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Bridge to Inclusion: Enhancing Digital Literacy for Preservice Teachers With Accessibility Integration

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While efforts are being made to integrate coding and computational thinking into K-12 teacher training, instruction on designing accessible software is often overlooked. To introduce accessibility into training for future teachers, the authors modified a 1st-year seminar for education to include the topic of accessibility through simulation games in a digital literacy module. They tested their approach using a quasi-experimental pretest-posttest nonequivalent groups with additional comparison groups. They surveyed 25 students across two sections of the course (one experimental and one control) and analyzed assignment data from 70 students across five sections (the original experimental and control groups along with an additional control group of three more sections). They found that preservice teachers who learned about accessibility developed greater empathy for people with disabilities and a better understanding of the software challenges they face. This was not true for the control group. Similarly, preservice teachers in the experimental group showed an increased desire to teach both accessibility and digital literacy. There was a significant difference in their inclusion of accessibility features in their final project, suggesting that accessibility training can influence education students to prioritize accessibility for an extended period.

Teaching kindergarten through 12th grade (K-12) students in the digital age has brought about radical changes in the ways both teachers and students utilize technology. As a result, teacher education must prioritize preparing teachers to effectively utilize technology in their teaching practices (Nelson & Voithofer, 2022). One framework for achieving this is the International Society for Technology in Education (ISTE) Standards (Crompton, 2023). A recent emerging objective within the ISTE standards as well as the standards released by the Computer Science Teachers Association (CSTA) is to ensure that all learners in grades K-12 acquire computational thinking and computer science (CS) skills necessary to contribute in an increasingly digital society as designers of technology (Madkins et al., 2020). Initiatives such as Computer Science for All (CsforAll; Smith, 2016) have been instrumental in supporting these endeavors.

An important goal in software design today is to address the challenges that people with disabilities face while using technology. This need has led to the incorporation of software accessibility education into university and college courses (e.g., Kearney-Volpe et al., 2019; Shinohara et al., 2018), ensuring that future software developers have the skills needed to design accessible software. However, as with initiatives such as CSforAll, we learned that waiting until students reach the university to introduce new topics can be too late.

K-12 education can lay the foundation for cultivating students' interest and skills in emerging areas, such as computational thinking and programming (Chen et al., 2017) and can, similarly, introduce students to the concepts of software accessibility. Just as preservice teacher education programs are adapting their curricula to incorporate computational thinking (Adler et al., 2023; Adler & Beck, 2020; Adler & Kim, 2018; Bean et al., 2015; Chang & Peterson, 2018; Papadakis & Kalogiannakis, 2019), accessibility can be integrated as well. However, while ensuring accessible technologies is becoming an important goal in K-12 (Shaheen & Lohnes Watulak, 2019), only a few studies to date have examined the success of training teachers or students in accessibility at the K-12 level (Adler & Kletenik, 2023; Kelly & El-Glaly, 2021).

To incorporate accessibility into teacher preparation for future teachers at the university level, computer and information science professors collaborated with education professors to integrate accessibility into a digital literacy module for a 1st-year education seminar (FYS). This integration involved simulated gaming experiences to illustrate barriers in digital designs. The partnership between computing faculty members, who include accessibility in their own courses, and education faculty, who have expertise in K-12 pedagogy, initiates the integration of accessibility content into a preservice teacher course and serves as a model for other education courses.

The current research takes place within a FYS at an urban community college in New York State. The FYS is a foundational, introductory course required for all new education majors. It combines elements of educational foundations, digital fluency, and college success, with the goal of helping students navigate college resources, explore the field of education, and begin building the skills they will need as both students and future teachers.

One focus of the FYS is developing digital fluency and computer science skills, as outlined in the New York State K–12 Computer Science and Digital Fluency Learning Standards, which all in-service teachers are now expected to meet (New York State Education Department, 2020). However, many teachers do not have background knowledge or a thorough understanding of such concepts (Chang & Peterson, 2018; Yadav & Berges, 2019; Yadav et al., 2014).

To better prepare in-service and preservice teachers to integrate these concepts and skills into their current and future classrooms, this community college education program designed activities that introduce these concepts and skills, including computational thinking, object-oriented programming using Scratch (<https://www.scratchfoundation.org/>), and digital literacy across the curriculum. In particular, in the FYS, students complete a module on digital literacy during the 2nd week of the 12-week semester and a module on computational thinking and Scratch during the 5th week. A more detailed description of the course and its major assignments is provided in the Methodology section.

Background

Accessibility Training in CS Classrooms

Given that over 1 billion people live with disabilities worldwide (World Health Organization, 2011), it is imperative for software developers to learn how to incorporate accessibility in their design of software. Inaccessible software poses barriers for users with disabilities, hindering their ability to accomplish tasks effectively or at all.

For instance, software lacking alternative text may hinder individuals with visual impairments from interpreting graphics; videos without closed captions may not be comprehensible to users with auditory impairments; and websites that rely solely on mouse navigation can exclude people with physical or motor impairments from accessing their content. The impact of inaccessible software on people with disabilities can be profound, potentially leading them to forgo the use of computing devices altogether.

Designing accessible software ensures that individuals with disabilities can fully engage in digital platforms. Many researchers have advocated for the inclusion of accessibility training in computer science and engineering programs at the university level, either as standalone courses or integrated into existing classes (Carter & Fourney, 2007; Kearney-Volpe et al., 2019; Keates, 2015; Kletenik & Adler, 2022, 2023; Kurniawan et al., 2010; Martin-Escalona et al., 2013; Wald, 2008).

At the university level, there are a number of initiatives such as Teach Access (Kearney-Volpe et al., 2019) that provide resources to help faculty members include accessibility in their courses. Common pedagogical approaches for teaching accessibility include in-class activities, hands-on projects, and traditional lectures. Few, however, argue that educators can begin preparing students in accessibility even earlier, starting at the K-12 level (Adler & Kletenik, 2023; Kelly & El-Glaly, 2021).

In this work, we argue that it is vital to include accessibility topics within K-12 education. By doing so, students can learn to prioritize accessible design from the outset, recognizing it as a fundamental component of software development.

Currently, students tend to regard accessibility as an afterthought in software projects (Conn et al., 2020; Edwards et al., 2006; Patricia, 2011), an attitude that is exacerbated by the fact that often students learn about accessibility long after they have learned to program. Consequently, students may find themselves needing to unlearn poor habits related to inaccessible design. Furthermore, because research indicates that no single intervention effectively changes student attitudes toward accessibility in the long term (Conn et al., 2020; Zhao et al., 2020), accessibility must be taught early and consistently to impact students. For these reasons, including accessibility in K-12 CS education is essential for training future software developers in accessible design. Yet, a survey of over 2,000 preK-12 teachers found that the computing topic taught least often was accessibility (Blaser et al., 2024).

A number of initiatives have recently been developed to introduce accessibility within the K-12 space. For example, Kelly and El-Glaly (2021) implemented an online accessibility module for high school students using interactive lectures and quizzes. They found the module to be effective not only in raising students' awareness of disabilities and knowledge of accessibility, but also in maintaining a high interest in pursuing a computing degree.

Zhou et al. (2024) targeted students in grades 8-12 with a focused accessibility module. This was followed by the work of Liu, Wang et al. (2025) and Liu, Zhou et al. (2025), who targeted mostly middle school students. However, to bring about true change in this area, the focus should shift from teaching individual groups of K-12 students to integrating accessibility directly into preservice preparation for K-12 teachers.

Teaching Accessibility vs. Teaching Accessibly

The topics of accessibility and universal design may in fact be familiar to preservice teachers. The Universal Design for Learning (UDL) principles (CAST, 2018) currently guide K-12 teachers to create learning experiences that are accessible and inclusive of all learners. The UDL framework establishes that variability is typical in learning environments and underscores the importance of designing educational settings to cater to the needs of diverse learners. Thus, the topic of accessibility extends the universal design practices that teachers are already using in their pedagogic practices.

Some studies discuss the importance of teaching computer science concepts *accessibly* – that is, to students with disabilities – in K-12 (Ladner et al., 2019; Sentance et al., 2023; Stefik et al., 2019). Our goal is to take this one step further and not only introduce the topic of accessibility to preservice teachers so they may *teach accessibly*, but also to focus on how to teach accessibility to K-12 students – that is, how to

teach K-12 students to design software that is appropriate for the needs of people with disabilities.

Teaching Accessibility Through Empathy

In teaching university computing students about accessibility, a major pedagogical focus that has been identified is to help students empathize with people with disabilities (Putnam et al., 2016) and to enable them to comprehend the software barriers faced by people with disabilities (Shinohara et al., 2018). The same goal manifests in teaching K – 12 students and preservice teachers. Some instructors attempt to foster empathy using simulations, videos, and interactions with people with disabilities (Baker et al., 2020).

Other engaging techniques include using people with disabilities as external stakeholders on projects (Ludi, 2007; Zhao et al., 2020), persona cards (Genaro Motti & Dura, 2021), social media posts (Motahar et al., 2023), and even a virtual reality escape room (Mateen et al., 2023). Empathy serves as a crucial means to heighten awareness of diverse experiences and to contemplate perspectives that may lie beyond the typical experiences of the designer (Zwoliński et al., 2023).

Simulations, in particular, can inspire empathy and make otherwise unrelatable topics more understandable. Simulations have been used successfully in K-12 computing education (Adler & Kim, 2018; Musicant & Guzey, 2015), and accessibility simulations can help demonstrate the challenges people with disabilities face when using technology that is inaccessible. To ensure the effectiveness of disability simulations in enhancing attitudes toward people with disabilities (see Nario-Redmond et al., 2017), it is advisable to illustrate accessible design solutions, thereby avoiding a sole emphasis on the challenges experienced by people with disabilities (Burgstahler & Doe, 2004). Indeed, some studies have effectively used simulations to educate university students about accessibility and to introduce design solutions (El-Glaly et al., 2020).

Gaming too has proven to be an effective approach for teaching concepts in K-12 education (Olano et al., 2014; Thomas et al., 2019). In fact, some scholars have suggested leveraging gamification as a method to teach accessibility (e.g. Lorgat et al., 2022; Spyridonis et al., 2017). In this work, we chose to use a series of accessibility simulation games to teach a class of preservice teachers. This approach was selected because it is an engaging method that these future educators can later implement in their own K-12 classrooms, fostering empathy and promoting accessible design. These games have already been evaluated directly with K – 12 students by Zhou et al. (2024), Liu, Wang, et al. (2025) and Liu, Zhou, et al. (2025) and were found to be engaging, useful and instructive. They have also previously been used in teacher education. For instance, Adler and Kletenik (2023) integrated the games into a web development course for in-service teachers. The teachers thought that the games would be an effective way to teach about accessibility in K-12 education.

Integrating Accessibility Training in Classrooms for Preservice Teachers

In our preservice teaching, we used the accessibility games we developed and described in Kletenik and Adler (2022, 2023). In Adler and Kletenik (2023), the games were used by in-service teachers, who reported strong support for including accessibility – and in particular, these games – in elementary, middle school, and high school classrooms. We expand on this work by (a) examining the inclusion of the games with *preservice* teachers; (b) using a control group to examine accessibility differences between those who played the games and had accessibility education and those who did not; and (c) comparing whether the inclusion of accessibility education and games results in more significant accessibility inclusion in students' digital literacy assignments. Our research questions are as follows:

1. Does learning about accessibility through games result in greater increases of preservice teacher empathy towards people with disabilities and consideration of disabilities when designing software, compared to those who do not receive accessibility education?
2. Will preservice teachers have a stronger desire to integrate accessibility and digital literacy into their future classrooms after completing these games, compared to those who do not receive accessibility education?
 - 2a. Will preservice teachers consider including interventions to teach about accessibility in their future classrooms?
 - 2b. Will preservice teachers consider including digital literacy in their future classrooms?
 - 2c. Will preservice teachers consider the use of games to teach about accessibility in their future classrooms?
3. Does learning about accessibility and playing accessibility games result in increased desire for accessible teaching in K-12 classrooms, compared to those who do not receive accessibility education?
4. Does learning about accessibility and playing accessibility games result in increased consideration of disabilities in practice, compared to those who do not receive accessibility education?

Methodology

To help us understand the impact of accessibility education on preservice teachers, we introduced accessibility games at the university level in a digital literacy module for a FYS at a public community college in New York State. In this section, we present the methodology of our study, including background on the 1st-year seminar, an explanation of our study design, a description of our participants, and a discussion of our measures.

Context

The education program at this college offers an associate in arts degree in education with concentrations in bilingual, childhood, early childhood, and secondary education. The program has a dual mission of preparing students for careers and/or transfer in education and serves approximately 580 students yearly. The FYS is required for all 1st-year education students, and the program typically runs five sections of the FYS each semester.

This course introduces students to college life, college resources (e.g. advising, transfer, and cocurricular events), the field of education, state certification requirements, the liberal arts, digital communication skills, and integrative learning. As part of the program, students are to maintain a core electronic portfolio (ePortfolio), which they create in the FYS and continue to develop while in the program.

This course is also supported by a Studio Hour, a lab where students receive support creating and developing their ePortfolio. The education ePortfolio template consists of several web pages, some of which are blank, and some contain pregenerated structure and prompts, such as placeholders for images or adding text. One of the first assignments that students complete in the FYS is the creation of an About Me web page, through which the students introduce themselves to the ePortfolio reader. They include attributes such as their major, their hobbies, and their favorite quote. Students are graded on their ability to use multimodal design elements, such as the use of images, captions, texts, text color, background images, and links to convey and/or support a message.

The final assignment in this course is an integrative digital project, called a Dream Deferred. In this assignment, students are asked to reflect on key assignments related to the social justice theme of the course. Students are also required to use multimodal elements, such as links, images, and videos, and to personalize the background using color or images. The assignment measures two key skills: (a) integrative learning, the ability to apply knowledge to new situations by reflecting on how ideas and experiences connect and (b) digital communication, the ability to use multiple forms of media to communicate effectively.

Accordingly, one of the modules that was specifically designed for all sections of this course is a 3-hour digital literacy unit. In this module, students are introduced to equitable access to digital information, the importance of understanding digital literacy, digital fluency, and digital communication to their careers and academic development at the college.

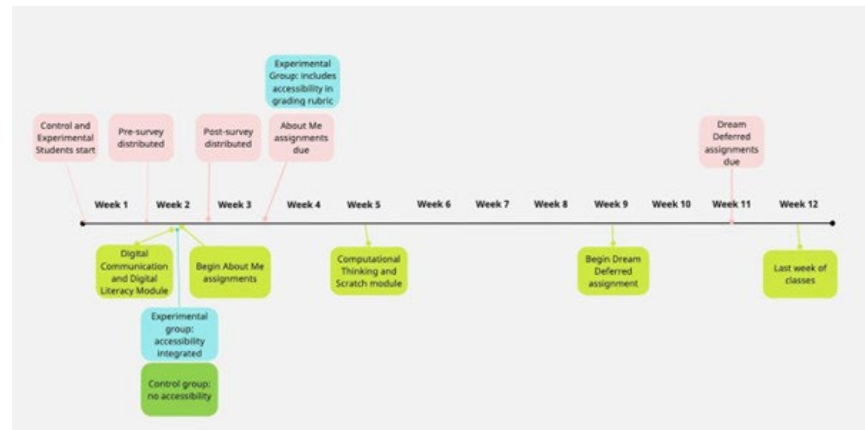
Research Design

We used quasi-experimental pretest-posttest nonequivalent groups design for our study. In the semester in which we ran this study, five sections of the FYS were offered. For the purposes of this study, one section of this course served as an experimental group, in which the instructor was trained in software accessibility and included concepts of accessible design in the digital literacy module. The other four sections were left as the control group.

Instructors of all five sections of the FYS (the four control and one experimental) were instructed to give the preservice teachers a survey before and after the digital literacy module, which assessed their empathy toward people with disabilities and attitudes regarding teaching accessibly, teaching accessibility, and teaching digital literacy. However, instructors of three of the sections did not administer the postsurvey due to scheduling issues and time constraints. We, therefore, exclude students in those sections from the pretest-posttest portion of our study, but reserve them as an additional comparison group for the analysis of their design artifacts (see Figure 1 for a timeline of the events).

In addition, the experimental group responded to several posttest-only questions that assessed reactions to specific elements of the intervention (i.e., the suitability of the games for K-12 students and modifications necessary to make them useable in a K-12 setting). These questions were not asked of the control group, as they were only relevant for participants who experienced the simulation game intervention.

Figure 1
Timeline of Events



Timeline of Events, including the pre/post-surveys given to preservice teachers ($n=25$) and the student artifacts analyzed from all five sections of the course ($n = 70$).

Participants

A total of 70 preservice teachers across five sections of the course in one semester were recruited to participate in this IRB-approved study, consented to participate, and completed the presurvey. One of the sections, with the instructor trained in accessibility, was the experimental group (for a total of 51 preservice teachers in the control group and 19 in the experimental). Of these participants, only 25 preservice teachers, across two sections of this course, completed both the presurvey and the postsurvey (11 in the control group; 14 in the experimental). These 25 preservice teachers comprised our participants for the pre- to postsurvey analysis, which we used to answer Research Questions (RQ) 1-3. (See demographic characteristics of these participants in [Appendix A](#).) To answer RQ4, we directly analyzed participant projects and did not rely

upon survey responses. Therefore, for this question, we included all 70 participants. (See demographic characteristics of these participants in [Appendix B](#).)

Measures

In addition to asking about basic demographic information about the participants, the pre- and postsurveys consisted of 13 closed-ended 5-point Likert scale questions (1 = *Strongly Disagree*; 5 = *Strongly Agree*) designed to assess participants' attitudes toward people with disabilities and software accessibility. Seven out of the 13 pre- and postsurvey questions around empathy were taken or modified from instruments by Kletenik and Adler (2022, 2023), which were, in turn, modified from Carmichael et al. (2007). Six questions pertained to teaching intentions, such as whether participants planned to teach accessibly, teach digital literacy, or use games in teaching; the first and last of this group were modified from Adler and Kletenik (2023).

Items were grouped into constructs based on thematic domains to derive five measures, and internal consistency was assessed via Cronbach's alpha (reported in the discussion of each measure). The full text of the 13 questions is displayed in Table 1, labeled by the corresponding measure.

The postsurvey for the experimental group asked for general comments about the activity, along with two additional open-ended questions designed to capture preservice teachers' reflections on the game-based accessibility activity: "Please explain your thoughts about using this game to teach about accessibility to K-12 students," and "What modifications do you think would be necessary to make this game more suitable for K-12?" Responses were analyzed using the thematic analysis approach of Braun and Clarke (2006), reviewing and coding the data to identify recurring patterns and themes. Two coders independently reviewed and coded the data and discrepancies were discussed and resolved through consensus.

Empathy

The Empathy measure consisted of the average of the responses to the first seven questions and measured the preservice teachers' empathy toward people with disabilities, understanding of the challenges that they face, and intent to design accessibly. These questions and this measure were based on previous work examining participants' attitudes toward accessibility (Kletenik & Adler, 2022). However, to improve internal reliability, we modified some of the statements so that they were all worded in the same positive way, such as "People with disabilities are interested in new technology," rather than "People with disabilities are not interested in new technology." Cronbach's alpha for our Empathy scale for the pre- and postsurvey were .725 and .877, respectively.

Table 1
Pre- and Postsurvey Questions and Their Corresponding Measures

Measure	Question
Empathy	Many current software applications are difficult for people with disabilities to use.
	People with disabilities are interested in new technology.
	Software developers should provide technology suitable for use by people with disabilities.
	A person with disabilities should not have to rely on someone around who can help.
	People with disabilities are likely to face challenges when interacting with many applications.
	People with disabilities are likely to feel frustrated while interacting with many applications.
	When I create designs, I will try to keep in mind people with disabilities.
Teach Accessibly	Teachers should incorporate accessible designs when creating materials for their classroom.
Teach Accessibility	K - 12 teachers should include topics on accessibility.
	As a K - 12 teacher, I would likely include topics on accessibility.
Teach Digital Literacy	K - 12 teachers should include topics on digital literacy.
	As a K - 12 teacher, I would likely include topics on digital literacy.
Teach with Games	If I were to teach K - 12, I would likely use a game to teach about accessibility.

Teach Accessibly

The Teach Accessibly measure consisted of the response to a single question examining preservice teachers' attitudes toward ensuring accessible teaching within K-12 classrooms: "Teachers should incorporate accessible designs when creating materials for their classroom."

Teach Accessibility

The Teach Accessibility measure consisted of the average of the responses to two questions examining preservice teachers' attitude toward teaching

accessibility in K-12 classrooms: “K - 12 teachers should include topics on accessibility,” and “As a K - 12 teacher, I would likely include topics on accessibility.” Cronbach’s alpha for the Teach Accessibility measure for the pre- and postsurvey were .654 and .823, respectively.

Teach Digital Literacy

The Digital Literacy measure consisted of the average of the responses to two questions examining preservice teachers’ attitudes toward teaching digital literacy in K-12 classrooms: “K-12 teachers should include topics on digital literacy,” and “As a K-12 teacher, I would likely include topics on digital literacy.” Cronbach’s alpha for the Teach Digital Literacy scale for the pre- and postsurvey were .821 and .783, respectively.

Teach With Games

The Teach With Games metric consisted of the responses to a question that focused specifically on the use of games to teach about accessibility: “If I were to teach K-12, I would likely use a game to teach about accessibility.”

ePortfolio Metrics

A separate set of metrics was derived from submissions to two e-portfolio projects and apply to a wider pool of 70 participants. For each of two preservice teacher e-portfolio submissions, About Me and Dream Deferred, two reviewers coded submissions as 0, 1, or 2 corresponding to their inclusion of accessibility elements, where 0 = does not contain evidence that accessibility has been considered; 1 = contains evidence that accessibility has been considered in at least one of the following ways: usage of color, captions, links, and alt-text.; and 2 = contains evidence that accessibility has been considered in at least two of the following ways: usage of color, captions, links, and alt-text.

Scoring

The assignments were scored by two reviewers. Prior to initiating the scoring process, the reviewers engaged in a norming session. During the norming session, the reviewers coded five of the assignments independently and then discussed responses. Reviewers agreed on the 0–2 coding. If the assignment could not be opened or was missing, it was coded as not scorable. After the norming session, each reviewer independently coded all the assignments. Both reviewers then met once more to compare scores. There was no disagreement between the reviewers’ scores.

Implementation of Accessibility Intervention for Experimental Group

Preservice teachers in the experimental group took part in a 3-hour digital literacy module, where they were provided with opportunities to consider accessibility as it relates to digital literacy. In the 1st hour, participants were asked to reflect on what they knew about digital literacy and complete

the presurvey. Then, they were introduced to games that they were told related to digital literacy and played the games. After they completed the games, they engaged in a class discussion about their experience playing the games, followed by a class discussion in the 2nd hour about the reasons for accessible design. Participants were then asked to consider the relevance of digital literacy to the field of education and to their learning.

In the final hour, the preservice teachers participated in a class discussion beginning with a series of prompts, including, “What is something new you learned? What is something that surprised you? What questions do you have?” Discussion also centered around a digital literacy related podcast the participants had watched. The preservice teachers were then told about their first ePortfolio project, the About Me web page, and given time to create a storyboard drawing of their page (e.g., what the various sections would include such as text, pictures, media, etc.). They then posted pictures of their storyboard on an online platform, Padlet (<https://padlet.com/>), used to share files among students and faculty members. Participants then completed the postsurvey before leaving class for Studio Hour, where they received support creating an ePortfolio and beginning their About Me ePortfolio page.

Accessibility Games

We used accessibility games created by Kletenik and Adler (2022, 2023) that simulate five disabilities (i.e., color blindness, auditory impairments, blindness, low vision and physical/motor disabilities). For each disability, the game proceeds in four rounds:

Round 1: Game mode: Players play with no simulated disability.

Round 2: Simulation mode: Players experience the game with one of the simulated disabilities. For example, in the physical impairments game, the mouse action shakes as though because of a tremor.

Round 3: Game + Accessibility mode: Players experience the game with no simulated disabilities and with an accessibility option enabled. For example, keyboard support is present in the physical impairments game.

Round 4: Simulation + Accessibility mode: Players experience the final round with a return of the simulated disability, this time with the accessibility option to mitigate the challenges posed by the simulation. For example, the mouse is once again shaky but the keyboard support offers an alternative modality for selection.

After completing each game, the player is given information about how to make software more accessible for someone with that disability, including ideas such as not using color alone for feedback and enabling keyboard support.

As mentioned earlier, when developing accessibility simulations, it is crucial that the focus should be on providing practical ideas on how to ensure accessibility and incorporate universal design principles. A

simulation that focuses just on the challenges that a person with disabilities might face may leave participants “with the notion [that] the disability causes lack of access” (Burgstahler & Doe, 2004). If, however, the simulation shows how accessible design can make navigation smoother and easier, participants learn that “the web page designer, not the disability, created barriers through poor, inaccessible design” (Disability-Related Simulated section, para. 5). For that reason, Rounds 3 and 4 and the accessibility information page are crucial parts of the simulation games that help inspire awareness of the drawbacks of inaccessible design and the drive to remedy them.

Results

RQ1: Preservice Teacher Empathy Toward People With Disabilities

In our first research question, we examined whether teaching about accessibility and playing games increased preservice teacher empathy and understanding of the challenges that people with disabilities face. To answer RQ1, we compared the presurvey responses of the Empathy questions with the postsurvey responses of the control and experimental groups using a two-tailed Wilcoxon signed-rank test, with $\alpha = .05$, since our data was nonparametric.

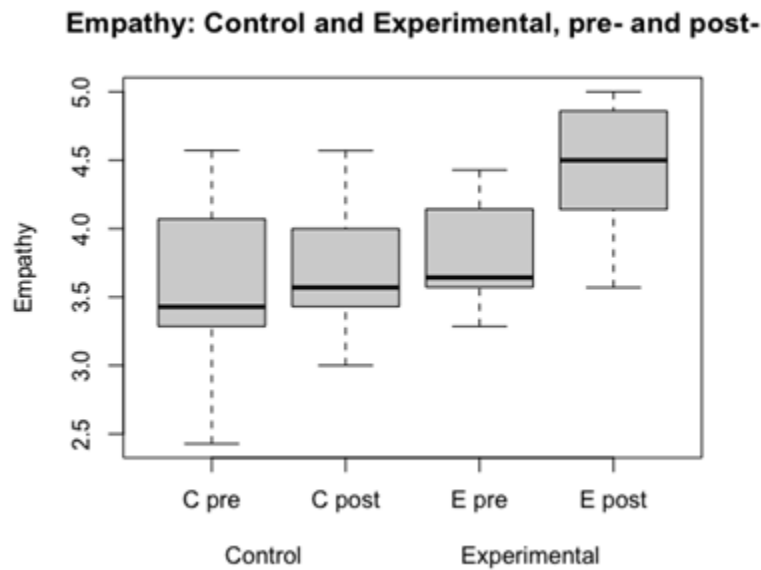
We found statistically significant changes from the presurvey to the postsurvey responses for the Empathy questions in the experimental group: presurvey mean and median for the Empathy questions were 3.8 and 3.6, respectively; postsurvey mean and median increased to 4.5 and 4.5, $p < .01$, $r = .86$.

Based on the conventional classification of effect sizes, where $.1 \leq r < .3$ is considered small, $.3 \leq r < .5$ is medium, and $r \geq .5$ is large (Cohen, 1988), we noted statistically significant changes and a large effect size for participants in the experimental group increasing their empathy for people with disabilities and understanding the challenges that they face. In contrast, we found no statistically significant changes in the control group: presurvey mean and median for the Empathy questions were 3.5 and 3.4, respectively; postsurvey mean and median were 3.7 and 3.6, respectively, $p = .07$.

We also directly compared the Empathy measures between the two groups, using a Mann-Whitney U test, because the ordinal data is nonparametric. As would be expected, there was no statistically significant difference between the Empathy scores for both groups on the presurvey ($W = 49$, $p = .13$). However, the experimental group had significantly higher Empathy scores on the postsurvey compared to the control group ($W = 20$, $p < .01$), with a large effect size ($r = .63$). Figure 2 depicts the box plots of the pre- and postsurvey Empathy metric for both groups. Thus, findings related to our first research question indicated that preservice teacher empathy for people with disabilities and understanding of the challenges that they face increased with accessibility education and interacting with accessibility games.

Figure 2

Pre- and Postsurvey Empathy Metric, for Control and Experimental Groups



RQ2: Intent to Teach Accessibility and Digital Literacy

To answer our second research question, we evaluated preservice teacher attitudes toward topics that K-12 teachers (including themselves as future teachers) should cover. We examined the Teach Accessibility (RQ2a) and Teach Digital Literacy (RQ2b) metrics for each group, experimental and control, as measured on both pre- and postsurveys.

Using a Wilcoxon signed-rank test, we once again found statistically significant increases with a large effect size for the experimental group for the Teach Accessibility metric from the presurvey results (mean = 4.4, median = 4.5) to the postsurvey results (mean = 4.7, median = 5.0, $p = .01$, $r = .65$), as well as for the Teach Digital Literacy metric (presurvey mean and median: 4.3; postsurvey mean: 4.7, postsurvey median: 5.0; $p < .01$, $r = .72$).

No such significant changes were found for the members of the control group (Teach Accessibility: presurvey mean: 4.2, presurvey median: 4.0; postsurvey mean: 4.2, postsurvey median: 4.0; $p = .86$; Teach Digital Literacy: presurvey mean: 4.0, presurvey median: 4.0; postsurvey mean: 4.2, postsurvey median: 4.0; $p = .22$).

Once again, a direct comparison between the control and experimental groups revealed no statistically significant differences in the presurvey metrics of Teach Accessibility (Mann-Whitney U test, $W = 65.5$, $p = .53$) and Teach Digital Literacy ($W = 53$, $p = .18$), but significant differences were found for the both postsurvey metrics: Teach Accessibility, with a medium effect size ($W = 38.5$, $p < .05$, $r = .45$); Teach Digital Literacy,

with a large effect size ($W = 34$, $p < .05$, $r = .5$). The metrics are displayed in box plots in Figures 3 and 4.

Figure 3
Teach Accessibility Metric

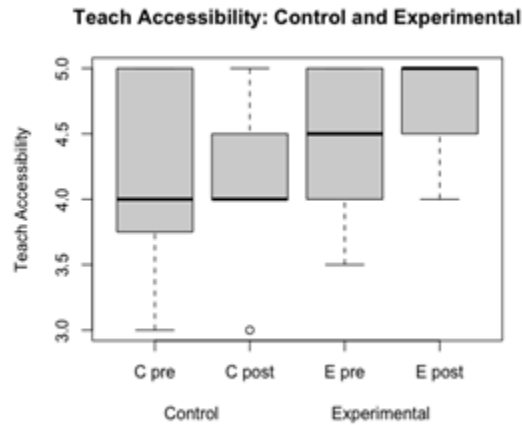
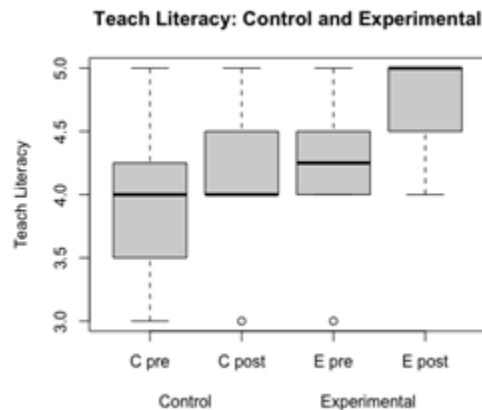


Figure 4
Teach Literacy Metric



Furthermore, we examined preservice teacher attitudes specifically toward using games to teach about accessibility (RQ2c) by analyzing pre- to postsurvey differences of the Teach With Games metric. Once again, statistically significant differences were found only for the experimental group (presurvey mean: 4.4, presurvey median: 4.0; postsurvey mean: 4.8, postsurvey median: 5.0; $p = .02$, with a large effect size of $r = .62$), but not for the control group (which revealed no change, with pre- and postsurvey means both of 4.3 and pre- and postmedians both of 4.0, $p = 1$).

This difference was further supported by a statistically significant difference between the two groups on the postsurvey Teach With Games metric, reflecting a medium effect size (Mann-Whitney U test, $W = 43$, $p <$

.05, $r = .43$). No significant difference was found in the presurvey metric ($W = 74$, $p = .88$). Thus, findings related to the second research question indicate that accessibility initiatives increased preservice teacher perceptions of both the importance of teaching accessibility and that of teaching digital literacy, as well as their own plans to teach these subjects. They also increased preservice teacher interest in using games to teach about accessibility.

Our analysis of the experimental group's open-ended questions sheds additional light on their thoughts about the use of the games in K-12 education. For the first open-ended question on the use of games in K-12 education, the most frequently appearing theme was that of how the games helped improve preservice teacher empathy toward people with disabilities (expressed by nine participants, or around 64% of those in the experimental group). One student commented, "Before these games I didn't really understand how upsetting it may feel for people with disabilities to use certain computer software when they are not [accommodated] in the software." A second pointed out, "This game will teach perspective to students. To actually make them walk a mile in someone else's shoes. That is better than telling anyone anything." Another student wrote, "The game really taught me and helped me understand how many different disabilities there are and everyone needs different help and therefore people need accessibility to learn better."

Two participants (14%) reflected specifically on the use of games to teach about accessibility, with comments such as, "Using a game is the best way to keep kids intrigued and make them want to interact and converse. Even spark a little competition among each other." One participant said that it "is very important for young kids to learn" about but thought that the games are too complex for young children and suggested another approach to teach accessibility: "I feel as though using this game to teach preschool - fifth grade is unnecessary only because they are little and it may be a lot and difficult for them to understand." Finally, two participants did not leave any comments.

Participants in the experimental group were also asked to reflect on modifications necessary to make the games more appealing to K-12 students. The most frequent theme included integrating more engaging interactions. Six participants (43%) included a suggested modification. Some thoughtful and interesting ideas included the following: "I think it would need more sorts of childish imaging. For example, maybe instead of balloons it could be animal heads, or cookies versus cupcakes, something like that which will excite the K-12 kids more than the basic." Another suggested, "a small video in the beginning to kind of introduce a bit of it and a video at the end to summarize what happened and further explain the disabilities in more detail."

Three participants did not think that the games needed any modification to make them useful for the K-12 audience, or for a select part of the audience: "I actually think the game is perfect in my opinion. It has simple and clear instructions and it seems fun for children." One of the three was the participant quoted earlier, who thought it was too complex for elementary school-aged children, but commented that the game is "perfect for 6th grade - 12th grade." Five participants (36%) did not leave a comment.

RQ3: Increased Desire for Accessible Teaching

Although learning about accessibility and playing accessibility games increased preservice teachers' desire to teach about accessibility, there was no significant change in their desires for accessible teaching. A Wilcoxon signed-rank test found no statistically significant changes from pre- to postsurvey for the Teach Accessibly metric for either the experimental Group (presurvey mean: 4.6, presurvey median: 5.0; postsurvey mean: 4.7, postsurvey median: 5.0; $p = .59$) or the control Group (presurvey mean: 4.3, presurvey median: 4.0; postsurvey mean: 3.8; postsurvey median: 4.0; $p = .28$). Our data suggest that the reason for the lack of significant change for the Accessibility group was because their presurvey scores were already so high for this metric, leaving little room for improvement, even after learning more about accessibility. In contrast, the control Group scores for this metric actually decreased from pre- to postsurvey.

This hypothesis is supported by the fact that we found a statistically significant difference between the postsurvey Accessible metric for the experimental and control groups, with a large effect size ($W = 25$, $p < .01$, $r = .63$) but not for the presurvey metric ($W = 52$, $p = .13$).

RQ4: Consideration of Accessibility in Practice

In this section, rather than examining preservice teachers' beliefs or perceptions on accessibility, we examined preservice teachers' inclusion of accessibility principles in practice, by analyzing student artifacts in their ePortfolios. We used the About Me and Dream Deferred metrics, which tabulated the inclusion of accessibility elements in e-portfolio projects.

About Me

Submissions from 14 preservice teachers in the control group and one in the experimental group were excluded because they had either not completed their assignments or had not published them. The remaining 55 submissions (37 control, 18 experimental) were graded from 0-2, as discussed in the Measures section. Since a Shapiro-Wilk test indicated that the data are not normally distributed, we used a Mann-Whitney U test to compare the About Me metric for the control (mean = .22, median = 0) and experimental groups (mean = .22, median = 0). We found no statistically significant differences between the two groups ($W = 331$, $p = .97$).

Dream Deferred

Sixteen submissions from the control group and six from the experimental group were unable to be graded. The remaining 48 submissions (35 control, 13 experimental) were graded on a scale of 0-2. Once again, we used a Mann-Whitney U test to compare the metric of the control group (mean = .2, median = 0) to the experimental group (mean = .92, median = 1), this time finding a statistically significant difference with a medium effect size ($W = 87$, $p < .001$, $r = .46$).

We also directly compared each preservice teacher's About Me metric to the Dream Deferred using a Wilcoxon signed-rank test for evidence of progression over the course of the semester. We found no statistically significant differences between the two metrics for the control group ($p = .82$) but we did find statistically significant increases from the About Me metric to the Dream Deferred metric for the experimental group, with a large effect size ($p < .05$, $r = .56$).

Thus, findings related to RQ4 indicated mixed evidence: While there were signs that accessibility education informed participants' considerations of accessibility in practice, the evidence was not comprehensive. We discuss these findings in the next section.

Discussion

Similar to previous work that modified existing courses for preservice teachers to include coding and computational thinking (Adler & Kim, 2018; Jaipal-Jamani & Angeli, 2017; Kim et al., 2018; Yadav et al., 2014), we modified a digital literacy module in a seminar for preservice teachers, which already includes computational thinking and coding with the Scratch visual programming language, to include accessibility education. The goal of this addition was to increase preservice teachers' empathy for the barriers that people with disabilities face when using software and to strengthen their commitment to inclusive design.

The inclusion of accessibility topics and games appeared to positively impact preservice teacher attitudes. Preservice teachers reported increased empathy, a stronger understanding of the challenges faced by people with disabilities, and a greater intent to integrate accessibility into their future K–12 teaching. Many participants also expressed interest in using the games in their own classrooms. Interestingly, the introduction of the accessibility topic also heightened preservice teacher interest in teaching digital literacy; that is, learning about accessibility concurrently strengthened preservice teacher interest in the learning goals of the module itself.

In this study, we extended the work of Adler and Kletenik (2023) by applying their techniques to preservice teachers, rather than in-service teachers. We also extended this work by comparing an experimental group of preservice teachers who were exposed to an accessibility module, to a control group who were not. We further examined whether the attitudinal shifts we observed in the experimental group translated into observable differences in preservice teachers' work.

Our most surprising findings pertained to the practical inclusion of accessibility in artifacts. In the early e-portfolio About Me assignment, preservice teachers in the experimental group were explicitly informed that they would be graded on accessibility and given a rubric outlining expectations. Yet, preservice teachers in this group were no more likely to include accessibility practices than those in the control group, and accessibility implementation rates were low across both groups.

Anecdotally, we observed that barriers to accessibility inclusion at this stage of the course were too high. Participants were required to submit

their About Me project only 7 days after creating an e-portfolio and while they were still struggling to learn how to use the digital platform. These first-order barriers – tight timelines and limited digital fluency – seemed to overwhelm their ability to apply what they had learned, even with a grading incentive.

In contrast, in a final assignment due 11 weeks later, with no grading incentive or accessibility reminder, preservice teachers in the experimental group showed increased inclusion of accessibility practices. This finding suggests that the intervention had a lasting impact on preservice teacher attitudes, even in the absence of extrinsic motivators. However, their median grade of 1.0 out of 2 indicates that implementation remained limited.

These results align with Ertmer's (1999) distinction between first-order barriers (e.g., time, experience, and tool fluency) and second-order barriers (e.g., beliefs and attitudes). Our module appears to have reduced second-order barriers – preservice teachers expressed empathy and intent – but first-order barriers persisted and interfered with early implementation.

Our findings are also consistent with research by Tondeur et al. (2012), who argued that embedding theoretical understanding within practical experiences is essential for meaningful technology integration. Similarly, Luo et al. (2017) found that preservice teachers' comfort with web-based tools developed through scaffolded, authentic application, not passive instruction. These findings suggest that preservice teachers need time and opportunity to build fluency with the tools before they can successfully apply abstract concepts like accessibility.

Vallera and Syed (2020) showed that well-designed disability simulations can enhance empathy and awareness, though they also cautioned that long-term impacts are difficult to determine without repeated exposure and contextual support. Taken together, our findings suggest that accessibility training can shift attitudes, but sustained practice, platform fluency, and reduced cognitive load are necessary for these shifts to manifest in observable teaching practices, especially early in the course.

Lessons Learned From This Study

These lessons emerged directly from our experience designing and delivering accessibility instruction in a preservice technology teacher education context. They reflect internal takeaways we would apply to future iterations of this work:

1. Preservice teachers were generally open to accessibility once introduced. Despite some initial hesitation or confusion, most preservice teachers engaged thoughtfully with accessibility content once it was embedded in their work. We learned that early exposure, even a single module, can activate interest and reflection, especially when tied to real design decisions.
2. Technical readiness matters more than expected. Preservice teachers in the experimental group struggled with implementing

accessibility features primarily due to technical limitations, not lack of motivation. In future versions of the course, we would frontload relevant technical skills before introducing accessibility content.

3. Don't mistake early resistance for failure. Initial preservice teacher resistance did not predict long-term outcomes. While accessibility was not immediately evident in early assignments, many preservice teachers integrated it meaningfully into final projects. The module was still impactful, just not on the timeline that we had envisioned.
4. Many preservice teachers showed intent to carry accessibility into their future teaching. Many participants expressed a desire to teach accessibility to their future K–12 students. This was a notable outcome: not just technical adoption, but a willingness to become advocates. We learned that accessibility instruction can inspire preservice teachers to think beyond themselves.

Implications for Technology Teacher Education and Policy

Our findings have several implications for instructors, curriculum designers, and policymakers engaged in technology teacher education. In particular, we recommend the following:

1. Scaffold technical skills to support accessibility learning. Accessibility cannot be taught effectively without a technical foundation. Technology teacher education programs should ensure that preservice teachers build technical fluency early, so they are better positioned to grasp and implement accessibility features later. This may require adjusting course sequencing or providing supplemental technical support.
2. Evaluate long-term learning, not just immediate gains. Accessibility learning gains may not manifest immediately. Educators should assess preservice teachers' accessibility competencies across multiple assignments and time points to capture deeper shifts in thinking. Programs should also reinforce accessibility topics throughout the curriculum to promote retention and transfer.
3. Integrate accessibility across courses and clinical experiences. A single session or module is likely insufficient. As Kletenik and Adler (2023) argued about integrating accessibility into computing education, a single session or module is likely insufficient. Accessibility principles should be woven across the technology education curriculum, from instructional design courses to practicum experiences. Program-level planning is necessary to ensure sustained and meaningful exposure.
4. Prepare teachers to teach accessibility, not just understand it. The ultimate goal of teaching future teachers about accessibility is for the preservice teachers to use this knowledge to teach their future K-12 students how to design accessibly. Other studies have shown

that when teaching future teachers' computational thinking, the preservice teachers sometimes mistook the goal to be the improvement of their own computational thinking knowledge, rather than that of their students (Adler et al., 2023). Similarly, it is critical to ensure future teachers understand their ultimate goal is to introduce accessibility to their students at a young age. We found significant results in future teachers' desire to teach about accessibility after learning the accessibility module, which holds promise. More research is necessary to investigate whether this module actually influenced participants' inclusion of accessibility in their own classrooms. Technology teacher education should include instructional strategies for introducing accessibility at the elementary and secondary levels, so that inclusive design becomes a core value passed on to the next generation of learners.

5. Link computer science education with accessibility in program requirements. As computer science training becomes a requirement in more science, technology, engineering, and mathematics K-12 teacher programs, accessibility should be treated as a parallel competency. Certification requirements, accreditation standards, and curricular frameworks should be updated to reflect the joint importance of computer science and inclusive design.

Limitations

Our largest limitation was our small sample size. With only 25 preservice teachers (from two sections of the course) submitting both pre- and postsurveys, and 47-55 gradable portfolio assignments, it was difficult to extrapolate or generalize from our results. Additionally, participants were assigned to control and experimental groups based on course enrollment rather than through random assignment. Specifically, one of the author's seminar sections served as the experimental group and the others as controls. Although presurvey responses did not show significant differences between groups, we cannot exclude the possibility of unmeasured differences influencing the results.

Third, while our focus was on K-12 education, a notable portion of participants (seven out of 25, or 28%) expressed interest solely in teaching early childhood education. This divergence limits the direct applicability of our findings to K-12 contexts and suggests that future studies might tailor interventions more specifically by intended teaching level.

Fourth, while we observed a lasting effect of the accessibility module over an 11-week period, the durability of this impact beyond the course remains unknown. Previous longitudinal research (Zhao et al., 2020) has indicated that single interventions may not yield sustained gains over multiple years, highlighting the need for further long-term study.

Finally, since the control group did not receive any accessibility education, we cannot isolate the effects of specific components such as the accessibility games. Future work should consider providing both groups with baseline accessibility instruction and varying only the game-based intervention to better understand its unique contribution.

Conclusion

This study explored the impact of incorporating accessibility games into preservice teacher education on future teachers' empathy, understanding, and intentions regarding accessibility in K-12 classrooms. Our findings highlight that experiential, game-based learning can effectively enhance preservice teachers' awareness of the challenges faced by people with disabilities and foster greater empathy.

Participants who engaged with the accessibility module expressed a stronger desire to integrate both accessibility and digital literacy into their future teaching. Many also indicated interest in using the games as tools to teach these concepts, pointing to the potential for such approaches to shape future classroom practices.

Although early assignments did not demonstrate immediate gains in the practical application of accessibility features, likely due to limited technical familiarity, later work showed that preservice teachers who received accessibility training were more likely to incorporate these features in their final projects. This finding suggests that sustained exposure and practice are crucial for translating empathy and understanding into concrete design actions.

Importantly, the results suggest that accessibility education combined with simulation experiences and gaming can increase preservice teachers' commitment to fostering inclusive learning environments in K-12 settings, which is a key goal given the growing emphasis on equitable education.

While these outcomes are promising, the study's limited sample size and duration underscore the need for larger, longitudinal research to assess the persistence and generalizability of these effects. Nonetheless, as science, technology, engineering, and mathematics teacher preparation programs increasingly include computer science education, integrating accessibility training through engaging methods like simulation games offers a valuable pathway to prepare educators capable of teaching and designing for all learners.

References

- Adler, R. F., & Beck, K. (2020). Developing an introductory computer science course for pre-service teachers. *Journal of Technology and Teacher Education*, 28(3), 519–541. <https://www.learntechlib.org/primary/p/214351/>.
- Adler, R. F., Hibdon, J., Kim, H., Mayle, S., Pines, B., & Srinivas, S. (2023). Assessing computational thinking across a STEM curriculum for pre-service teachers. *Education and Information Technologies*, 28, 8051–8073. <https://doi.org/10.1007/s10639-022-11508-4>
- Adler, R. F., & Kim, H. (2018). Enhancing future K-8 teachers' computational thinking skills through modeling and simulations. *Education and Information Technologies*, 23(4), 1501–1514. <https://doi.org/10.1007/s10639-017-9675-1>

- Adler, R. F., & Kletenik, D. (2023). Accessibility for all: Introducing IT accessibility in postsecondary computer science programs for K-12 teachers. *Journal of Postsecondary Education & Disability*, 36(1).
- Baker, C. M., El-Glaly, Y. N., & Shinohara, K. (2020). A systematic analysis of accessibility in computing education research. *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, 107–113. <https://doi.org/10.1145/3328778.3366843>
- Bean, N., Weese, J., Feldhausen, R., & Bell, R. S. (2015, October). Starting from scratch: Developing a pre-service teacher training program in computational thinking. In *2015 IEEE Frontiers in Education Conference* (pp. 1-8). IEEE.
- Blaser, B., Ladner, R. E., Twarek, B., Stefik, A., & Stabler, H. (2024, May). Accessibility and disability in preK-12 CS: Results from a landscape survey of teachers. In *Proceedings of the 2024 on RESPECT Annual Conference* (pp. 13-20). ACM.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Burgstahler, S., & Doe, T. (2004). Disability-related simulations: If, when, and how to use them in professional development. *Review of Disability Studies*, 1(2), 4-17.
- Carmichael, A., Newell, A. F., & Morgan, M. (2007). The efficacy of narrative video for raising awareness in ICT designers about older users' requirements. *Interacting With Computers*, 19(5-6), 587-596.
- Carter, J. A., & Fourney, D. W. (2007). Techniques to assist in developing accessibility engineers. *Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 123–130). <https://doi.org/10.1145/1296843.1296865>
- CAST. (2018). UDL guidelines: Universal design for learning. <https://udlguidelines.cast.org/>
- Chang, Y., & Peterson, L. (2018). Pre-service teachers' perceptions of computational thinking. *Journal of Technology and Teacher Education*, 26(3), 353–374. <https://www.learntechlib.org/primary/p/181433/>
- Chen, G., Shen, J., Barth-Cohen, L., Jiang, S., Huang, X., & Eltoukhy, M. (2017). Assessing elementary students' computational thinking in everyday reasoning and robotics programming. *Computers & Education*, 109, 162–175. <https://doi.org/10.1016/j.compedu.2017.03.001>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Erlbaum.
- Conn, P., Gotfrid, T., Zhao, Q., Celestine, R., Mande, V., Shinohara, K., Ludi, S., & Huenerfauth, M. (2020). Understanding the motivations of final-year computing undergraduates for considering accessibility. *ACM*

Transactions on Computing Education, 20(2), 1–22. <https://doi.org/10.1145/3381911>

Crompton, H. (2023). Evidence of the ISTE standards for educators leading to learning gains. *Journal of Digital Learning in Teacher Education*, 39(4), 201–219. <http://doi.org/10.1080/21532974.2023.2244089>

Edwards, A., Wright, P., & Petrie, H. (2006). HCI education: We are failing--why. *Proceedings of HCI Educators Workshop*. https://www.researchgate.net/profile/Alistair-Edwards-2/publication/228501479_HCI_education_We_are_failing-why/links/0912f508a5f83cfb09000000/HCI-education-We-are-failing-why.pdf

El-Glaly, Y., Shi, W., Malachowsky, S., Yu, Q., & Krutz, D. E. (2020). Presenting and evaluating the impact of experiential learning in computing accessibility education. *2020 IEEE/ACM 42nd International Conference on Software Engineering: Software Engineering Education and Training* (pp. 49–60). <http://doi.org/10.1145/3377814.3381710>

Ertmer, P. A. (1999). Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, 47(4), 47–61.

Genaro Motti, V., & Dura, E. (2021). Evaluating an accessibility intervention based on persona cards with diverse needs to teach accessibility to undergraduate students. *Universal Access in the Information Society*, 22, 369–385. <https://doi.org/10.1007/s10209-021-00853-9>

Jaipal-Jamani, K., & Angeli, C. (2017). Effect of robotics on elementary preservice teachers' self-efficacy, science learning, and computational thinking. *Journal of Science Education and Technology*, 26(2), 175–192. <https://doi.org/10.1007/s10956-016-9663-z>

Kearney-Volpe, C., Kletenik, D., Sonka, K., Sturm, D., & Hurst, A. (2019). Evaluating instructor strategy and student learning through digital accessibility course enhancements. *The 21st International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 377–388). <https://doi.org/10.1145/3308561.3353795>

Keates, S. (2015). A pedagogical example of teaching universal access. *Universal Access in the Information Society*, 14(1), 97–110. <https://doi.org/10.1007/s10209-014-0398-4>

Kelly, B., & El-Glaly, Y. (2021). Introducing accessibility to high school students. *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education* (pp. 163–169). <https://doi.org/10.1145/3408877.3432466>

Kim, C., Yuan, J., Vasconcelos, L., Shin, M., & Hill, R. B. (2018). Debugging during block-based programming. *Instructional Science*, 46(5), 767–787. <https://doi.org/10.1007/s11251-018-9453-5>

Kletenik, D., & Adler, R. F. (2022). Let's play: Increasing accessibility awareness and empathy through games. *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education* (pp. 182–188). <https://doi.org/10.1145/3478431.3499277>

Kletenik, D., & Adler, R. F. (2023). Who wins? A comparison of accessibility simulation games vs. classroom modules. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education, Vol 1* (pp. 214–220). <https://doi.org/10.1145/3545945.3569769>

Kurniawan, S. H., Arteaga, S., & Manduchi, R. (2010). A general education course on universal access, disability, technology and society. *Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 11–18). <https://doi.org/10.1145/1878803.1878808>

Ladner, R. E., Stefik, A., & Blaser, B. (2019). Addressing disability in CS for All. *2019 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, 1. <https://doi.org/10.1109/RESPECT46404.2019.8985671>

Liu, C., Wang, A., Iyer, M., Slaughter, G., Bosch, A., Lodvikov, E., Zhou, K.Z., Kletenik, D. & Adler, R. F. (2025, April). Teaching accessibility: A family workshop for middle school students. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems* (pp. 1-8). ACM

Liu, C., Zhou, K. Z., Sy, S., Lodvikov, E., Shan, J., Kletenik, D., & Adler, R. F. (2025, February). Opening digital doors: Early lessons in software accessibility for K-8 students. In *Proceedings of the 56th ACM Technical Symposium on Computer Science Education* (Vol 1; pp. 722-728). ACM.

Lorgat, M. G., Paredes, H., & Rocha, T. (2022). An approach to teach accessibility with gamification. *Proceedings of the 19th International Web for All Conference*. <https://doi.org/10.1145/3493612.3520478>

Ludi, S. (2007). Introducing accessibility requirements through external stakeholder utilization in an undergraduate requirements engineering course. *Proceedings of the 29th International Conference on Software Engineering* (pp. 736–743). <https://doi.org/10.1109/ICSE.2007.46>

Luo, T., Murray, A., & Crompton, H. (2017). Designing authentic learning activities to train pre-service teachers about teaching online. *International Review of Research in Open and Distributed Learning*, 18(7). <https://doi.org/10.19173/irrodl.v18i7.3037>

Madkins, T. C., Howard, N. R., & Freed, N. (2020). Engaging equity pedagogies in computer science learning environments. *Journal of Computer Science Integration*, 3(2). <https://doi.org/10.26716/jcsi.2020.03.2.1>

Martin-Escalona, I., Barcelo-Arroyo, F., & Zola, E. (2013). The introduction of a topic on accessibility in several engineering degrees. *Proceedings of the 2013 IEEE Global Engineering Education Conference* (pp. 656–663). <https://doi.org/10.1109/EduCon.2013.6530177>

Mateen, S., Wiesemüller, P., & Voß-Nakkour, S. (2023). Design of an accessible VR-escape room for accessibility education. *SMART ACCESSIBILITY 2023: The Eighth International Conference on Universal Accessibility in the Internet of Things and Smart Environments*, (pp. 19–24). IARIA.

Motahar, T., Brown, N., Wiese, E. S., & Wiese, J. (2023). Building “design empathy” for people with disabilities: An unsolved challenge in HCI education. *Proceedings of the 5th Annual Symposium on HCI Education*, (pp. 68–71). <https://doi.org/10.1145/3587399.3587409>

Musicant, D., & Guzey, S. S. (2015). Engaging high school students in modeling and simulation through educational media. *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, (pp. 464–469). <https://doi.org/10.1145/2676723.2677237>

Nario-Redmond, M. R., Gospodinov, D., & Cobb, A. (2017). Crip for a day: The unintended negative consequences of disability simulations. *Rehabilitation Psychology*, 62(3), 324. <https://doi.org/10.1037/rep0000127>

Nelson, M. J., & Voithofer, R. (2022). Coursework, field experiences, and the technology beliefs and practices of preservice teachers. *Computers & Education*, 186, 104547. <https://doi.org/10.1016/j.compedu.2022.104547>

New York State Education Department. (2020). *Computer science and digital fluency learning standards: K–12*. <https://www.nysed.gov/sites/default/files/programs/standards-instruction/computer-science-digital-fluency-standards-k-12.pdf>

Olano, M., Sherman, A., Oliva, L., Cox, R., Firestone, D., Kubik, O., Patil, M., Seymour, J., Sohn, I., & Thomas, D. (2014). SecurityEmpire: Development and evaluation of a digital game to promote cybersecurity education. *2014 USENIX Summit on Gaming, Games, and Gamification in Security Education (3GSE 14)*. <https://www.usenix.org/conference/3gse14/summit-program/presentation/olano>

Papadakis, S., & Kalogiannakis, M. (2019). Evaluating a course for teaching introductory programming with Scratch to pre-service kindergarten teachers. *International Journal of Technology Enhanced Learning*, 11(3), 231–246. <https://doi.org/10.1504/IJTEL.2019.100478>

Patricia, L. (2011). Service learning: an HCI experiment. *Proceedings of the 16th Western Canadian Conference on Computing Education* (pp. 12–16). <https://doi.org/10.1145/1989622.1989626>

Putnam, C., Dahman, M., Rose, E., Cheng, J., & Bradford, G. (2016). Best practices for teaching accessibility in university classrooms: cultivating awareness, understanding, and appreciation for diverse users. *ACM Transactions on Accessible Computing*, 8(4), 13. <https://doi.org/10.1145/2831424>

Sentance, S., Barendsen, E., Howard, N. R., & Schulte, C. (2023). *Computer science education: Perspectives on teaching and learning in*

school. Bloomsbury Publishing. <https://doi.org/10.1080/03004279.2019.1617329>

Shaheen, N. L., & Lohnes Watulak, S. (2019). Bringing disability into the discussion: Examining technology accessibility as an equity concern in the field of instructional technology. *Journal of Research on Technology in Education*, 51(2), 187–201. <https://doi.org/10.1080/15391523.2019.1566037>

Shinohara, K., Kawa, S., Ko, A. J., & Ladner, R. E. (2018). Who teaches accessibility?: A survey of US computing faculty. *Proceedings of the 49th ACM Technical Symposium on Computer Science Education* (pp. 197–202). <https://doi.org/10.1145/3159450.3159484>

Smith, M. (2016). *Computer science for all*. <https://obamawhitehouse.archives.gov/blog/2016/01/30/computer-science-all>

Spyridonis, F., Daylamani-Zad, D., & Paraskevopoulos, I. T. (2017). The gamification of accessibility design: A proposed framework. *Proceedings of the 2017 9th International Conference on Virtual Worlds and Games for Serious Applications* (pp. 233–236). <https://doi.org/10.1109/VS-GAMES.2017.8056606>

Stefik, A., Ladner, R. E., Allee, W., & Mealin, S. (2019). Computer science principles for teachers of blind and visually impaired students. *Proceedings of the 50th ACM Technical Symposium on Computer Science Education* (pp. 766–772). <https://doi.org/10.1145/3287324.3287453>

Thomas, M. K., Shyjka, A., Kumm, S., & Gjomemo, R. (2019). Educational design research for the development of a collectible card game for cybersecurity learning. *Journal of Formative Design in Learning*, 3(1), 27–38. <https://doi.org/10.1007/s41686-019-00027-0>

Tondeur, J., Van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education*, 59(1), 134–144.

Vallera, F., & Syed, N. (2020, April). Encouraging awareness and empathy for diversity through experiential, practiced simulations. In *Proceedings of the Society for Information Technology & Teacher Education International Conference* (pp. 611–617). Association for the Advancement of Computing in Education.

Wald, M. (2008). Design of a 10 credit Masters level assistive technologies and universal design module. *Proceedings of the International Conference on Computers for Handicapped Persons* (pp. 190–193). https://doi.org/10.1007/978-3-540-70540-6_27

World Health Organization. (2011). *World report on disability 2011*. https://apps.who.int/iris/bitstream/handle/10665/44575/9789240685215_eng.pdf

- Yadav, A. & Berges, M. (2019). Computer science pedagogical content knowledge: Characterizing teacher performance. *ACM Transactions on Computing Education*, 19(3). <https://doi.org/10.1145/3303770>
- Yadav, A., Mayfield, C., Zhou, N., Hambruch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education*, 14(1), 1–16. <https://doi.org/10.1145/2576872>
- Zhao, Q., Mande, V., Conn, P., Al-khazraji, S., Shinohara, K., Ludi, S., & Huenerfauth, M. (2020). Comparison of methods for teaching accessibility in university computing courses. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 1–12). <https://doi.org/10.1145/3373625.3417013>
- Zhou, K. Z., Liu, C., Shan, J., Kletenik, D., & Adler, R. F. (2024). Accessible adventures: Teaching accessibility to high school students through games. In *Proceedings of the Association for Information Science and Technology*, 61(1), 457–468.
- Zwoliński, G., Kamińska, D., Haamer, R. E., Coelho, L. F., & Anbarjafari, G. (2023). Enhancing empathy through virtual reality: developing a universal design training application for students. *Medycyna Pracy*, 74(3). <https://doi.org/10.13075/mp.5893.01407>

Appendix A **Demographic Characteristics of Experimental Group** **(N = 14) and Control Group (N = 11) for the** **Presurvey-Postsurvey Analysis**

Characteristic	Experimental	Control	Total
Gender			
Female	10	10	20
Male	4	1	5
Disability status (multiple selection)			
Learning disability	1	2	3
Neurodiversity	0	1	1
Visual disability	3	0	3
None	5	4	9
Prefer not to say	6	3	9
Knowledge of someone with a disability?			
No	6	3	9
Yes, acquaintance/ colleague	1	1	2
Yes, close family/friend	5	3	8
I'm not sure	2	4	6
Race			
Asian	0	1	1
Black or African-American	3	0	3
Hispanic or Latino	6	8	14
White	2	1	3
Two or more races	2	1	3
Prefer not to say	1	0	1
Grades planned to teach (multiple selection)			
Early childhood (birth through second grade)	10	8	18
Elementary school (grades 1-6)	6	2	8

Characteristic	Experimental	Control	Total
Middle school (grades 6-8)	1	0	1
High school (grades 9-12)	2	0	2
I'm not sure	0	1	1
Early childhood (birth through second grade)	10	8	18

Appendix B
Demographic Characteristics of the Wider Pool of
Participants, Including the Additional Comparison
Group, Used in the Analysis of Student Artifacts ($n = 70$)

Characteristic	Number
Gender	
Female	62
Male	7
Prefer not to say	1
Disability status (multiple selection)	
Learning disability	11
Neurodiversity	1
Visual disability	4
Epilepsy	1
Heart problem	1
None	33
Prefer not to say	20
Knowledge of someone with a disability?	
No	23
Yes, acquaintance/ colleague	9
Yes, close family/friend	26
I'm not sure	12
Race	
Asian	4
Black or African-American	8
Hispanic/Latino	41
White	9
Two or more races	6

Characteristic	Number
Prefer not to say	2
Grades planned to teach (multiple selection)	
Early childhood (birth through second grade)	44
Elementary school (grades 1-6)	23
Middle school (grades 6-8)	14
High school (grades 9-12)	7
I'm not sure	2