Cognitive Analysis

**Team: Access-Ability Innovators**

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**CS-6795: Introduction to Cognitive Science**

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### Hypotheses

**Hypothesis 1: *Intuitive design thinking helps designers promote accessibility advancements that can positively impact individuals with disabilities:*** We hypothesized that providing accessible documents with inclusive design principles influences the lives of students with disabilities positively. The interviews showed examples of increased independence, inclusion, and adopting new ways of assessment from these advancements.

**Hypothesis 2: *Collaboration and feedback improve the quality of accessible document creation.***By involving multiple stakeholders such as users, designers, document creators will provide improved accessible documents by reducing errors and increasing user satisfaction. This was evident from interviews that designers used inclusive and universal design principles when creating accessible documents.

**Hypothesis 3:** ***There are barriers in the accessibility domain for the designers*.** We hypothesized that there are no barriers in converting documents to accessible format as we thought automated software were readily available. We found that there are several challenges in providing accessible student materials. For example, PowerPoint files are harder to convert because they tend to have lots of images.

**Hypothesis 4:** ***Difference between expert and novice designers in awareness of accessibility in our group*:** We hypothesized individuals with disabilities or those working with various accessibility initiatives have a deeper understanding and appreciation of such concepts than the general group. Our interviews showed similar results. The people who work closely with disabled people and the disabled community know more available tools than regular people who don't use assistive technologies.

### Methods

Our group employed various study methods to enhance our understanding and acquire knowledge to design an accessible document application for designers of disabled user groups. Here are some commonly used methods:

1. **Interviews:** This was our primary mode of cognitive study. Qualitative interviews allowed us to gather personal insights of the designers. It was beneficial for studying problem solving, subjective perceptions and decision making. We used a mix of structured vs semi-structured interview protocols.
   1. **Structured Interviews:** We used a predetermined set of questions with standard wordings and order to make sure it was consistent with participants. Various interviewees responses could be easily compared to get a quantitative analysis.
   2. **Semi-Structured Interviews**: Sometimes we had flexible formats where the participants had more to exchange information allowing them to elaborate on their experiences and share additional information. It allowed us to capture more open ended responses. It was instrumental in the case of Participant D (Occupational Therapist at Georgia Tech) whose interview was in this format.

### Note-Taking: In order to retain information, the best way to summarize is taking notes. It involves jotting down key points, concepts, and ideas while reading or attending lectures. During our interviews, we used note-taking strategies to gain the knowledge to design the cognitive task.

1. **Active Listening:** we recorded and reviewed the interviews multiple times before summarizing them into a final interview document. During the interview, we used our listening skills to ask questions more than we had outlined in our study protocol.
2. **Visual Aids:** The concept schema document provided a more visual representation of the prototype of our cognitive project. It simplified the representation, concept, preposition and rules connecting the concepts. It helped us visualize the representation and the referents to be grounded.
3. **Online Resources:** we also used online resources to understand new tools our interviewers use to help with the accessibility document they design. Some of these tools were new for our group like NVDA, JAWS etc.

### Study Participants

Our goal is to create an application that can substantially enhance the design process of course materials for students with disabilities. Considering the broad definition of disabilities, we are narrowing our focus for our project to visually impaired individuals.

Our study will involve developers and designers of the existing tools which aim at aiding visually impaired individuals (for example, the developers of sonification tools and accessibility-oriented websites or apps). These designers have tremendous knowledge and invaluable insights with their extensive research and practical experience in this domain. Furthermore, they have first-hand experience receiving feedback about their products, which can shed light on the final products after their design process.

A challenge we faced was finding study participants significantly after we shifted our focus domain to visual impairment instead of a more generalized disability. Despite that, we had a well-represented pool of participants as it had experts and novice designers in designing accessibility materials for visually impaired students or users. Furthermore, the interview findings were consensus for us to accept or reject our hypotheses.

After reviewing the existing apps and their designers, we contacted them and initiated interviews about our project following our interview protocol. We also contacted the university disability center and made appointments with the advisors. The table below contains the participant's design background:

| Participant ID | Background |
| --- | --- |
| A | Designer at Microsoft with a focus on dyslexia, epilepsy and blind people |
| B | Master’s student in Engineering Psychology specializing in Accessible Design |
| C | Occupational Therapist at Georgia Tech working on changing materials for vision impairments students |
| D | Undergraduate student in Industrial Design |
| E | Instructional Designer, CIDI, Georgia Tech |
| F | Eye doctor specializing in visual impairment and assistive tools |

### Study Protocol

#### Introduction:

Good morning/afternoon/evening, thank you for taking the time to participate in our interview. My Name is [Name], and I’m a researcher working on a project that aims to create an application to aid the design process of designers. We are interested in how learning materials are designed to accommodate the needs of students with disabilities and enhance their learning experience.

This interview will take about 30 minutes, and your responses will be recorded. Please note that your participation is entirely voluntary, and you may choose to stop the interview at any point. Your answers will be treated confidentially and used only for our project. Can you confirm that you are comfortable proceeding with this interview?

#### Questions:

1. Could you tell me a bit about you and your field?
2. What barriers or constraints as designers you have to take into account when designing a system for visually impaired users?
3. Can you give me an example of how you apply different tools, applications, and methods to help users overcome~~?~~
4. Visual impaired users used different tools on their computers to aid themselves, how did this impact your design? And what did you do to accommodate this?
5. Can you share any experiences where you modified content? What changes were made? Can you tell me about your process when you make these changes
6. What did you do to confirm that your designs were helping visual impaired users? And if your designs were intuitive?
7. Do you think collaboration and feedback improve the quality of the accessible document creation process? How do you measure these improvements?
8. How long have you been designing accessible documents? So do you consider yourself to be a novice or expert designer? How has your thinking evolved from being a novice to expert level in designing accessible documents?
9. Final thoughts on how CIDI positively impacts student experience at Georgia Tech?

#### Closing:

Thank you for taking the time to participate in our interview. Is there anything else you would like to share with us at this moment? Your responses will greatly help our project to enhance the accessibility of learning materials for students with disabilities.

At this point, can you be open to follow-up questions in the future? If yes, can we collect your contact information? Also, if you are interested in the results of our study, it's our pleasure to share them with you. If you have any questions about our project, don't hesitate to contact our advisor, Dr. Michael Helms, at michael.helms@me.gatech.edu.

Thank you once again for your time and participation.

### Data Description

For each interview, we record the interview of the participants in a .wav format; then, we proceed to transcript the data with Otter.ai. On average, the recordings were 10-15 minutes, most of the interviews were conducted alone, and the person doing the interview was responsible for data analysis.

Since the interviews can sometimes be very open-ended to explore what the participants mean, for example, the transcription below does not follow our protocol strictly, but it is essential to understand the context:

**Interviewer:***“So earlier, you said that there was a lot of cluttering in the current system? And can you talk a little bit more than that? Like why cluttering would not be a good idea for visual impairment students?”*

**Participant:***“So like, for someone who can see they can keep looking around to try to find it. They can use their eyes to be able to find something but someone with visual impairment can't and it can create more frustration, and you want it to be more convenient for them.”*

For such, cluttering meant something other than the amount of information given but how they were organized. It could be easily misinterpreted if we were only strictly following the study protocol.

Our interpretation of some parts of the interviews is also limited as we couldn’t see the system they designed. We had to rely solely on their description to depict their design. For example, when the participants mentioned assistive technology such as NVDA, JAWS, etc., we did not clearly understand these tools since we had never used them.

Besides that, we expect to have some errors with the transcription due to audio cuts, lagging, background audio, etc., that can interfere with the recording. We manually checked these errors when analyzing the data to sort them based on the interview questions they were related to.

### Data Analysis

The data we collected were qualitative interviews; despite having a protocol to guide us through the interviews, some interviews were much more open-ended, which required us to manually go back and use the transcript to sort out relevant information. Although the interviews were rich with data about disabled students, we were still able to spot some of the relevant findings regarding the design process to answer our hypotheses.

**Hypothesis 1: *Intuitive design thinking helps designers promote accessibility advancements that can positively impact individuals with disabilities:***

| **Participant ID** | **Supporting Quotes** |
| --- | --- |
| A | “every new event that is created, the user needs to be able to navigate through it, be able to read everything clearly” |
| B | “So like when someone's interacting with something, they want it (the system) to be intuitive, like they want it to match what other systems that they use” |
| C | “Since students use different assistive technology on their computer, we want to like make it (the design) seamlessly integrate into their (existing) computer” |
| E | “At CIDI, universal design and inclusive design principles create content for everyone and I think that accessibility should be a core concept, not an afterthought”  “By making products, services, and environments accessible, we can cater to the needs of diverse student populations which can also create new opportunities.” |
| F | “Balancing aesthetics and accessibility can be a challenge, as modifications may be needed to prioritize usability for all users.” |

From our interviews, inclusive and intuitive design is a relevant goal for designers. Significantly, an intuitive design will help users use the system easier as it matches their cognitive schema. These design principles are often complex to validate as they require many iterations of testing to ensure the designs work, which can take up most of the designer’s time.

**Hypothesis 2: *Collaboration and feedback improve the quality of accessible document creation.***

| **Participant ID** | **Supporting Quotes** |
| --- | --- |
| B | “I had to receive a lot of guidance from my professor to understand the system”  “Through the usability tests you will see new unintended ways that the users can interact with the website” |
| D | “Hmm we bounce off lot of ideas from teammates in brainstorming phase”  “User feedback is probably the most important thing in any project” |
| E | “I do think by involving users / students and faculty will provide improved accessible documents by reducing errors and increasing user satisfaction.”  “We incorporate inclusive and universal design principles in creating accessible documents” |
| F | “Manual testing is also crucial to evaluate the user experience and ensure that the content is perceivable, operable, understandable, and robust for all users. User feedback is invaluable in ensuring accessibility.” |

User feedback is another big concept widely discussed by the participants, especially in creating a new system for visually impaired users. By involving the users early in the design process, the designers can mitigate the risk of designing irrelevant features that are not valuable for visually impaired students.

**Hypothesis 3: *There are barriers in the accessibility domain for the designers***

| **Participant ID** | **Supporting Quotes** |
| --- | --- |
| A | “(visually impaired) Individuals rely on keyboards rather than mouse”  “Screen readers provide clear descriptive information” |
| B | “Matching the expectations of visually impaired users”  “One challenge is explaining concepts to visually impaired individuals effectively”  “One challenge is explaining concepts to visually impaired individuals effectively” |
| C | “they might use screen reading technology. We use JAWS and NVDA tools”  “We were able to go in and modify the document (Incompatible Math type), changing the MathType equations into office math.”  “creating math content for screen readers is also a challenge as there are different ways to do it, depending on the reader used by the student” |
| E | “Graphics, graphs and charts were hard to convert especially those found in statistics books”  “We incorporate inclusive and universal design principles in creating accessible documents”  “It is also a fundamental right, and efforts should be made to remove barriers and promote access for everyone” |
| F | “One of the biggest challenges is catering to the diverse needs of individuals with different types and levels of visual impairments. Visual impairments can range from low vision to complete blindness, and each person may require different accommodations. ”  “If websites lack proper consideration for accessibility standards, visually impaired users may struggle to navigate, access content, or interact with various website features.”  “Elements like poor color contrast (color blindness), inadequate labeling of form fields or buttons (input difficulty), or non-descriptive links (visually impaired people don’t know it’s a link) can pose significant barriers.” |

Designers need to take into account the limited tools used by students with disabilities, as well as the challenges of designing for unexpected formats to ensure a system that is tailored to each student. These recurring findings in the design process are crucial for designers to accommodate students' unique situations and be mindful of the dynamic nature of resources during run-time.

**Hypothesis 4: *Difference between expert and novice designers in awareness of accessibility in our group:***

| **Participant ID** | **Supporting Quotes** |
| --- | --- |
| A | “That's (screen reader) our main testing tool… for everything we test out” |
| B | “I modified the tutorial videos multiple times based on participant feedback” |
| D | “researching how visually impaired individuals learn mathematics and use computers”  “I think I'll do some research about it (a project). Because it tends to be like an area that I'm not too familiar” |
| E | “At CIDI, universal design and inclusive design principles create content for everyone and I think that accessibility should be a core concept, not an afterthought”  “It (accessibility design) is also a means to empower students with disabilities, promoting independence and to bridge the gap ensuring people with disabilities participate in the college experience fully.” |
| F | “A more convenient point is that college courses always have multimedia content… The courses included videos and audio recordings. We only need to ensure that multimedia players are compatible with screen readers and keyboard navigation.” |

The difference between expert designers and novice designers is also highlighted through the interviews. Experts talk on a higher level, using user-centered design principles to truly understand how their design could help the visually impaired student being just getting accessible. On top of that, the conceptual schema of visually impaired students is widened by experts, allowing them to chunk information effectively. Even with these subtle differences, they can change the result of the designs.

### Conclusion

After conducting several interviews, the data shows that the three hypotheses we framed were close to our expectations (1, 2, and 4). We found that hypothesis 3 is incorrect. There are several barriers the designers face in generating accessible documents. These barriers include translating mathematical equations and images into appropriate formats and the language of the text that a screen reader can read.

We hope to gain a profound understanding of cognitive processes and design more effective and efficient solutions for designing accessible documents. Using our interview analysis, designers can create more inclusive and usable websites and applications. As suggested by our data analysis, the design process for individuals with disabilities involves a combination of cognitive processes, including information processing, adaptation, collaboration, and learning. The occupational therapist's work at Georgia Tech highlights the importance of understanding the specific needs and preferences of individuals with disabilities and tailoring solutions to ensure equal access to educational materials.

### Implications

Our project aims at helping designers to design more accessible course materials for visually impaired students. We have sought advice from developers of existing apps or websites and professional therapists to comprehend how these students learn and cognize new knowledge. The data we gather from the interviews can be used to improve existing computational cognitive models. Based on our interview findings, we can outline the design schema for our computational cognitive model, which incorporates critical considerations and strategies for creating accessible learning tools for visually impaired students.

The first step for a good design process is understanding the needs and challenges of users. Researching how these students learn is fundamental in this stage. It includes understanding the limited tools they may be using and their preference for specific input devices (Participant D).

Also, Designers need to consider dynamic events. Since a lot of interfaces include dynamic events and students may interact with the tools, designers need to ensure that each new event can be navigated and read clearly by visually impaired users (Participant A). Another essential part of the design process is continually testing and refining the product based on user feedback. This iterative process ensures that the product effectively addresses the problems it's designed to solve. Designers should not hesitate to modify their work based on this feedback (Participant B) as it is the most crucial part of any project (Participant D).

Our project provides a framework that can systematically analyze user needs, work with accessibility tools, design for dynamic events, incorporate iterative testing and feedback, and address the learning curve for new designers. The framework for our computational cognitive model enables a more effective and inclusive design process in the future. This schema can serve as a roadmap for other designers looking to create accessibility tools, ensuring that the needs of visually impaired students are considered and met in every step of the design process.

Computational shortcuts are strategies or simplifications people employ when dealing with complex computational tasks. In our design, we also used some computational shortcuts.

Predefined Templates are the first shortcut we found. Designers often use pre-existing templates or frameworks as shortcuts to expedite the design process. These templates provide a foundation and predefined structure, allowing designers to focus on customization rather than starting from scratch. This shortcut saves time and effort, enabling designers to create the application's interface and functionality efficiently. With predefined templates, designers can invest substantial time and resources in building the basic structure of the application from the ground up. It would delay the development process, increase the overall complexity, and potentially lead to consistency in design and functionality.

Parallel Processing is also a helpful shortcut. In this, tasks are divided into smaller chunks of subtasks that can run in parallel on multiple nodes. By utilizing parallelism, computations are performed concurrently, leading to faster processing times and increased throughput. Without parallel processing, tasks would need to be executed sequentially, significantly increasing the time required to complete computations. It would limit scalability and hinder the ability to efficiently process large amounts of data.

The interview section involves sampling shortcuts. It involves analyzing a representative subset of data selected from a bigger sample data. Analyzing the sample instead of the entire dataset helps conserve computational resources resulting in decreased analysis time. Without sampling, the analysis happens on the entire dataset, which could be computationally intensive and time-consuming resulting in decreased performance and increased resource requirements.

The complexity increases when scaling up the schema to "human-sized" data. Scaling up the schema to handle larger datasets introduces higher data management, processing, and analysis complexity. It necessitates more robust computational models and algorithms to handle the increased volume and variety of data. Also, dealing with larger datasets requires more hardware and software to handle load. Scaling up the schema would demand efficient data storage, retrieval, and processing mechanisms to ensure timely and accurate analysis. As the data size increases, computational shortcuts become even more crucial for maintaining acceptable performance levels. Efficient algorithms, optimized data structures, and parallel processing techniques are necessary to handle the increased computational load and maintain responsiveness.

Our design process, driven by the computational cognitive model, aims to change users' behavior by providing accessible and inclusive course materials. The application encourages visually impaired students to engage with the content more effectively, promoting independent learning and academic success through features like text explanations, text descriptions, and haptic feedback. The cognitive model also suggests that the application can enhance cognitive processes such as comprehension, memory, and navigation by incorporating alternative modalities and sensory feedback. The hypothesis is that these enhancements will lead to improved information processing and better retention of course materials among visually impaired students. The implications for the computational cognitive model in designing for visually impaired students highlight the importance of efficient decision-making, integration of alternative modalities, and sensory feedback. The design process becomes more effective by taking computational shortcuts, managing cognitive load, and ensuring scalability.