at the level of tasks and operations rather than activities.
- Focusing upon tasks is too limiting.
- Design for individuals and the results may be wonderful for the particular people they were designed for, but a mismatch for others. Design for activities and the result will be usable by everyone.
- A major benefit is that if the design requirements are consistent with their activities, people will tolerate complexity and the requirements to learn something new. As long as

the complexity and the new things to be learned feel appropriate to the task, they will feel natural and be viewed as reasonable.

- **ITERATIVE DESIGN VERSUS LINEAR STAGES:**
- The traditional design process is linear, sometimes called the **waterfall method** because progress goes in a single direction, and once decisions have been made, it is difficult or impossible to go back. This is in contrast to the iterative method of human-centered design, where the process is circular, with continual refinement, continual change, and encouragement of backtracking, rethinking early decisions.
- Many software developers experiment with variations on the theme, variously called by such names as Scrum and Agile.
- Linear, waterfall methods make logical sense. It makes sense that design research should precede design, design precede engineering development, engineering precede manufacturing, and so on.
- Iteration makes sense in helping to clarify the problem statement and requirements; but when projects are large, involving considerable people, time, and budget, it would be horribly expensive to allow iteration to last too long. On the other hand, proponents of iterative development have seen far too many project teams rush to develop requirements that later prove to be faulty, sometimes wasting huge amounts of money as a result. Numerous large projects have failed at a cost of multiple billions of dollars.
- The most traditional waterfall methods are called **gated methods** because they have a linear set of phases or stages, with a gate blocking transition from one stage to the next. The gate is a management review during which progress is evaluated and the decision to proceed to the next stage is made.
- Both methods (waterfall and iteration) have virtues and both have deficits. In design, one of the most difficult activities is to get the specifications right: in other words, to determine that the correct problem is being solved. Iterative methods are designed to defer the formation of rigid specifications, to start off by diverging across a large set of possible requirements or problem statements before convergence, then again diverging across a large number of potential solutions before converging. Early prototypes have to be tested through real interaction with the target population in order to refine the requirements. The iterative method, however, is best suited for the early design phases of a product, not for the later stages. It also has difficulty scaling its procedures to handle large projects. It is extremely difficult to deploy successfully on projects that involve hundreds or even thousands of developers, take years to complete, and cost in the millions or billions of dollars. These large projects include complex consumer goods and large programming jobs, such as automobiles, operating systems for computers, tablets, and phones, and word processors and spreadsheets. Decision gates give management much better control over the process than they have in the iterative methods. However, they are cumbersome. The management reviews at each of the gates can take considerable time, both in preparation for them and then in the decision time after the presentations. Weeks can be wasted because of the difficulty of scheduling all the senior executives from the different divisions of the company who wish to have a say.
- Many groups are experimenting with different ways of managing the product development process. The best methods combine the benefits of both iteration and stage reviews. Iteration occurs inside the stages, between the gates. The goal is to have the best of both worlds: iterative experimentation to refine the problem and the solution, coupled with management reviews at the gates. The trick is to delay precise specification of the product requirements until some iterative testing with rapidly deployed prototypes

has been done, while still keeping tight control over schedule, budget, and quality. It may appear impossible to prototype some large projects, but even there a lot can be done. The prototypes might be scaled objects, constructed by model makers or 3-D printing methods. Even well-rendered drawings and videos of cartoons or simple animation sketches can be useful. Virtual reality computer aids allow people to envision themselves using the final product, and in the case of a building, to envision living or working within it. All of these methods can provide rapid feedback before much time or money has been expended.

- The hardest part of the development of complex products is management: organizing and communicating and synchronizing the many different people, groups, and departmental divisions that are required to make it happen. Large projects are especially difficult, not only because of the problem of managing so many different people and groups, but also because the projects' long time horizon introduces new difficulties. In the many years it takes to go from project formulation to completion, the requirements and technologies will probably change, making some of the proposed work irrelevant and obsolete; the people who will make use of the results might very well change; and the people involved in executing the project definitely will change. Some people will leave the project, perhaps because of illness or injury, retirement or promotion. Some will change companies and others will move on to other jobs in the same company. Whatever the reason, considerable time is lost finding replacements and then bringing them up to the full knowledge and skill level required. Sometimes this is not even possible because critical knowledge about project decisions and methods are in the form we call **implicit knowledge**, that is, within the heads of the workers. When workers leave, their implicit knowledge goes with them. The management of large projects is a difficult challenge.
- **What I Just Told You? It Doesn't Really Work That Way:**
- While the HCD process describes the ideal, the reality of life within a business often forces people to behave quite differently from that ideal.
- Market-driven pressures plus an engineering-driven company yield ever-increasing features, complexity, and confusion. But even companies that do intend to search for human needs are thwarted by the severe challenges of the product development process, in particular, the challenges of insufficient time and insufficient money.
- **DON NORMAN'S LAW OF PRODUCT DEVELOPMENT:**
- The law is "The day a product development process starts, it is behind schedule and above budget."
- Product launches are always accompanied by schedules and budgets. Usually the schedule is driven by outside considerations, including holidays, special product announcement opportunities, and even factory schedules. Moreover, product development takes time even to get started. People are never sitting around with nothing to do, waiting to be called for the product. No, they must be recruited, vetted, and then transitioned off their current jobs. This all takes time, time that is seldom scheduled.
- Product development involves an incredible mix of disciplines from designers to engineers and programmers, manufacturing, packaging, sales, marketing, service and more.
- The product has to appeal to the current customer base as well as to expand beyond to new customers. Patents create a minefield for designers and engineers, for today it is almost impossible to design or build anything that doesn't conflict with patents, which means redesign to work one's way through the mines.

- Each of the separate disciplines has a different view of the product. Each has different but specific requirements to be met. Often the requirements posed by each discipline are contradictory or incompatible with those of the other disciplines, but all of them are correct when viewed from their respective perspective. In most companies, however, the disciplines work separately, design passing its results to engineering and programming, which modify the requirements to fit their needs. They then pass their results to manufacturing, which does further modification, then marketing requests changes. It's a mess.
- The way to handle the time crunch that eliminates the ability to do good up-front design research is to separate that process from the product team. Have the design researchers always out in the field, always studying potential products and customers. Then, when the product team is launched, the designers can say, "We already examined this case, so here are our recommendations." The same argument applies to market researchers.
- The clash of disciplines can be resolved by multidisciplinary teams whose participants learn to understand and respect the requirements of one another. Good product development teams work as harmonious groups, with representatives from all the relevant disciplines present at all times. If all the viewpoints and requirements can be understood by all participants, it is often possible to think of creative solutions that satisfy most of the issues. Note that working with these teams is also a challenge. Everyone speaks a different technical language. Each discipline thinks it is the most important part of the process. Quite often, each discipline thinks the others are stupid and that they are making inane requests. It takes a skilled product manager to create mutual understanding and respect.
- The design practices described by the double-diamond and the human-centered design process are the ideal. Even though the ideal can seldom be met in practice, it is always good to aim for the ideal, but to be realistic about the time and budgetary challenges. These can be overcome, but only if they are recognized and designed into the process. Multidisciplinary teams allow for enhanced communication and collaboration, often saving both time and money.
- **The Design Challenge:**
- It is difficult to do good design. That is why it is such a rich, engaging profession with results that can be powerful and effective. Designers are asked to figure out how to manage complex things, to manage the interaction of technology and people. Good designers are quick learners, for today they might be asked to design a camera; tomorrow, to design a transportation system or a company's organizational structure. How can one person work across so many different domains? Because the fundamental principles of designing for people are the same across all domains. People are the same, and so the design principles are the same.
- Designers are only one part of the complex chain of processes and different professions involved in producing a product. Other aspects of the product are important. For example, its engineering effectiveness, which includes its capabilities, reliability, and serviceability; its cost; and its financial viability, which usually means profitability. Will people buy it? Each of these aspects poses its own set of requirements, sometimes ones that appear to be in opposition to those of the other aspects. Schedule and budget are often the two most severe constraints.
- Designers try hard to determine people's real needs and to fulfill them, whereas marketing is concerned with determining what people will actually buy. What people need and what they buy are two different things, but both are important. It doesn't matter

how great the product is if nobody buys it. Similarly, if a company's products are not profitable, the company might very well go out of business. In dysfunctional companies, each division of the company is skeptical of the value added to the product by the other divisions.

- In a properly run organization, team members coming from all the various aspects of the product cycle get together to share their requirements and to work harmoniously to design and produce a product that satisfies them, or at least that does so with acceptable compromises. In dysfunctional companies, each team works in isolation, often arguing with the other teams, often watching its designs or specifications get changed by others in what each team considers an unreasonable way. Producing a good product requires a lot more than good technical skills. It requires a harmonious, smoothly functioning, cooperative and respectful organization.
- **PRODUCTS HAVE MULTIPLE, CONFLICTING REQUIREMENTS:**
- Designers must please their clients, who are not always the end users. For example, in businesses, purchasing departments make decisions for large companies and owners or managers, for small companies.
- In any case, the purchaser is probably interested primarily in price, perhaps in size or appearance, almost certainly not in usability and once devices are purchased and installed, the purchaser has no further interest in them. The manufacturer has to attend to the requirements of these decision makers, because these are the people who actually buy the product. Yes, the needs of the eventual users are important, but to the business, they seem of secondary importance.
- In some situations, cost dominates. Suppose, for example, you are part of a design team for office copiers. In large companies, copying machines are purchased by the Printing and Duplicating Center, then dispersed to the various departments. The copiers are purchased after a formal "request for proposals" has gone out to manufacturers and dealers of machines. The selection is almost always based on price plus a list of required features. Usability? Not considered. Training costs? Not considered. Maintenance? Not considered. There are no requirements regarding understandability or usability of the product, even though in the end those aspects of the product can end up costing the company a lot of money in wasted time, increased need for service calls and training, and even lowered staff morale and lower productivity. The focus on sales price is one reason we get unusable copying machines and telephone systems in our places of employment. If people complained strongly enough, usability could become a requirement in the purchasing specifications, and that requirement could trickle back to the designers. But without this feedback, designers must often design the cheapest possible products because those are what sell. Designers need to understand their customers, and in many cases, the customer is the person who purchases the product, not the person who actually uses it. It is just as important to study those who do the purchasing as it is to study those who use it.
- To make matters even more difficult, yet another set of people needs to be considered: the engineers, developers, manufacturing, services, sales, and marketing people who have to translate the ideas from the design team into reality, and then sell and support the product after it is shipped. These groups are users, too, not of the product itself, but of the output of the design team. Designers are used to accommodating the needs of the product users, but they seldom consider the needs of the other groups involved in the product process. But if their needs are not considered, then as the product development moves through the process from design to engineering, to marketing, to manufacturing,

and so on, each new group will discover that it doesn't meet their needs, so they will change it. But piecemeal, after-the-fact changes invariably weaken the cohesion of the product. If all these requirements were known at the start of the design process, a much more satisfactory resolution could have been devised.

- Usually the different company divisions have intelligent people trying to do what is best for the company. When they make changes to a design, it is because their requirements were not suitably served. Their concerns and needs are legitimate, but changes introduced in this way are almost always detrimental. The best way to counteract this is to ensure that representatives from all the divisions are present during the entire design process, starting with the decision to launch the product, continuing all the way through shipment to customers, service requirements, and repairs and returns. This way, all the concerns can be heard as soon as they are discovered. There must be a multidisciplinary team overseeing the entire design, engineering, and manufacturing process that shares all departmental issues and concerns from day one, so that everyone can design to satisfy them, and when conflicts arise, the group together can determine the most satisfactory solution. Sadly, it is the rare company that is organized this way.
- Design is a complex activity. But the only way this complex process comes together is if all the relevant parties work together as a team. It isn't design against engineering, against marketing, against manufacturing. It is design together with all these other players. Design must take into account sales and marketing, servicing and help desks, engineering and manufacturing, costs and schedules. That's why it's so challenging. That's why it's so much fun and rewarding when it all comes together to create a successful product.
- **DESIGNING FOR SPECIAL PEOPLE:**
- There is no such thing as the average person. This poses a particular problem for the designer, who usually must come up with a single design for everyone. The designer can consult handbooks with tables that show average arm reach and seated height, how far the average person can stretch backward while seated, and how much room is needed for average hips, knees, and elbows. **Physical anthropometry** is what the field is called. With data, the designer can try to meet the size requirements for almost everyone, say for the 90th, 95th, or even the 99th percentile. Suppose the product is designed to accommodate the 95th percentile, that is, for everyone except the 5 percent of people who are smaller or larger. That leaves out a lot of people. The United States has approximately 300 million people, so 5 percent is 15 million. Even if the design aims at the 99th percentile it would still leave out 3 million people. And this is just for the United States: the world has 7 billion people. Design for the 99th percentile of the world and 70 million people are left out.
- Some problems can't be solved by adjustments or averages.
- Sometimes it is simply impossible to build one product that accommodates everyone, so the answer is to build different versions of the product.
- Consider the special problems of the aged and infirm, the handicapped, the blind or near blind, the deaf or hard of hearing, the very short or very tall, or people who speak other languages. Design for interests and skill levels. Don't be trapped by overly general, inaccurate stereotypes.

- **THE STIGMA PROBLEM:**
- Many devices designed to aid people with particular difficulties fail. They may be well designed, they may solve the problem, but they are rejected by their intended users. This is because most people do not wish to advertise their infirmities. Actually, many people do not wish to admit having infirmities, even to themselves.
- Designing for people with special needs is often called **inclusive** or **universal design**.
- The best solution to the problem of designing for everyone is flexibility. Flexibility in the size of the images on computer screens, in the sizes, heights, and angles of tables and chairs. Allow people to adjust their own seats, tables, and working devices. Allow them to adjust lighting, font size, and contrast. Flexibility on our highways might mean ensuring that there are alternative routes with different speed limits. Fixed solutions will invariably fail with some people, but flexible solutions at least offer a chance for those with different needs.
- **Complexity Is Good; It Is Confusion That Is Bad:**
- While complexity is essential, it is confusion that is undesirable.
- The difference between complexity and complicated is that **complexity** is what we need to match the activities we take part in and **complicated** means confusing.
- The most important principle for taming complexity is to provide a good conceptual model.
- Complex things are no longer complicated once they are understood.
- **Standardization and Technology:**
- If we examine the history of advances in all technological fields, we see that some improvements come naturally through the technology itself while others come through standardization. The early history of the automobile is a good example. The first cars were very difficult to operate. They required strength and skill beyond the abilities of many. Some problems were solved through automation: the choke, the spark advance, and the starter engine. Other aspects of cars and driving were standardized through the long process of international standards committees. Some examples include: which side of the road to drive (constant within a country, but variable across countries), which side of the car the driver sits (depends upon which side of the road the car is driven), and the location of essential components: steering wheel, brake, clutch, and accelerator.
- Standardization is one type of cultural constraint. With standardization, once you have learned to drive one car, you feel justifiably confident that you can drive any car, anyplace in the world. Standardization provides a major breakthrough in usability.
- **ESTABLISHING STANDARDS:**
- A small company can standardize its products without too much difficulty, but it is much more difficult for an industrial, national, or international body to agree to standards.
- There even exists a standardized procedure for establishing national and international standards. A set of national and international organizations works on standards. When a new standard is proposed, it must work its way through the organizational hierarchy. Each step is complex. Each proposal is debated at the standards committee meeting where it is presented, then taken back to the sponsoring organization where objections and counter-objections are collected. Then the standards committee meets again to discuss the objections. And again and again and again. Any company that is already marketing a product that meets the proposed standard will have a huge economic advantage, and the debates are therefore often affected as much by the economics and politics of the issues as by real technological substance. The process is almost guaranteed to take five years, and quite often longer. The resulting standard is usually a

compromise among the various competing positions, oftentimes an inferior compromise. Sometimes the answer is to agree on several incompatible standards.

- Standardize and you simplify lives. Everyone learns the system only once, but don't standardize too soon as you may be locked into a primitive technology, or you may have introduced rules that turn out to be grossly inefficient, even error-inducing. Standardize too late, and there may already be so many ways of doing things that no international standard can be agreed on. If there is agreement on an old-fashioned technology, it may be too expensive for everyone to change to the new standard.
- **Deliberately Making Things Difficult:**
- While most things are intended to be easy to use, some things are deliberately difficult to use and ought to be. The number of things that should be difficult to use is surprisingly large:
    1. Any door designed to keep people in or out.
    2. Security systems, designed so that only authorized people will be able to use them.
    3. Dangerous equipment, which should be restricted.
    4. Dangerous operations that might lead to death or injury if done accidentally or in error.
    5. Secret doors, cabinets, and safes. You don't want the average person even to know that they are there, let alone to be able to work them.
    6. Cases deliberately intended to disrupt the normal routine action. Examples include the acknowledgement required before permanently deleting a file from a computer, safeties on pistols and rifles, and pins in fire extinguishers.
    7. Controls that require two simultaneous actions before the system will operate, with the controls separated so that it takes two people to work them, preventing a single person from doing an unauthorized action (used in security systems or safety-critical operations).
    8. Cabinets and bottles for medications and dangerous substances deliberately made difficult to open to keep them secure from children.
    9. Games, a category in which designers deliberately flout the laws of understandability and usability. Games are meant to be difficult. In some games, part of the challenge is to figure out what is to be done, and how
- Even where a lack of usability or understandability is deliberate, it is still important to know the rules of understandable and usable design, for two reasons. First, even deliberately difficult designs aren't entirely difficult. Usually there is one difficult part, designed to keep unauthorized people from using the device while the rest of it should follow the normal principles of good design. Second, even if your job is to make something difficult to do, you need to know how to go about doing it. In this case, the rules are useful, for they state in reverse just how to go about the task. You could systematically violate the rules like this:
    1. Hide critical components: make things invisible.
    2. Use unnatural mappings for the execution side of the action cycle, so that the relationship of the controls to the things being controlled is inappropriate or haphazard.
    3. Make the actions physically difficult to do.
    4. Require precise timing and physical manipulation.
    5. Do not give any feedback.

6. Use unnatural mappings for the evaluation side of the action cycle, so that system state is difficult to interpret.

- Safety systems pose a special problem in design. Oftentimes, the design feature added to ensure safety eliminates one danger, only to create a secondary one. When workers dig a hole in a street, they must put up barriers to prevent cars and people from falling into the hole. The barriers solve one problem, but they themselves pose another danger, often mitigated by adding signs and flashing lights to warn of the barriers. Emergency doors, lights, and alarms must often be accompanied by warning signs or barriers that control when and how they can be used.
- **Design: Developing Technology for People:**
- Design is a marvelous discipline, bringing together technology and people, business and politics, culture and commerce. The different pressures on design are severe, presenting huge challenges to the designer. At the same time, the designers must always keep foremost in mind that the products are to be used by people. This is what makes design such a rewarding discipline. On the one hand, woefully complex constraints to overcome; on the other hand, the opportunity to develop things that assist and enrich the lives of people, that bring benefits and enjoyment.