CS 4712 User Interface Engineering

MODULE_3 – TOPICS

Design Process of User Interface

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DESIGN PROCESS OF USER INTERFACE

3.1 - Introduction and Background

The purpose of user interface design is to create and implement interfaces in software or computerized devices with a focus on looks, style, and usability. A designer must take appropriate steps with these goals in mind to create designs that users will find easy and pleasurable to use. "UI design typically refers to graphical user interfaces but also includes others, such as voice-controlled ones." (Galitz, W. O.)

"The process of interaction design involves four basic activities: establishing requirements, designing alternatives, prototyping, and evaluating." (Preece, J., Rogers) This process is designed to be repeated, to allow for feedback and revisions to the design for maximal efficiency. Assessing what has been created from these potential user helps the designer key in on areas needed to be improved. The feedback from potential users is essential and is the core of interaction design.

When establishing requirements, it is vital to know who the intended users are. This development involves a lot of data gathering. After the gathering phase, the developer begins creating designs and alternatives based on requirements. Next is the prototyping phase, in which an actual functioning interface is developed for testing and evaluation. Evaluation defines the capabilities and competence of the design assessed in relation to variation of usability and the overall user experience.

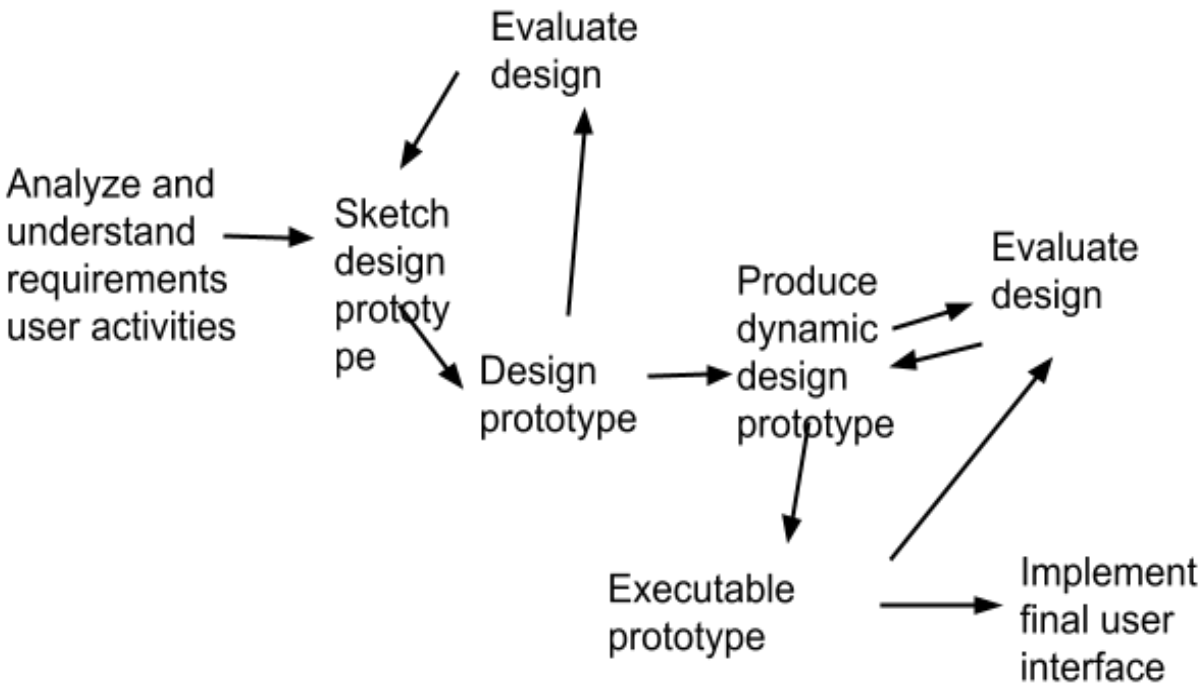

Figure 1.1 Design Process
Created by: Albert Cortez

There are three other important factors that must also be considered in the design process:

- Analyzing psychological and physical needs of the user
- Implementing human/user characteristics
- Creating a theoretical framework

Analyzing the psychological and physical needs of the user is fundamental when evaluating UI requirements. Different types of users will have different needs, and the UI must satisfy those needs for a successful outcome. As an example, an interface meant to be accessible by autistic children may need to be creative but also simplistic.

Implementing human characteristics in the design is of great importance. User interface design's overall goal is to deliver an experience that satisfies specific user needs. The functions of the design should be technical, but simple. While the designer is creating a prototype, it is key to implement human characteristics to assist in usability.

Lastly, a theoretical framework involves creating a structure of ideas to support research or study. This is important before implementing a design. It serves as a guide and ensures that each hypothesis is tested thoroughly. In user-centered design (UCD), research is the backbone of the design process. Designers need to develop a plan or framework to structure their research around.

3.2 - Importance of Human/User Characteristics in Design

UI design is based around predicting the needs of the users and providing an interface that contains "elements that are easy to access, understand, and use" (User Interface Design Basics). Perception, which is defined as "our awareness and understanding of the elements and objects of our environment through the physical sensation of our various senses, including sight, sound, smell, and so forth" (Important Human Characteristics in Design), is a core human characteristic that considered in user interface design. Perceptual characteristics include proximity, similarity, matching patterns, succinctness, closure, unity, balance, expectancies, context, and signals versus noise. Each of these characteristics plays a part in achieving an exceptional UI.

Another foundational characteristic is memory. Memory is divided into two parts: long-term memory and short-term memory. Short-term memory processes information from the previous 10 to 30 seconds. The information is then sorted by knowledge, experience, and familiarity which "govern the size and complexity of the information that can be remembered" (Important Human Characteristics in Design). Long-term memory contains a process that moves information from the short-term memory to the long-term called learning. The memory characteristic contains "an important memory consideration, with significant implications for interface design, is the difference in ability to recognize or recall words" (Important Human Characteristics in Design).

Sensory storage, "the buffer where the automatic processing of information collected from our sense takes place" (Important Human Characteristics in Design), works similarly to a radar by taking in the current environment, choosing important information to give attention. If the design over-stimulates this part of the user, the information trying to be conveyed to the user is lost within the "noise." This is referred to as habituation. The interface should be designed so that each design element has a specific purpose and the user can comfortably use those elements. By minimizing the number of elements, the user automatically has less visual stimulation, which increases the importance of each present element.

Visual perception plays an enormous role in the design characteristics of user interfaces. Visual acuity is the ability of the eye to discriminate. When we decide to focus on a single object, that object becomes more

defined and the features and characteristics become more distinct. When we look away, that object is still in our vision, but the details become fuzzier, since we are not focusing on it. Foveal and peripheral vision also fall into the category of visual perception. Foveal vision is the ability to focus in on one specific object, while peripheral vision includes everything else in the surrounding area. All of these are intertwined together to provide "clues where the eye should go next in the visual search of a screen" (Important Human Characteristics in Design).

Fitts' Law states, "The time to acquire a target is a function of the distance to and size of the target. This simply means that the bigger the target is, or the closer the target it, the faster it will be reached" (Important Human Characteristics in Design). This law is used in both user experience and user interface design. When applying Fitts' Law to user interface design, there are a few major implications: command buttons, the outer edges and corners, pop-up menus, selecting options, and task bars. Command buttons must be unique in size and design. By increasing the size of the buttons, the user may spend less time trying to click on them. Small buttons are more difficult to click and can be quite time consuming. So instead, large buttons are available to provide a more accurate and efficient usage.

Outer edges and corners are another important aspect. Since the mouse is restricted to the screen due to the pinning action, the outer edges and corners are the most accessible parts of the computer screen.

Pop-up menus are performed with immediate action. Different than dropdown menus, users can access elements immediately rather than having to move the cursor somewhere on the screen. Selecting options is way that users choose what they want to view or interact with. These elements can be displayed in vertical or horizontal linear menus or pie menus. Pie menus decrease the travel time for the user, since all of the options are the same traveling distance from one another. In linear menus, the user must travel the length of the list.

Finally, task bars require more precision and impede movement in the interface. The user can become confused unless the users, "engage consciously with the screen arrangement to ensure appropriate selection" (Fitts' Law: The Importance of Size and Distance in UI Design).

3.3 - Psychological and Physical Features of Users

When designing a user interface, one of the most important steps in the design process is analyzing the psychological and physical needs of the user. Different types of users will have different needs. As an example, an interface meant to be accessible by children would need to be much more simplistic than one designed for a business.

To expand on this idea, a study done in Singapore presents an interface design for Special Needs Children (SNC) which considered the physical and psychological features of the users (Akbar, Kaburuan, & Effendy, 2017). The interface was intended to schedule events that were provided by other parents that have experience with raising an autistic child. Autism is described by the Autism Society as a developmental disease that affects a person's ability to communicate and interact with others (autism-society.org). With this disorder, it can be difficult, if not impossible for autistic children to understand the concept of time management.

The study identified several issues to address prior to the design stage. They interviewed parents to understand the issues they went through trying to schedule activities with their kids. Usually parents stated they would "write a list of paper or board activities" (Akbar, Kaburuan, & Effendy, 2017). The child would require guidance through the list; then, if they ever felt like they did not understand their parents, they would often completely shut down in a fit of stress and panic. It was also identified during these interviews the

medium in which the autistic children would be most comfortable: a smartphone. This method of design is called UCD, or user-centered design. It heavily involves learning about the user to create a design suited for them rather than designing around the end function of the interface. This requires a large amount of research before even beginning the design process.

The first step in the design process was to specify context of use. This involves interviews and observations of the intended users to identify the persona of the users. Persona was described as "demographic, skill level, behavior, activity, and needs that will affect in building the design solution" (Akbar, Kaburuan, & Effendy, 2017). Basically, it is an attempt to create a representation of the general user base so that a tailored solution can be applied.

The second step in the process is specifying requirements. This is where the needs that have been identified are transformed into features. The third stage in the design process involves actually producing solutions to the features described in the previous process. In the Akbar, Kaburuan, & Effendy study, a scheduling interface was created with photos and text descriptions in addition to clear video and audio instructions for the children. A smiley-face reward screen would then pop up when the children completed the task.

After this step is completed, the design enters an evaluation period. The purpose of this stage of development is simply to ensure the UI does what it is supposed to and is suitable for the users for whom it was designed. This specific study used a Quality in Use Integrated Measurement (QUIM) method. This may seem much more complicated that it really is. It simply involves reviewing how effective the users are at performing the functions of the interface. In the study, for instance, the first testing phase found that parents had issues creating new activities.

The next stage in design was verifying that the system is satisfied. This can be one of the lengthier stages, as real issues become more apparent and immediate fixes must be implemented and retested. However, if the UCD process is followed thoroughly, changes required in this stage can be minimized. This stage involves taking the findings of the evaluation period and adding changes and fixes to the software. One specific change the study cited was that it simplified the screen in which parents created new activities. Since there were significant changes to the software, another evaluation period was begun. This process repeats until a usability threshold is met.

Another study that does a good job analyzing both the psychological and physical features of the user in the design process was published in the *Journal of Medicinal Internet Research.* This study analyzed a design for older adults with multiple chronic conditions (Portz, et al., 2008). The reason this study is important is that we uniquely have a group that is both psychologically and physically unique from the general public. These users are more likely to have limited experience with digital interfaces and to have significant physical constraints. Therefore, the design process must account for both the psychological and physical limitations of a broad user base.

This study analyzed the design of Patient Portals, also known as tethered personal health records (Portz, et al., 2008). This was a digital interface for which a user could perform various health care functions such as refilling a prescription, scheduling appointments, viewing records and communicating with their physicians. Since older adults have significantly higher utilization of healthcare services, they are one of the largest blocks that might use a service like this. The study cites issues they identified with this group of users. Technology discomfort, privacy and security concerns, and lack of relative advantages were cited as the main

concerns (Portz, et al., 2008). The main focus of the study was on the user experience aspects of UI design for this group.

The study used a Technology and Acceptance model as a framework. This model proposes that a person's intent to use (acceptance) and usage behavior are based on whether or not that person perceives the technology to be useful and easy to use (Portz, et al., 2008). The main idea behind this framework is essentially that a high-quality user experience will result in a high adoption rate. This framework was especially useful in this study, as new technology is often shrugged off as too difficult to use by older adults.

The study had a few clear usage issues. Actions such as pharmacy refills, appointments, and lab results were frequently used. Actions such as the retrieval of medical records and the live chat feature were almost never used. Using these results, it became clear that there were several issues in the UI and UX that were affecting the use of certain parts of the portal. The main issue appeared to be that at times users would attempt to create an appointment or refill a prescription only to find out later that the process was never completed. This was related to backend issues as well as user issues (Portz, et al., 2008). The main problem appeared to be related to technological anxiety and efficacy.

This brings up and interesting topic in UI design. What should designers do when the user is afraid to use new technology? They will need to figure out how to make the user believe that the interface is not only easy to learn, but easy to use and time saving. When someone has limited experience with these sort of systems, this can be extremely difficult. It can be difficult to interview these users; they may not know exactly what went wrong or they may dislike certain features simply because they do not understand them. An example of this in this particular study is that users did not believe communicating digitally over non-emergency issues via the live chat feature was useful in any way. It made much more sense to them to visit face-to-face for these issues no matter how trivial (Portz, et al., 2008). This is a very good example of lack of perceived usefulness.

How do designers increase perceived usefulness? Users in the study stated that they wouldn't use it because they didn't see the need to, but they could still *see* the features as being useful (Portz, et al., 2008). This poses a major problem for the designer. The user sees no benefit in using the feature and even cites they believe it could be useful. This likely will require some sort of training or suggestion by the doctor to explain the usefulness of the feature. It also could be integrated into some sort of tutorial system for the less technologically experienced users like in this study.

The study itself actually suggested integrating a robust patient portal training regimen for these users. It cites the main focus of future design for this group to be focused on promoting usefulness and ease of use (Portz, et al., 2008). These ideas can be applied across all UI design and become increasingly important and the user base widens.

Studies like this are a very good way to understand the process involved in user interface designs. While most applications won't have such a specific demographic to address, studying one that does can help to ensure that the needs of all users are addressed as thoroughly as possible. The case of a UI being made for a very specific group in autistic children gives a very unique look into the psychological analysis involved in UI design.

3.4 - Theoretical Frameworks for Cognition

A theoretical framework involves creating a structure of ideas to support research or study. It serves as a way to guide researchers through the study and ensure that each hypothesis is tested thoroughly enough to reach a conclusion. In user-centered design (UCD), research is the backbone of the design process. Designers need to develop a plan or framework around which to structure their research.

Humans are complex beings; each one will process information and solve problems in their own unique ways. Some may give up if they feel something is too difficult, while others will become increasingly frustrated as they attempt to solve the problem. UI design requires a lengthy analysis of multiple groups of users and requires an understanding of basic human cognition. Therefore, it is essential that a theoretical framework is established to study the cognitive abilities of the intended users.

To understand how to create this type of theoretical framework, we can review a study by a University of Calgary titled *The Theoretical Framework of Cognitive Informatics*. Cognitive informatics is described as the science behind the way information is processed (Wang, Jan 2007). The article is broken down into several different theories.

The first is theory called the information-matter-energy model (Wang, Jan 2007). This theory looks to the real world to study how information is processed. In the real world, we have real physical objects and forces acting on them. A person may see an object that looks familiar to them, and they will believe it to behave similarly to other similar objects. They do not, however, know the abstract details of the object until they are allowed to study it. If they see a ball on the ground, they assume they can pick it up and throw it, since every ball they have seen up until then could be picked up and thrown. However, this ball may have an entirely different weight, temperature etc… and cannot actually be thrown. It is the job of the designer to make sure that both the physical and abstract functions of the UI elements are clear and concise to the user. Otherwise the user may assume how the UI functions and believe that the UI is not fully functional when, really, they simply aren't aware of how to use it.

Another good case study is research performed in 2016 at The Pediatric Neuro-rehabilitation Research Center, University of Social Welfare & Rehabilitation Sciences in Tehran, Iran to research the effectiveness of lane departure warning systems (LDWS) (Maddahi, Pouyakian, Ghomsheh, Piri, & Osqueizadeh, 2016). While not exactly a user interface, it gives an interesting view on developing a framework to study visual cognition of users.

With the ever-changing technology in automobiles today, various warning systems are added in nearly every new generation of cars. These new warning symbols may be alien to a significant portion of possible drivers, and so it's up to the companies to create something that is self-explanatory. This study found that human perceptual and cognitive systems are not attuned to static stimuli, and so dynamic warning signs are more capable of attracting human senses and help them to detect new changes (Ng and Chan 2008b). The idea is that instead of just having a generic warning for a category, the system would give the user more dynamic information about it. For example, when tire-pressure sensors were first placed on cars, they would often trigger the generic maintenance light or check engine light. The problem with this is that future check engine lights could be shrugged off as just being a bad sensor, or a change in temperature lowering the tire pressure.

The Maddahi et al. study was broken down into five categories, all of which will be useful in UI design (2016). The first was simplicity: analyzing the number of elements and the complexity of those elements. The second was familiarity. This concept was described in the last study, and means that the symbols must mean the same thing throughout all of their functions. The third was concreteness: objects having real-

world comparisons. The fourth test, meaningfulness, describes how multiples elements can have meaning alongside each other.

The last, and the most complicated, is "semantic closeness." To better understand this concept, consider a situation where there is a page that has a variety of physical statistics about the planet Saturn with a header "Saturn Facts." Semantic closeness of this page would define that each of the bullet points or facts are equally relevant to the header (i.e. that they are all facts about Saturn), but each new fact gets further away from the header (Slawski, 2013). If the list was 1,000 facts long, the user may not know they are still viewing Saturn facts if the header is too far away from the current bullet point. This helps to create a framework to define the proximity of semantically similar elements.

In this study, various graphic symbols were designed to represent to the driver of the car when they left their current lane. All variations involved only 4 symbols: a car, an arrow, multi-arrows, and dotted lines for lanes. A set of 6 symbol combinations were created and static and dynamic variations were created for each one. The dynamic variations often had moving or blinking symbols, while the static just had the warning signs flip on or off. They designed a questionnaire to analyze the 5 categories as described above and had a group that demographically represented the general populace use the new lane departure system and fill out the questionnaire (Maddahi, Pouyakian, Ghomsheh, Piri, & Osqueizadeh, 2016). Using these ideas, a framework can be created to determine what works best for the user base in its entirety.

A framework is a sort of a design of a design. A system is designed so that the proper steps can be taken before the real design process even begins. These two studies give a detailed and accurate set of rules that are commonly followed to account for the nature of human cognition in design. Quite possibly the most important aspect of UI design is to ensure that it can be understood by as many people as is possible within certain constraints.

3.5 - Concise Summary

The design process for user interfaces has two fundamental requirements of predicting the needs of the potential users and predicting an interface that is easy to navigate through. That is why testing and prototyping are key components of the design process. Implementing human characteristics and psychological features along with a theoretical framework will enhance the overall process.

Understanding human characteristics is an essential part of the design process. This includes concepts such as perception and memory when analyzing how a user may use the interface. Perception focuses on awareness and understanding of the elements and objects of our environment through the physical sensation of our various senses. Most human characteristics in design are derived from perception. Memory is another focus. Users need to be able to be able to understand the interface through short-term and long-term memory. The user should be able to understand through a combination of visual perception and using long-term knowledge to identify similarity in elements to easily determine their use.

Studying psychological and physical features can be used to ensure that specific needs of unique users are met. Two studies are helpful in this regard: one on the design of a user interface for children with autism and the other on the usefulness of a patient portal medical service for older users. These studies broke down a complicated system in which individual needs of test groups were analyzed through testing and interviews. This aspect of the design process requires developing a relationship with the user group to make sure the design process includes all needs and concerns.

Developing a theoretical framework involves creating a structure of ideas to support research or study. These ideas will define how research is done. Designers must understand that objects in a UI should have some sort of real-world concrete comparison. This can also be achieved by creating relational metaphors to real work objects. It’s essential to design research around the idea that this is a necessity.

3.6 - Extended Resources

Descriptions & Links

1. UI/UX Design Process | Product Design Process
   https://youtu.be/HL1-Be71URU

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2. The Psychological Basis for UIE Design Rules
   https://youtu.be/3Gw2bnwQRno

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3. Designing Fantastic User Experiences with Psychology
   https://youtu.be/VKRHzoz8aSQ

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4. User Experience (UX) Design Tutorial - The Process of User Experience Design
   https://www.youtube.com/watch?v=Xlj_WGWH_vg

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5. Four stages of UI Design → UI Design Basics
   https://www.youtube.com/watch?v=_7LZ14xtfOc

3.7 - References

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