Designing for Accessibility in Online Learning: A Design Case

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Abstract

Despite laws in the United States (e.g., Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act of 1990 and its 2008 Amendments), students with various disabilities continue to experience access barriers to instructional content and inclusion in course activities. Online learning environments can present especially challenging circumstances for disabled students despite the advantages they could potentially bring. In this article, we present the design and development of three self-paced e-learning modules following a three-phased design process to prepare instructional design students to create accessible online learning content. The instructional design planning and development process can provide rich experiences for learning. In this design case, the authors tell the stories of the design team to delineate the recursive three-phased design process, aiming to present (a) the ideation, design, creation, and implementation of the accessibility modules to teach novice instructional designers the importance and methods to create accessible online instructional content and (b) the lessons learned by the design team as a result of the design process.

Keywords: disability, accessibility, online learning, instructional design

Summary of Relevant Literature

Over the past few decades, online learning has continued to grow in both K-12 (Barbour, 2013; Carter et al., 2020; Cavanaugh et al., 2009) and higher education settings (BestColleges, 2020, 2021; Seaman et al., 2018), and it has been perceived as a viable solution to many educational problems (e.g., increase in the enrollment of nontraditional students, financial constraints), especially in the wake of the COVID-19 pandemic. However, it is imperative to design learning experiences for all learners, including individuals with various physical, sensory, mental, and cognitive disabilities, which may affect their ability to learn and interact with online content (Burgstahler, 2014). In 2019, the Annual Report on People with Disabilities in America found that 13.2% of the U.S. population had disabilities (Houtenville & Rafal, 2020). The estimated number of disabled postsecondary students reached 2.4 million in 2016 (Accredited Schools Online, 2016). Despite the dramatic increase in online learning enrollments in general, researchers suggest that the rate of participation in online programs by disabled persons may be lower than expected, possibly due to problems with access (Huss & Eastep, 2016; Moisey, 2004). According to the National Center for Education Statistics, 7.3 million students aged 3-21 received special education services under the Individuals with Disabilities Education Act (IDEA) in 2019-2020 (Irwin et al., 2021). The transition to online learning has exposed many barriers to this group of students, such as a lower level of comfort with technology (Schaeffer, 2020). Disabled students might be more likely to enroll in and remain enrolled in online programs if access barriers were removed, including providing sufficient accommodations for online content.

The World Health Organization's (WHO) definition of a person's disability as a dynamic interaction between their health conditions (e.g., disorders, injuries) and contextual factors (WHO, 2001, 2011), has been adopted by the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD)

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and put into force in 2008. In other words, society's creation of such barriers in combination with people's health conditions results in disabilities. This shift from a "medical model" to a combination of "medical + social model" calls for actions to design accessible content for learners in online education. However, when developing online learning content, students with accessibility needs are often not considered (Kinash et al., 2004; van Rooij & Zirkle, 2016), resulting in significant learning barriers and challenges. Barriers include lack of screen reader support, text that is challenging to read, missing visual and non-visual orientation clues, small touch targets, lack of volume control, omitted closed captions, repetitive navigation, lack of alternative text for graphics, lack of meaningful labels in the markup for forms, and confusing heading structure (Lewis et al., 2007).

As the creators of instructional content developed for online courses, instructors and instructional designers should be aware of principles and guidelines for accessible design such as Universal Design for Learning (UDL; CAST, 2018), Universal Design of Instruction (UDI; Burgstahler, 2009), and the principles (perceivable, operable, understandable, robust) that underpin the Web Content Accessibility Guidelines (WCAG; Web Accessibility Initiative, 2018) and how to implement them to ensure online education is accessible to a diverse population of learners. While formal training represents an ideal opportunity to learn accessibility principles and practices, the existing curriculum in online learning design programs often fails to include accessibility topics. By providing opportunities for learners to develop competencies in accessible design in postsecondary courses, they will be prepared to transfer these competencies into practice in their jobs. Therefore, by teaching principles of accessible design through and tasks within real-life projects students are working on, we can create a more accessibility-aware workforce capable of understanding and meeting the needs of diverse learners.

Methodology: Design Case

As a method of disseminating design precedent (Boling, 2010; Howard et al., 2012), design cases differ from traditional naturalistic inquiry studies, research on design, or design-based research by focusing on the design product and contributing to the accumulation of design knowledge (Boling, 2010; Collins et al., 2004; Howard et al., 2012; Smith, 2010). In the following paragraphs we present our design case with consideration of five critical elements identified by Howard (2011): (a) situating the design; (b) describing the design; (c) depicting the experience of the design; (d) developing trustworthiness of the design through transparency, analysis, and reflection; and (e) removing aspects of design which confound the purpose.

Setting and Participants Demographics

The design team included a lead faculty member and three Ph.D. students in a Learning Design and Technology (LDT) program at a large public Midwestern university. Although our team members were well-versed in instructional design, we were not experienced in accessible design. We educated ourselves as we moved through the design process as a team.

After comparing different courses, we decided to implement the project in a graduate course focused on e-learning design: *Introduction to e-Learning*. Students in this course include full-time professionals in the instructional design field and those intending to transition into an instructional design position. The design team defined the target audience of this design case to include instructional designers who design instructional materials and content for online courses, students in the field of instructional design who are about to start a related career, and instructors in K-12 and higher education who teach online courses. Students in the *Introduction to e-Learning* course are required to develop an online course module on a topic of their choice. Before implementing this design project, instruction on accessibility was limited to a reading and a narrated PowerPoint on disability law and prevalent learner disabilities. Under the initial course design, students did not develop accessibility awareness and were not asked to create fully accessible online modules.

With the financial support of a small grant from Teach Access (Teach Access, n.d.), an organization with a mission to promote the teaching of accessible design in postsecondary courses, we engaged in iterative design, development, and engagement of a set of learning modules focused on developing accessibility knowledge competencies for the *e-Learning* course. The modules were embedded into the graduate course and students were encouraged to implement accessibility principles in the culminating course design project.

Description of Practice

This two-year-long design project underwent three major phases: (a) planning, (b) iterative design, and (c) iterative development. In reflecting on our design process, we adapted the Successive Approximation Model (SAM) to show the recursive process, as shown in Figure 1. Unlike a traditional ADDIE

process, our development, implementation, and evaluation underwent several iterations. Therefore, we categorized the iterative process, including the development, implementation, and evaluation into the iterative development phase.

Design Phases and Decisions

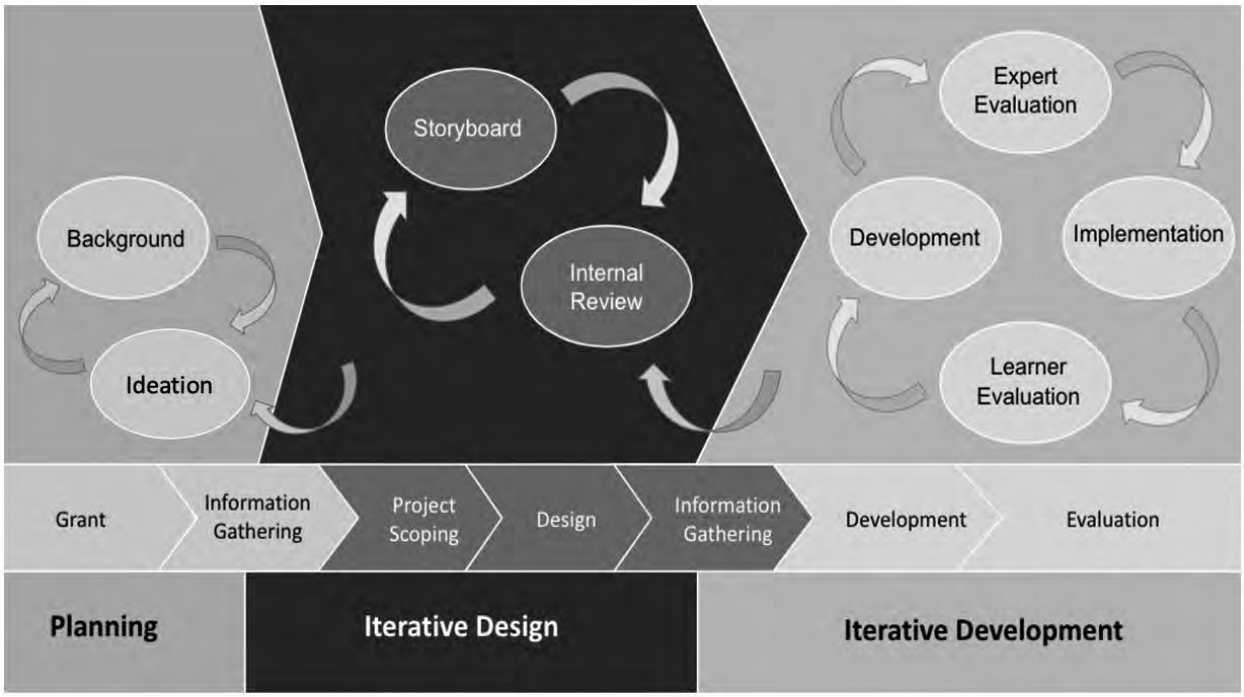
Planning

The three-phased design process started with Planning. To apply for the grant, we brainstormed potential possibilities and finalized a common vision of what we wanted to accomplish. Building on that, we started defining roles for each team member, determining initial module topics, deciding on the software platform, and identifying potential resources (e.g., computers, subject-matter experts). Specifically, the activities included:

1. Information gathering: As novices, we familiarized ourselves with accessible design by reviewing the content on major websites (e.g., the Web Content Accessibility Guidelines 2.0 A/AA Compliance) and searching for research including journal articles on disabilities and accessibility relevant to online learning. We also sought accessibility resources from our institution's accessibility design specialist and attended a training workshop conducted by the campus Disability Resource Center.
2. Selecting the technology: We determined that developing content through an authoring tool would enable us to create an engaging, self-paced training module. After comparing the features of different authoring tools, we decided Articulate Storyline was the most promising option due to its interactivity, device compatibility, layout system, navigation, multimedia capabilities, assessment tools, and learning management system (LMS) compatibility. Although Storyline generally supports WCAG standards, we learned that some Articulate Storyline features are not fully accessible (e.g., drag-and-drop interactions). Camtasia and PowToon were selected for making instructional videos.
3. Setting the goal: While our initial goal was to help instructional designers understand principles of accessibility and how to design and evaluate accessible instructional content, our planning led us to adopt three specific goals for potential students: (a) learners will understand the legal and historical principles surrounding disability and accessibility; (b) learners will be able to evaluate accessibility issues and user interface facilitators; (c) learners will be able to apply best practices for developing accessible learning modules.

Figure 1

The Design Process



4. Selecting the context: We wished to ensure that the learning context reflected the complexity of the performance context to ensure the successful transfer of learning. In selecting the context where the project would be implemented, we compared different courses taught by the lead faculty member of our team. The best fit was *Introduction to e-Learning*, in part because it requires students to create an online learning module, and they were encouraged to create modules based on a real-world need related to their personal, professional, or civic contexts.
5. Ideation: Our design team met regularly to scope the design project and ideate potential solutions to identified problems. Some ideas we discussed in one of the planning meetings regarding the scope are shown in Figure 2.

Iterative Design

Though project scoping was in the design phase as shown in Figure 1, it was actually an ongoing step since we started the ideation process. Based on the overarching goal, we discussed and finalized the objectives and scope of the project. The scope of the project was to train instructional design students on accessible design, which in turn impacts the widest population possible. One vision-impaired expert we consulted during the external review process mentioned, "I am impressed with the scope of this project. It covers a wide range of topics." With specific objectives clearly stated, we identified three individual modules aligned with our generated ideas during the ideation process. We divided the modules across the team of designers with each designer taking the lead on one module and providing guidance and feedback on the other modules.

To guide our design and streamline the process, an initial design process flowchart was created, as shown in Figures 3 and 4, to drive the design of content and activities. For example, the Flowchart Part 1 (Figure 3) delineated the goal, subgoals, key points upon which the team could make decisions, and the (sub)topics identified based on the determined scope. In Flowchart Part 2 (Figure 4), we focused on the challenges, decisions, and context to determine the methods we envisioned to adopt.

We started storyboarding iteratively with the collected information about the topics based on the visualized flow of potential content and outlined the navigation strategy (see Figures 3 and 4). Since the content of modules two and three built on the earlier modules, we created the initial storyboard for Module 1, which further informed the development of storyboards for modules 2 and 3. The initial storyboard of Module 1 was described in bullet points with detailed content notes based on a site map (see Figure 5), based on which Modules 2 and 3 storyboards were drafted. Besides describing the notes in bullet points, we also explored high-fidelity storyboards without affording interaction features to aid the prototyping design. Figure 6 presents an example of a high-fidelity storyboard. In creating detailed storyboards, we followed a table-based template to detail the exact on-screen content. Table 1 shows an example of Module 1. Each of the storyboards at different stages in the design project were reviewed by all members of the design team; revisions that incorporated feedback were made by the lead designer for the storyboard.

During the design process, we continued gathering relevant information. Questions regarding the project scope emerged, causing us to reconsider our objectives and potential content. For example, our research revealed the prevalence of disabilities among learners and introduced us to various types and categorizations of disabilities that could be considered as we developed our modules. This discovery required us to revisit our objectives and project scope to ensure that the project remained relevant and manageable.

Iterative Development

Our self-training with the selected authoring tools began in the *Planning* stage. Without previous experience with Articulate Storyline and Camtasia, we began learning by practice, relying heavily on the resources provided in Articulate's user community and other online tutorials. For example, the high-fidelity storyboard helped the team jumpstart our modules' development by exploring the features to determine the navigation and interactivities while keeping them accessible. The development phase underwent several rounds of iteration with feedback from reviewers (experts) and learners (graduate students in instructional design).

- Development: Once storyboards were developed and finalized, a full draft of the narration scripts for all module slides and videos was developed. Once scripts were completed and reviewed by the designers and other experts, two narrators were recruited through open recruitment email messages based on the designed characters (i.e., a male and female) in the modules. The modules were developed via Storyline and Camtasia by different designers simultaneously, who checked in with each other periodically during the development process for consistency (e. g., navigation, layout, graphic design). After the

Figure 2

Design Ideas

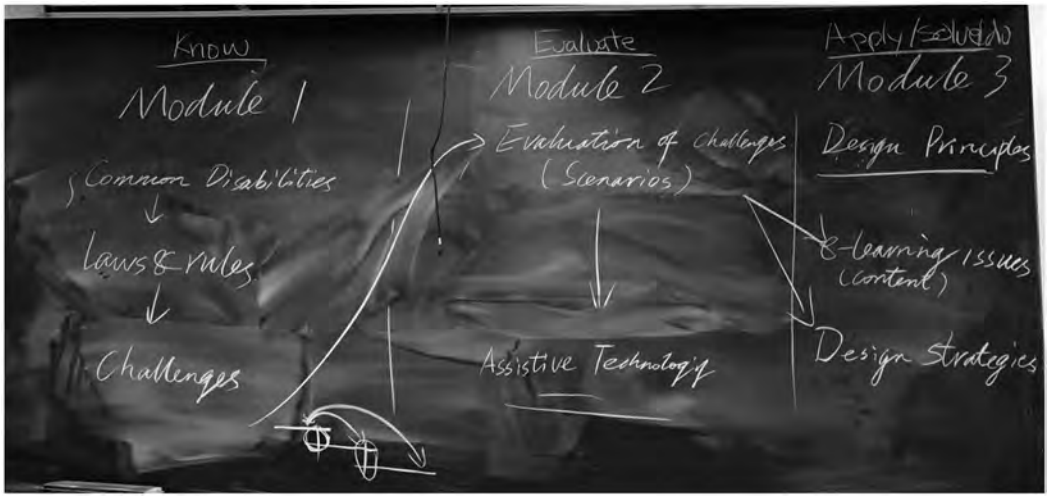


Figure 3

Design Process Flowchart Part 1

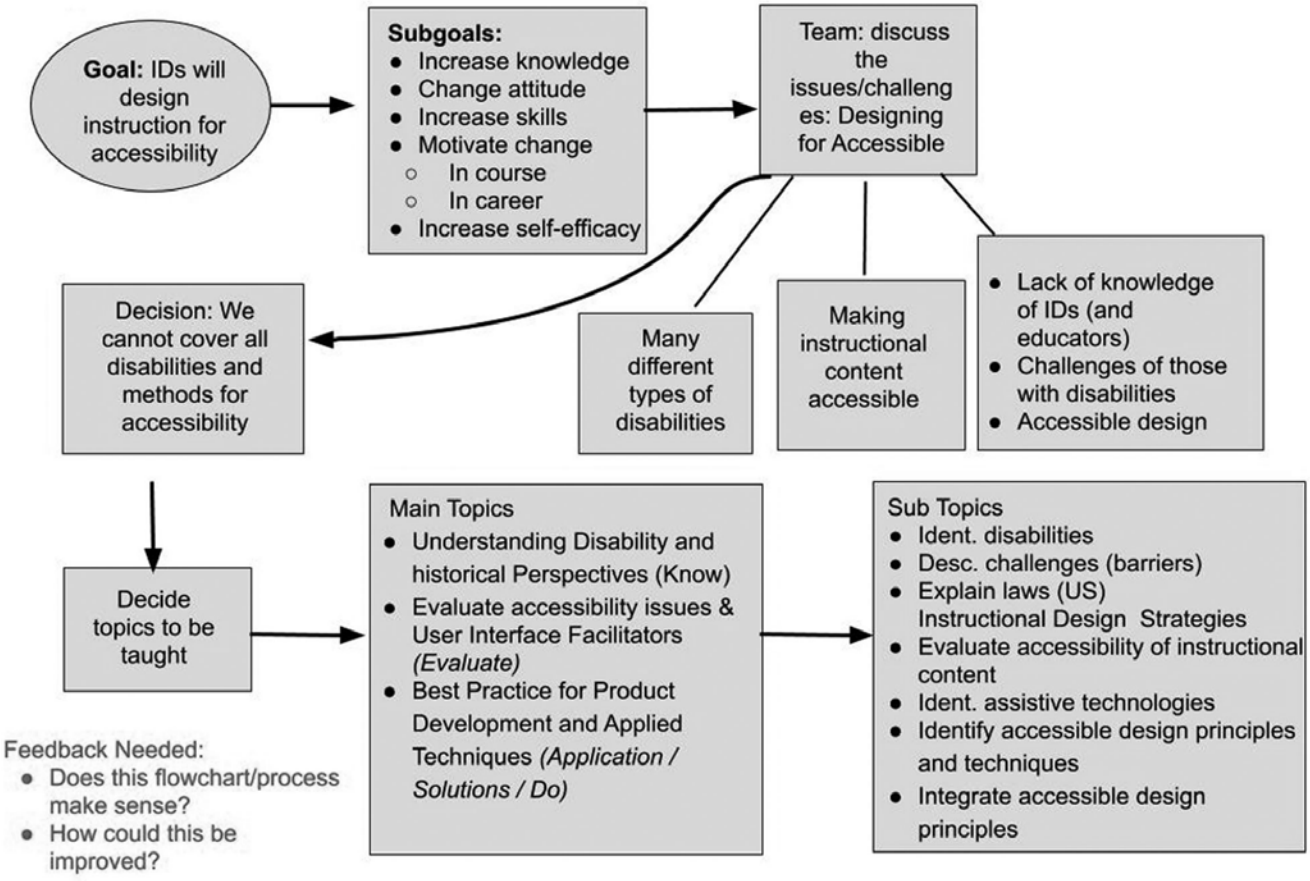


Figure 4

Design Process Flowchart Part 2

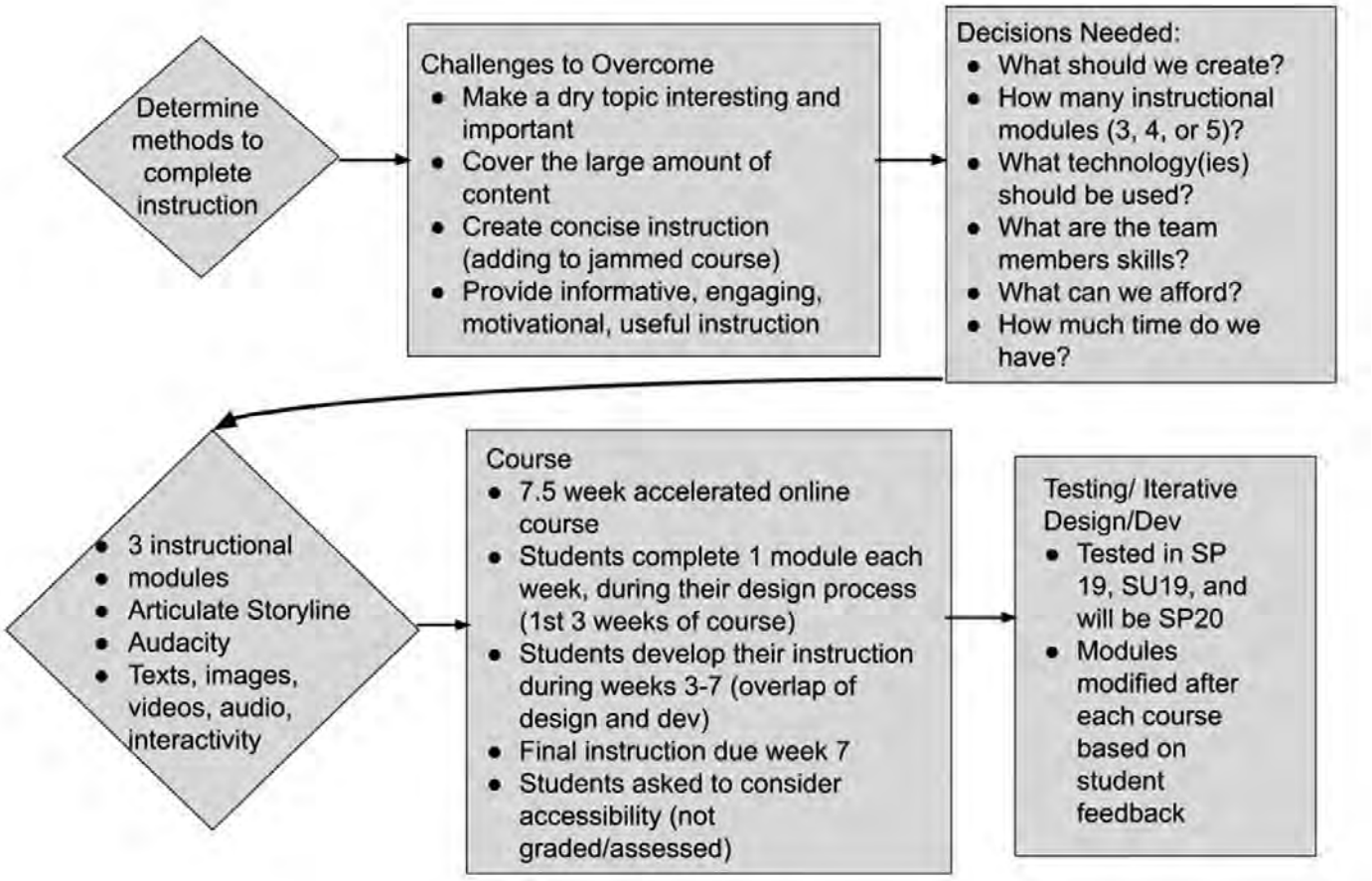


Figure 5

Module 1 Site Map

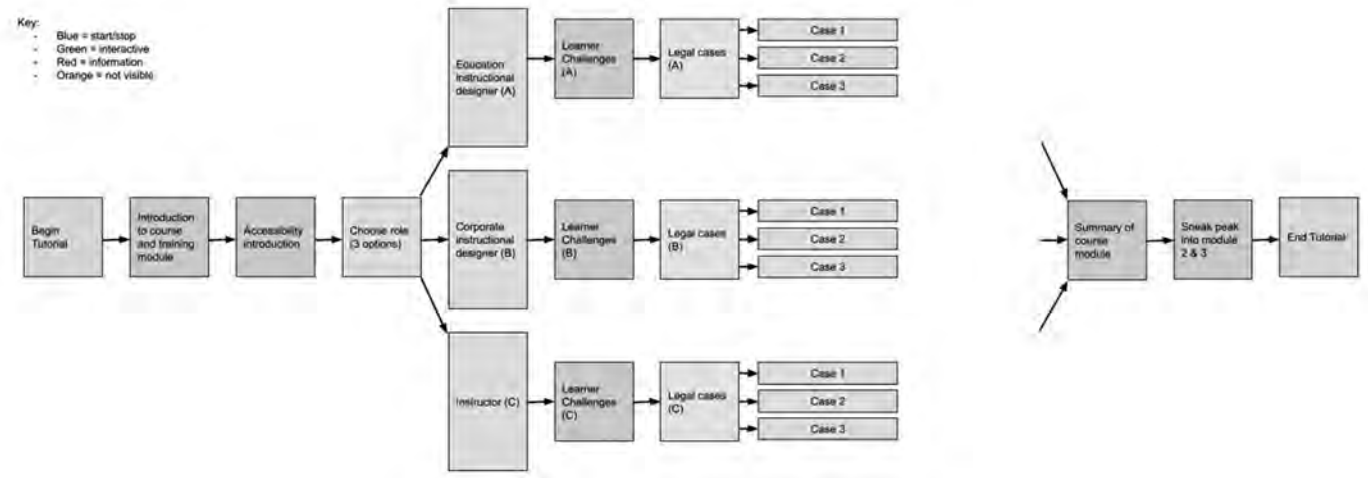


Figure 6

High-Fidelity Storyboard Without Interaction Example

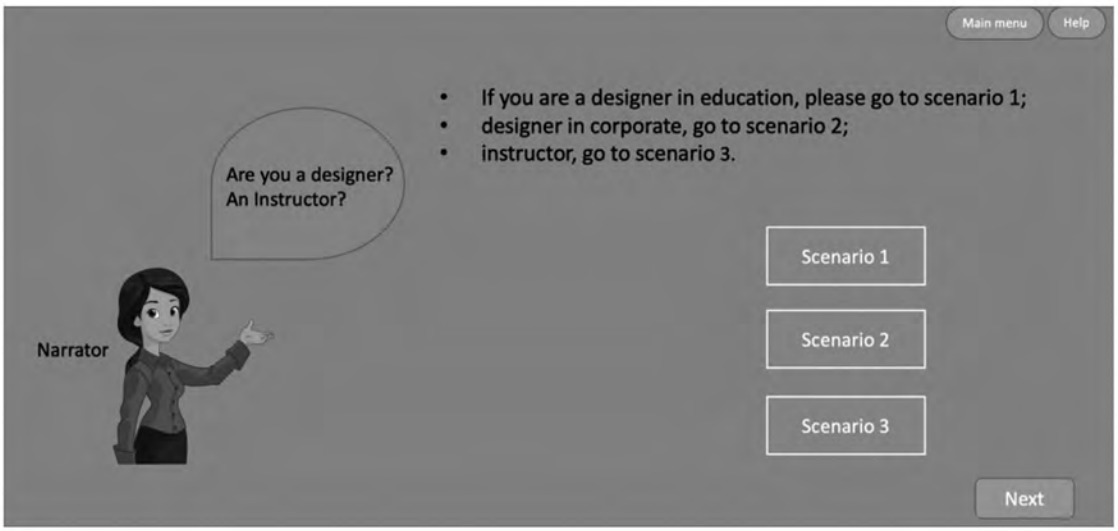


Table 1

An Example of the Table-Based Storyboard

Objective	Slide ID	Visual Display	Auditory Info/Narration	Element Timing/ Behavior
0	2.1 Introduction	(Text appears on the screen as it is read out loud) 1. Identify common disabilities that affect online learners 2. Describe specific challenges a learner might experience using computers and online instructional content 3. Explaining current laws and standards regulating the accessibility of online instruction	[audio file: 2.1] (narration) Hey there! I'm Peter. I'm guessing you want to learn a thing or two about designing for accessibility. Am I right? There's a lot to learn but we'll start with the basics, including: • Identifying common disabilities that affect online learners • Describing specific challenges a learner might experience using computers and online instructional content • Explaining current laws and standards regulating the accessibility of online instruction. "After these basics, you'll be able to put them into practice in the later modules. Let's get started!"	Let the bullets appear one at a time when the narration occurs

modules were developed in Storyline, they were tested with instructional design students recruited through our network via email, who shared similar backgrounds and experiences with our target learners.

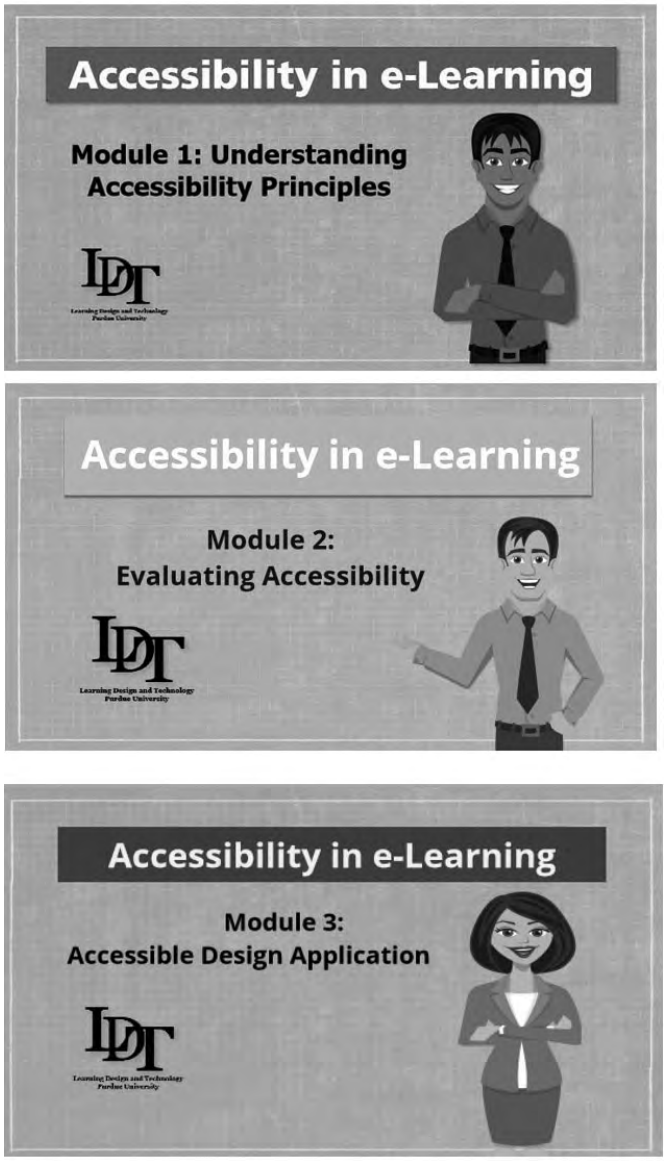
- Subject matter experts (SME) evaluation and revisions: A month before the course's implementation, the modules were sent to four SMEs identified and recruited via email with the help of the Teaching and Learning Technologies (TLT) department, two SMEs in online learning and two SMEs in designing for accessibility. Each of the SMEs had graduate degrees and significant working experience in their areas of expertise. Each module was reviewed by at least one SME in online learning and one in accessibility. The SMEs went through the modules and provided detailed feedback. For example, one expert in online learning said, "It would be a great discussion for learners to have - Storyline is a great tool. How can instructors/instructional designers use this tool and make it accessible to satisfy ethical and statutory responsibilities?" Although Articulate is making progress towards ensuring their products are designing content for accessibility, Storyline still was not fully accessible. For example, an accessibility SME said, "Storyline is not particularly accessible initially. When I evaluated this tool about a year ago, it did not play well with screen reader software. Try enlarging the browser by selecting CTRL+ (CTRL and + at the same time) until the enlargement is 300%. I am unable to see most of the content in the Storyline window." Each comment was taken into consideration as we modified the modules. Once revisions were completed, we recorded each comment along with what we did in response to them; this information was recorded to track our design process.
- Implementation: the revised modules were implemented in the online course as part of the instructional content. The course is an 8-week accelerated course on the topic of designing and developing e-learning instructional materials. Students reviewed the designing for accessibility modules during the design phase of their module, with the first module introduced in Week 2, the second module in Week 3, and the third module in Week 4. After reviewing the modules, students were asked to reflect on modules in the online course discussions and to consider the design attributes relevant to accessibility in their design documents. They were then asked to apply them to the e-learning instructional content for their course requirement to design and develop an e-learning module.
- Evaluation of the design: As part of the design process, students' feedback on the design and content of the modules as well as their attitudes towards designing for accessibility modules were collected through pre-, mid-, and post-course surveys. A knowledge check through open-ended questions was included in the pre-and post-course surveys to determine the potential impact of the training modules on students' designing for accessibility knowledge.
- Revisions: Revisions on the developed modules were made at different points as feedback came in from different perspectives. For instance, feedback from SMEs was focused on accessibility of the module, wording, navigation, content selection, etc. We addressed each of the comments respectively. Target learners' feedback focused on the instruction clarification, their need for more resources and examples, navigation, and skill gap to be covered. One example of facilitating students' easier navigation was recreated assessments. In module 2 videos were created to show different examples of accessibility issues. The original assessment asked learners to point out principles of accessibility that the case violated. The videos were chunked and included in the corresponding assessment slide to make the navigation easier and relieve their cognitive load so that they do not have to revisit the videos on the other slide during the assessment stage.

Project Management

The lead faculty member served as the project manager and developed a RACI matrix to help us manage the project while holding each team member accountable. RACI stands for responsible, accountable, consulted, and informed. The RACI matrix was created using an online spreadsheet. The researchers were added in rows in the matrix with content to the right of the researchers' names being assigned tasks and due dates. Columns of the matrix included major topics (e.g., project modules, research design, literature review). In addition, the team met bi-weekly and detailed meeting notes were kept on team discussions and decisions. The detailed notes were used to track the team's progress and update the RACI matrix spreadsheet. This matrix provided the team with a dashboard to refer to as the project was implemented.

Figure 7

Screenshots of Final Modules



Outcomes, Discussion, and Implications for Transferability

The Products

The final project consists of three separate self-paced Storyline modules hosted on an external website for dissemination. The team investigated options for hosting the modules. One option was to embed them into the courses and the other was to have them hosted on a web server and linked to the courses. The benefit of embedding them in the courses would be an easier collection of user and assessment data from the LMS, which prompted us to try to embed the modules into the Blackboard courses first. However, several challenges arose. We needed to be able to quickly make changes to the modules if a problem was reported. However, if the modules were embedded in courses, each time an issue was reported, we needed to fix it and re-embed the module into each course section (sometimes we had more than 10 sections), which would be very time-consuming. As we did not plan to collect user and assessment data at this stage, and due to the challenges of embedding the modules in the LMS and the need to access and modify the modules easily if issues were found, the design team decided in each course to insert links to the modules hosted on an external website during the initial implementation stages.

The modules included several innovative features designed to make them engaging and relevant. First, students could choose an instructional design "role" (e.g., corporate designer, educational designer) to ensure that the accessibility modules focused on content relevant to their career goals. Second, the modules included interactive characters who engaged students through a story as they proceeded through the modules. Finally, students were presented with various activities, including reading, listening, watching videos, and completing interactive assessments while completing the modules. Below is a summary of each module with a screenshot of each module, as shown in Figure 7.

1. Module 1. Understanding Disability and Historical Perspective (Why).
   Module 1 introduces learners to the concepts of disability, accessibility, and accessibility design. After defining disability and identifying the categories of disability that impact engagement in online learning, the module introduces accessible design using examples from the physical environment (e.g., curb cuts, automatic door openers) and within learning contexts. These examples emphasize that accessible design in any setting may be essential for some individuals while also extending benefits for all. Additionally, laws regulating accessibility practices are explained, including Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 and its 2008 Amendments. The module concludes with three video-based cases modeled after real-life legal cases. Cases are differentiated by educational or industry settings and learners are able to select cases based on their professional roles. As the introductory content in this series, this module is designed to describe why accessibility practices are essential in effective instructional design practice.
2. Module 2. Evaluate accessibility issues and User Interface Facilitators (What).
   Module 2 presents the common accessibility issues of online content and allows learners to evaluate real-world educational and corporate e-learning content. Videos introducing accessibility issues include examples (e.g., an existing inaccessible online course) covering various aspects regarding the accessibility of documents, images, tables, forms, videos, audio content, links, hyperlinks, navigation, interactivity, etc. Multiple assistive technologies were introduced, and links to additional content were provided.
3. Module 3. Best Practice for Product Development and Applied Techniques (How).
   Module 3 teaches learners how to integrate accessible design techniques in designing e-learning content. The module introduces Web Content Accessibility Guidelines (WCAG) to help learners conceptualize the design and development processes. Then it moves beyond the accessibility techniques to four fundamental principles of accessible design to strengthen learner understanding. Content in the module also explains how the principles work for educational and industry settings. Links to external videos and resources are included. The module concludes with a summary of an accessibility checklist (which links to external websites) to prepare learners to design accessible e-learning content, including that presented in HTML, PDFs, Microsoft documents, and Google Docs. An open-ended question is offered at the end of the module to help learners think about their own projects, such as audience, focus, scope, and how the three modules support their projects.

Learners' Design Consideration of Accessibility

The self-paced modules were offered four times from spring 2019 to summer 2020. Pre-, mid-, and post-surveys were implemented during each of the four offerings to track students' changes and progress. The number of students ranged from 90 to 130 students each semester. Reflections were built into the discussion board and final project. Students' final projects were evaluated to determine their accessibility. The collected data were analyzed on a semester basis. Based on data collected from spring 2019, over half of the students had never heard of "accessible design" before this class. At the end of this class, 90%-92% of students perceived the modules as "helpful" or "very helpful" in understanding the meaning, purpose, needs, importance, and methods of accessible design. About 82% of students believed the modules helped them to understand what they needed to know for accessible design. About 90% of students said they attempted to make their projects accessible. About 94% of students reported they would make their future projects accessible, an increase from 73% recorded in the pre-survey.

Lessons Learned

Reflecting on our design challenges and successes, we as designers obtained new design insights. Some lessons we learned include the following:

- Collaborative design. With the growth of online enrollment and available technologies for learning, we can reach a much wider population of learners. Ensuring the accessibility of online content is essential to facilitating a positive learning experience for diverse learners. To do so, instructional designers must collaborate with each other within the design team to provide awareness of all parts of the design and include multiple perspectives and different expertise for high-quality designs. In addition, instructional designers should collaborate with other stakeholders (e.g., accessibility experts) as needed to ensure content is accessible to a diverse audience enrolling in online programs. More specifically, our team learned the following:,
    - Our team realized that although each of the designers was working on a separate module, they needed to be cognizant of the other modules being created to ensure all content was covered without overlap, a consistent style and format was maintained, and there was a smooth flow and clear connection of content covered in the individual modules.
    - The iterative design process requires us to obtain insights and feedback from external stakeholders including SMEs in disability (e.g., personnel in the disability services office who could provide insights and connect us with reviewers), IT accessibility, the target audience of the modules, and project sponsors (university and grant agency) to ensure the quality and accessibility of the modules via usability testing; module reviewing; and the feasibility of storing, hosting, and delivering the final product.
- Flexibility in the design process. Design is not a linear progression. It is a process filled with surprises and failures. Therefore, a design team needs to be adaptive and responsive to challenges. Built-in flexibility and iterative processes are critical for the success of the final product.
- Time management for deliverables. The design process might take more time than planned, especially when the design team is facing scarce resources. Good time and project management strategies can maximize the design team's productivity, maintain team morale with constant progress, and deliver the project on time.
- Rapid prototyping. The preparation of the project took us much longer than we expected. Months after we embarked on the project, we still lingered over the information gathering and ideation stages due to the design team's lack of expertise in the subject matter and selected technology tool. A rapid prototyping approach could have helped the design team jumpstart the design process by getting into design earlier and obtaining design insights through early iterations that wouldn't be achieved otherwise. While acknowledging the importance of gathering information and conducting analyses (e.g., learner analysis, contextual analysis) the designers must carefully evaluate their situations (e.g., resources, timeline) to determine how long the upfront preparation and analysis will take.

Discussion and Implications

We encountered numerous challenges during the design process. To name a few, we had limited knowledge of accessibility and the authoring tool; there were limited resources (e.g., funding, people) available for a project with a defined scope; there was a lack of SMEs to assist us in understanding the scope and enormous number of different types of disabilities to consider; cultural shock experienced by two of the designers who had limited exposure to American culture and disabilities; accents of the designer that might potentially lead to accessibility issues regarding the video/audio; and lack of guidance on selecting the best methods to help others understand accessible design for our development of the training modules. On the one hand, as designers we knew how to educate ourselves on the subject matter as well as master using the authoring tools to ensure the logic and accuracy of the presented content. We had to ensure the accessibility of the modules in spite of some technical constraints of the tools at the time of developing the modules. For example, even though Storyline generally complied with WCAG, the tool was still not fully accessible (e.g., certain interactivities and multiple-level menus were not fully compatible with screen reader software). As pointed out by our external evaluators who reviewed our products, the tool was not intuitive for navigation. In making sure of the accessibility of these three modules, we simplified the on-screen elements and rearranged the layout so that the order these elements were processed by screen reader software aligned with our intended design.

While understanding the principles for designing for accessibility is not a significant focus in most instructional design programs, the potential impact of additional accessibility training through authentic

projects is substantial. Instructional designers train people, collaborate with others (e.g., instructors, clients, or SMEs), produce instructional content, and are often asked to lead large teams of developers and designers. Future instructional design students will benefit from having a clear awareness of disability issues as well as the legal requirements and knowledge about and skills in accessible design evidence-based practices to ensure the accessibility of e-learning and an inclusive online learning environment. There has been a paucity of research in studying evidence-based practices in accessible design, or design cases in delineating the design process to ensure accessibility in online education. This study can draw more attention to the importance of accessible design in online education and research. Furthermore, we hope the description of the design practice provides guidance for those who might have similar goals and encounter similar challenges to those that we experienced.

Conclusion

Instructional design graduates often lack the knowledge and awareness of accessibility in approaching their design projects, mainly due to the lack of accessibility training in the existing curriculum. It is especially important to make sure the content is accessible to the widest possible population of learners, as evidenced by the online transition during the Pandemic. The design case presented in this article included the development of three self-paced e-learning modules to train instructional design students on accessible design. Our recursive design process report provides implications for designers in approaching design projects amid multiple internal and external challenges. We call for more attention to research on accessible design to provide evidence-based practice and guidelines for design practice.

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