Final Analysis

Team: Access-Ability Innovators

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CS-6795: Introduction to Cognitive Science

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1. 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.

2. 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.
   a. **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.
   b. **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.

2. **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.

3. **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.

4. **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.

5. **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.

6. **Automated Interview Transcripts:** we used automated transcript generation mechanisms provided by the online meeting tools like Zoom and Teams proved extremely handy.

3. 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 (Karshmer, A. I., Pontelli, E., & Gupta, G., 1999).

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
G	HCI professor at GT
H	Braille Media Specialist at CIDI
I	Application Developer E-text and SAM units at CIDI
J	Digital Accessibility Specialist at CIDI
K	Research Scientist at CIDI
L	Manager of the E-Text Department at CIDI
M	iOS Developer for a Book App
N	Machine Learning Engineer for a Book App
O	Optical Engineer for VR product
P	Volunteer at Disable Action Center
Q	Researcher of Assistive Technology, CIDI, Georgia Tech
S	Designer at a tech startup specializing in accessibility and inclusive design
T	Phd student studying perceptual navigation strategies
U	Speech Therapist at a Rehabilitation Center

V	SDE developing solutions for accessible e-learning
W	UX designer at a mobile app company in voice-user interface (VUI)
X	Research Engineer at a tech firm, developing tactile feedback devices
Y	Special Education Teacher with expertise in adapting classroom materials for visually impaired students

Note: we are a group of four students and so our interview count is a bit smaller (20 interviews) as we had to distribute more tasks per person. We informed Dr. Helms that this is the case at the beginning of the semester.

4. Study Protocol

With primitive knowledge of the design process of creating accessible material, our protocol was very general at first. When we started getting insights into the field after interviewing a few people, we made our questions more specialized to tackle the points we wanted to touch on (Eligi, I., & Mwantimwa, K., 2017). Altering the interview questions and study protocol allowed us to align the research objectives better with the actual goals of the study. It ensures that the data collected will be more relevant and helpful in addressing the research questions. Every interview provided data collection viewpoints that led to modifications to our interview protocol, guiding to comprehensive learning of the subject. Different participants have unique perspectives and experiences, so the question set had minor changes for various interviewees to touch on their expertise more.

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.

5. 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.

6. 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 (Periša, M., Peraković, D., & Remenar, V, 2012):*

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."
H	"For braille users, consistency in braille formatting and usage of standard braille codes enhances readability and comprehension."
L	"Everything that we do is to make accessible materials for anyone who's using screen reader software or assistive technology to access content so that the content will be read aloud to them. So we are making a textbook accessible for someone who is listening to it and only using a keyboard to navigate."
M	"Certain color combinations may look great visually but can be problematic for people with color blindness or low vision."
N	"A goal we hope to achieve is to enhance our Text-To-Speech (TTS) feature so that it can handle complex sentences or phrases with more natural pronunciation. We aspire to ensure that all types of textual content are converted into speech that is not only intelligible but also sounds natural and fluid to the listener."
O	"This tactile information can provide valuable feedback, allowing users to 'feel' the virtual environment, making it more accessible to visually impaired users."
P	"I've gained insights into how these technologies are designed with cognition and perception in mind, particularly with an emphasis on non-visual modalities such as touch (haptic feedback) and sound (spatial audio cues)."
S	"Intuitive design process should be an instrumental to advance disability that every designers need to know. So an example, our designs aim to minimize cognitive load, ensuring that all our app features are easy to find and intuitive for everyone, especially individuals with disabilities."

T	"So my studies, I look at how normal people (see normally) experience with their learning process and bridge the gap (to the visually impaired people) through my designs. These designs gonna give them an intuitive way to mimic the experience (of learning)"
U	"Tools that can align with their natural communication patterns provides them a better experience interacting with assistive (technology) tool."
V	"In software development for e-learning, the intuitive design is very important. If the UI (User interface) feels familiar and easy to navigate, students, irrespective of their abilities, will be more engaged and better able to absorb the content."
W	"Voice-user interfaces can be a powerful tool for the visually impaired, but only if they are designed intuitively. The goal is to create interactions that feel as natural as speaking to a human. This can dramatically improve the accessibility and usefulness of mobile applications for visually impaired users."
X	"Developing tactile feedback devices involves deeply understanding the intuitive touch responses of visually impaired users. If we get this right, the devices become a seamless extension of their tactile world, significantly improving their interaction with digital content."
Y	"In my experience as a Special Education Teacher, I've found that adapting classroom materials using intuitive design principles can significantly enhance learning for visually impaired students. This approach allows for a more natural and engaging learning experience, effectively leveling the playing field for these students."

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. Therefore, understanding what the users know and designing a system that is cohesive to the users, especially users with disabilities will ensure the designs are effective to achieve the users goals. 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."
G	"(When working with other people) I can get ideas from areas that I don't know about and resulting in a more efficient work. Working alone has a perk that you can decide what to do but if it's something you are not familiar with, then you will need to research on your own more."
I	"As an Etext specialist, embracing collaboration and feedback enables you to leverage your technical background and expertise to create high-quality and accessible E-text materials."
J	"We have to make huge undertakings to get feedback from students to to get information about, like what the formats were that work best for them, like the sort of the system we have come up with, of providing PDF and docs and things like that has been a lot of trial and error for a lot of for a fairly long time"
K	"We perform thorough accessibility audits using automated testing tools and manual evaluations to ensure that the designs complied with accessibility standards, such as WCAG (Web Content Accessibility Guidelines). These audits helped identify any potential accessibility barriers and provided insights into areas that needed improvement."
L	"People who work at CIDI who do user testing help us look at our files and make sure that they are working correctly with the screen readers and the software."
M	"In our pursuit to create an engaging and accessible book app for iOS, the value of teamwork cannot be overstated. Each of us brings a unique

	perspective and a set of skills, whether it's in coding, design, user research, or testing. "
N	"It's only through our collaborative efforts that we can continuously research, learn, and adopt new Text-To-Speech (TTS) techniques. "
O	"We often encounter complex challenges that require a diverse set of skills and knowledge. The essence of overcoming these obstacles lies within our team dynamics. Each of us brings unique perspectives and expertise to the table, enabling us to develop innovative solutions that would be impossible for an individual alone."
P	"Each individual we help has unique needs and challenges, and it takes a collective effort to truly understand and address these."
Q	"For sure, the timeliness of the feedback is kind of part of the challenge. If I'm a professor, I won't know I have a problem unless somebody says something and if I get it at the end of the course in a course evaluation and may not be specifically tuned enough for me to say ohh it was this particular PowerPoint on this particular day that through this particular student to not be able to have an accessible document."
S	"Working with other designers, users, and stakeholders is a key factor, well i would say it's required factor, in the success of our accessibility designs. Their feedback is valuable in helping us understand what is working and what needs to be improved in our designs."
T	"Designing sounds easy but it's quite complex because you're not working alone, what's different from a school space and a work space is that you need to work with alot more people. Teamwork and feedback is essential as it's necessary for continuous evaluation."
U	"Our work with visually impaired clients is very much a collaborative process. It's not just about creating tools, but also about learning from their experiences and receiving feedback to continually refine our approach."
V	"Developing e-learning software is a constant iterative process. User feedback and collaboration are instrumental in enhancing the user experience, particularly when creating content for visually impaired students."
W	"Creating voice-user interfaces involves multiple stakeholders - designers, engineers, linguists, and of course, the end-users. Each of them brings unique

	insights to the table, contributing to the development of a more refined and accessible product."
X	"Collaborative work on tactile feedback devices has taught me the importance of a multi-disciplinary approach. The interplay of diverse expertise and consistent feedback loops can significantly enhance the product's final quality and efficacy."
Y	"Creating accessible classroom materials requires close collaboration with students, teachers, and accessibility experts. Their feedback helps identify barriers and fine-tune solutions. It's a constant learning and adapting process that ensures we are delivering truly accessible content."

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. Collaborating with people from different professions allows the designers to draw valuable insights that they might not get or hard to get if working alone. This provides a fast pace design process for the designers to get the solution out.

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."
H	"Braille documents have limited space, especially when compared to their print counterparts. Complex mathematical expressions may require more lines or space in braille, making it challenging to represent equations concisely." "Graphs, charts, and diagrams used in mathematical contexts can be difficult to represent tactually. Designing tactile graphics that convey the visual information effectively in braille requires expertise and creativity."
I	"E-text formats may not fully support MathML (Mathematical Markup Language), a standard for representing mathematical content on the web. Without adequate MathML support, the rendering of equations may not be accurate."
J	"Content creators put all text on all their images, but not every image needs to have alt text on it. So like if you have a, if you're looking at a page and it's got a lot of decorative elements on it, people started putting all text on those little decorative elements. A person who can't see the screen doesn't really care what the decoration is."
K	"Images, particularly those without appropriate alt text, can be inaccessible to users with visual impairments who rely on screen readers. Without descriptive alt text, visually impaired users are unable to understand the content and context of the images." "Some complex images and math equations may not be properly recognized by screen readers or other assistive technologies, limiting their usability for individuals with disabilities"

L	"One the biggest barrier in accessible content right now would be accessible math, especially higher level math. That's like linear algebra or calculus or anything there and above. When we get a book that is maybe 80 to 90 or more percent math equations to render that into an accessible math type of math speak, it just takes months just to do one book."
M	"While many apps offer TTS, they often do not implement it well. For instance, some apps might not read all the text, miss some critical information, or the speech may not be clear or natural-sounding."
N	"Many apps are designed primarily for touch or mouse input and do not fully support keyboard navigation. This can be a major barrier for visually impaired users who use a keyboard or assistive devices to navigate."
O	"Sometimes, apps are designed with complex interfaces that are difficult to navigate without sight. This includes crowded screens, small touch targets, or important actions that require precise gestures."
P	"Touchscreen interfaces pose a significant challenge as they lack physical differentiation. Traditional keyboards, for example, have keys that can be felt, whereas touchscreens are flat and uniform, making it difficult for visually impaired users to locate specific controls." "Many modern apps rely on complex touch gestures for navigation and interaction. However, these gestures can be challenging for visually impaired users to execute consistently and accurately."
Q	"Professors think that the documents have to be pretty, but sometimes it's better off to limit what we present to students in a format that we know every type of user will benefit from with the tools they have access to. "
S	"One of the major barriers we face is the sheer variety of devices and platforms. Ensuring our designs are accessible across all these platforms can be challenging and time-consuming."
T	"In my studies, I've found that designers often lack understanding about the specific needs of visually impaired users. It's like exponentially harder when something (technology) new is being introduced. This (lack of awareness) can lead to inaccessible designs."
U	"Creating accessibility solutions is not just about technology. It's about understanding the human side of the equation. We can't create something that's we think it's really good but no one use it. The needs of visually impaired individuals can be incredibly diverse, and understanding these needs can be a barrier."

V	"In e-learning, a common barrier is the lack of standardized guidelines for designing accessible content. Different platforms and tools often require unique accessibility approaches, which can make the design process complex."
W	"Creating voice-user interfaces for visually impaired users is an ongoing challenge. Now with the use of AI, it's slightly better, but it's still very new to utilize. Ensuring that voice commands are understood consistently and the system responds correctly can be a barrier, particularly for complex tasks."
X	"In developing tactile feedback devices, one of the main challenges is the lack of tactile feedback standards (especially within different buyers). This makes it difficult to create universally applicable solutions and can limit the efficacy of our products."
Y	"Creating accessible classroom materials is fraught with barriers, from insufficient tools for translating complex visual content to limitations in training and awareness among educators, we would be here the whole day if I keep going. These obstacles can impede our ability to provide fully accessible educational experiences."

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 (Jackson, R. M., & Presley, I., 2012):*

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."
G	"The hardest part is recruiting students to test it out and running the sessions, you usually need 5-7 people to get 99% of the insights out but as you can imagine, if we have more iterations, we need more participants"
H	"They are more aware of the barriers and challenges faced by braille users in accessing information."
I	"Expert designers are familiar with various assistive technologies used by individuals with disabilities, such as screen readers, braille displays, and voice recognition software so they consider how these technologies interact with Etext materials to ensure a seamless user experience."
K	"By engaging in these qualitative research methods throughout our time we can gain a deeper understanding of the challenges and opportunities in the realm of assistive technology and inclusive design."
L	"We were evolving by diversifying and really kind of trying to add new umm products and I think now instead of adding more things and more things and more things, I think we we got we got it and now we're trying to refine those things and make them make them more beautiful and more elegant and work." "Instead of expanding, we're trying to focus on the quality of what we do offer."
M	"To overcome this, apart from regular usability testing, we also work with accessibility consultants and conduct testing sessions involving users with visual impairments. "
N	"We use techniques like interviews, surveys, and user testing to understand their needs and how they interact with our app."
O	"This problem is compounded when apps change their layout or have inconsistent navigation patterns, as visually impaired users often rely on memorizing an app's layout for smooth use. "
P	"Our first step was to determine the key challenges by observing the user interacting with the app. We asked her to verbalize her thoughts and frustrations as she navigated the app, providing us with valuable insights."

Q	"We use Universal design as the guiding principles at CIDI" "I would consider myself more leaning towards being an expert since I have been working here for decades. I have been taking on advocacy roles, promoting accessibility awareness and educating others about our guiding principles, best practices in accessible document design. We are also diligent about testing our solutions with students. We incorporate feedback and iterate on our designs to improve continuously."
S	"Automated accessibility tools is a great way to brainstorm some ideas but they're not a final solution. I have tried using those tools but you can't replace manual testing and user feedback."
T	"Sometimes small details is what separates from expert and beginner designers, details are really important because a really small inconsistency would set off the users easily. And I always enjoy (seeing) firsthand how small design changes can make a big difference in usability for people with disabilities."
U	"Often I spend 80% of my time talking to my team to delegate tasks and actually planning, for me an expert is someone who's proficient at basic stuff. It's the same thing at designing accessibility materials."
V	"Trades off (between design and company goals) are something that is hard to learn and there's a certain rule to navigate through that. A more experience designer would think deeper into the users and their interactions (functionality, and accessibility) rather than just the surface such as aesthetics."
W	"Looking back as when I started out designing, I was more focused on meeting the bare minimum accessibility requirements. Now, as an expert, I'm passionate about pushing beyond compliance and creating designs that are truly inclusive, these are only learned through years of experience and meeting people."
X	"One key difference I see between expert and novice designers is the approach towards problem-solving. Experts are more likely to take a user-centric approach, actively seeking feedback and involving users in the design process. While novice designers do the same thing, but they do it (creating user scenarios) just to do it, they dont have a clear understanding of why they need to do that"
Y	"Novice designers often view accessibility as a constraint, while expert designers see it as an opportunity to innovate and design more robust and inclusive products."

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. Experts also know more about their domain and spend more time testing the system to uncover more problems (Janet L. Kolodner 2008), whereas novice designers need to research the domain they are assigned. Because of this, the final result from the expert is creative during the design process. Experts are also at the forefront of innovative solutions, advocate roles, and promote awareness and best practices in accessible design documents. Even with these subtle differences, they can change the result of the designs.

We observed several file formats used for preparing student course materials at the University System of Georgia from the various interviews we conducted. Figure 1 is a visualization that better explains the file formats used.

FIGURE 1: FILE FORMATS USED FOR COURSE MATERIALS
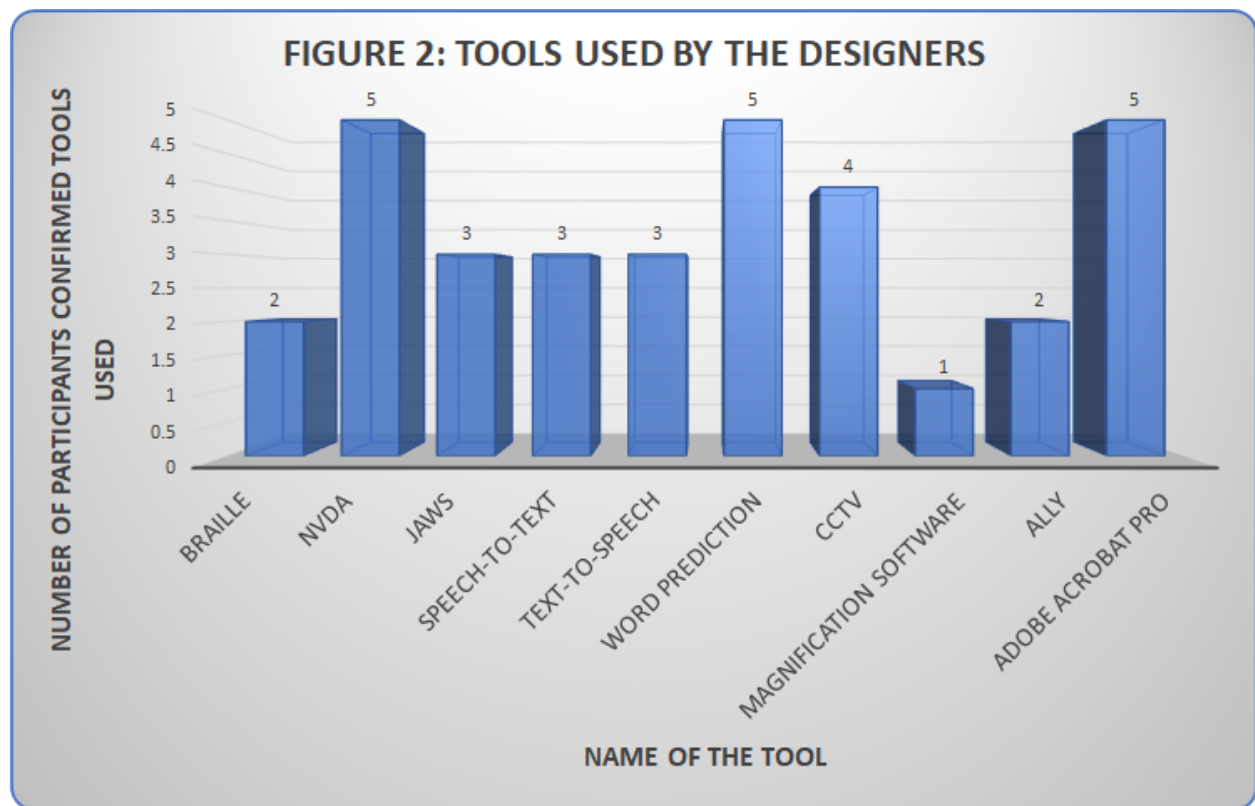
FIGURE 2: TOOLS USED BY THE DESIGNERS
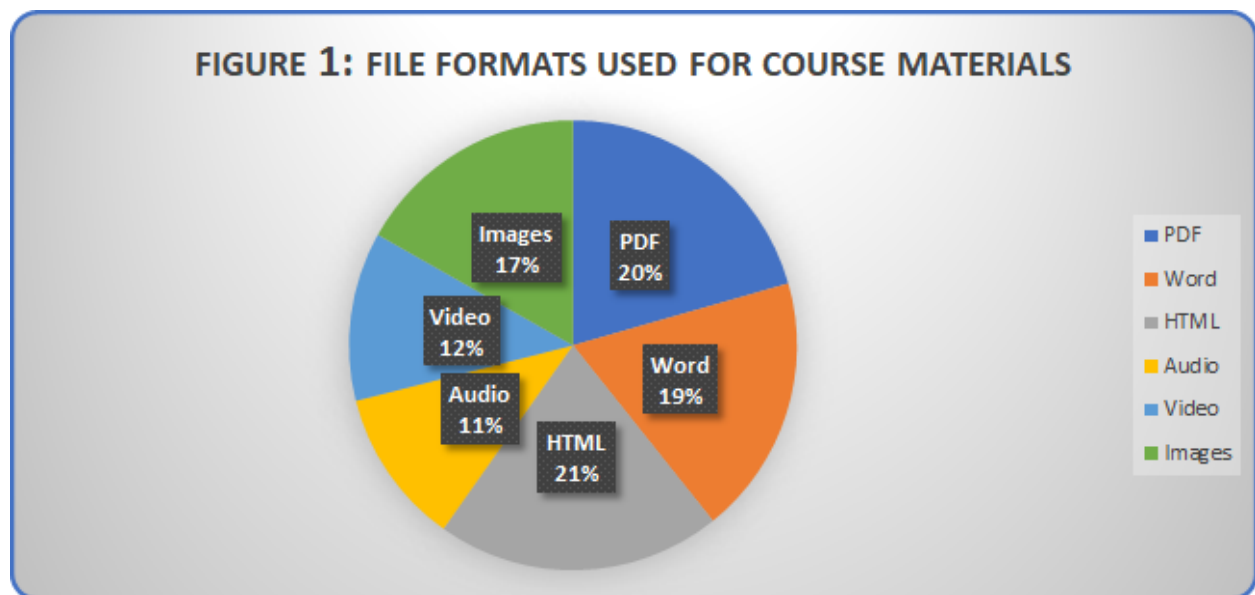
Figure 2 shows the data we collected for the various assistive tools used by our interviewees. It is a bar graph showing the top-tier tools for students with disabilities. NVDA was popular among the screen reader choices. Even though Ally was mentioned by two of our interviewees, it is popular among the staff at Georgia Tech primarily due to its integration with the Canvas learning management system.

FIGURE 3: HYPOTHESES CONFIRMATION FROM A TOTAL OF 22 INTERVIEWS

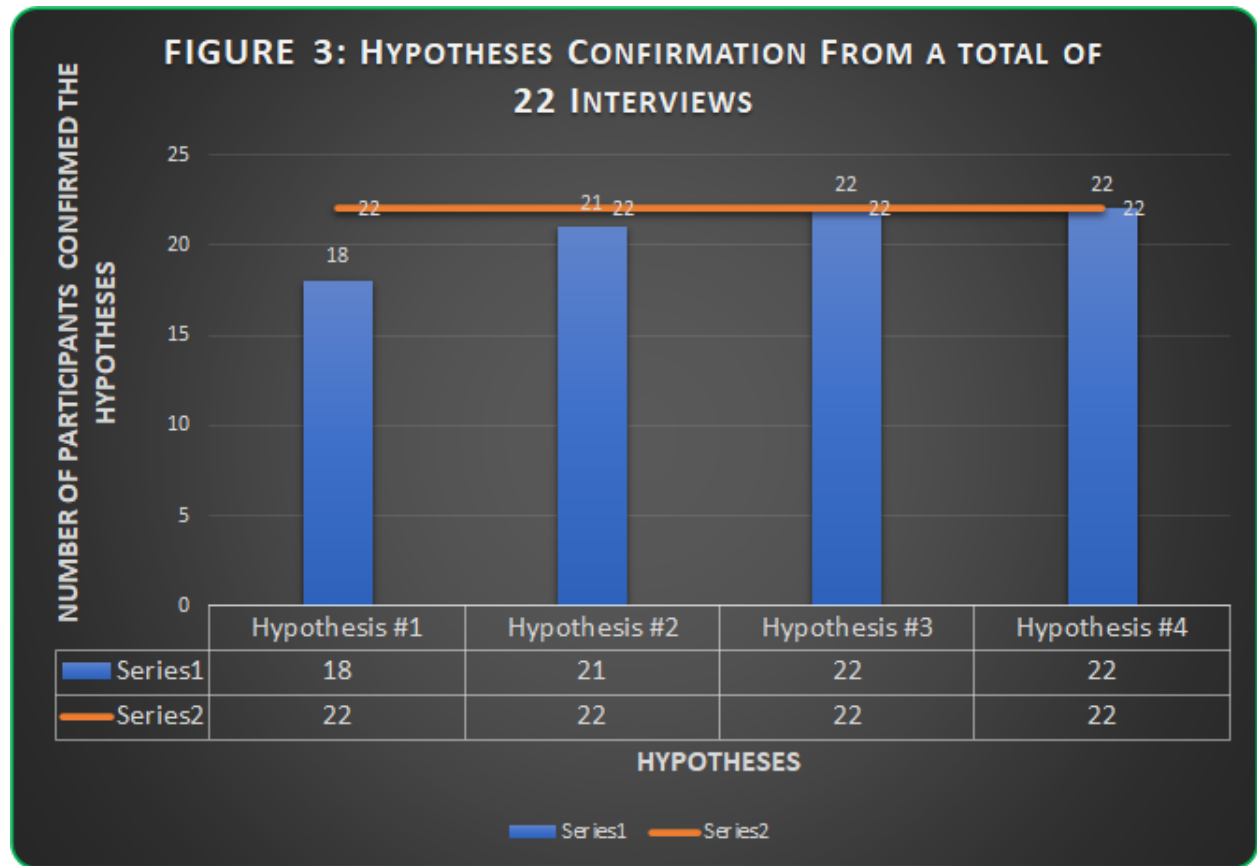|	Hypothesis #1	Hypothesis #2	Hypothesis #3	Hypothesis #4
Series1	18	21	22	22
Series2	22	22	22	22

Figure 3 shows the number of participants who confirmed our hypotheses were true or false. All participants confirmed our hypothesis 4 was true. We were incorrect in our assumptions about hypothesis 3. All of the participants faced barriers in designing accessible documents. All participants felt there was a difference between novice and experienced designers' levels of knowledge and expertise in designing accessible documents. We found 18 out of 22 participants emphasized using intuitive design principles. Almost all (21/22) participants highlighted that collaboration and feedback are essential to a creative solution.

7. 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.

8. Implications

Computational Cognitive Model

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 (Menzi-Çetin, N., Alemdağ, E., Tüzün, H., & Yıldız, M., 2017). 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.

Application

Our application aims to provide WCAG guidelines for HTML document designers. Designers can paste the source HTML code into the form and run accessibility checks. The application flags the violated html elements and allows collaboration and assignment of the errors to the appropriate teams. Either the designer can choose to fix the errors, re-run the checker until the HTML code is clear of all errors, or assign them to the appropriate team for further evaluation and fixing. For example, all the Contrast and color-related errors are assigned to 'Team 2', and image-related errors are assigned to 'Team 1'. We aimed to provide solutions to three of the items from our conceptual schema, namely:

1. Color and Contrast (assigned to Team 2)
2. Text Description for Images (jpeg, png, gif, etc.) (assigned to Team 1)
3. Error Handling - done via assign button

While rest of the three items from our conceptual schema are for future enhancements, namely:

1. Text Explanation for Mathematical Formulas (Sahin, M., & Yorek, N., 2009)
2. Text-to-Audio Technology (Screen Reader including JAWS, NVDA, etc.)
3. Haptic Feedback Assistant Technology) (Bandyopadhyay, S., & Rathod, B. B., 2017)

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