Mapping the Landscape of Digital Accessibility in Computer Science Education: A Mapping Literature Review

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Abstract

This mapping review examines the integration of digital accessibility within computer science education, a critical component of educational equity in our increasingly digital world. With the rapid shift to online course learning driven by events such as the COVID-19 pandemic, the need for accessible educational resources has become more pronounced, highlighting the challenges faced by both students and faculty. This review examines various scholarly publications to map out the current landscape of digital accessibility in higher education computing programs. It identifies prevalent challenges and explores those efforts undertaken by educational researchers to enhance the accessibility of their curricula.

The review adopts a mapping literature review methodology, enabling a broad coverage of relevant studies without focusing on detailed critical appraisals. Key databases such as IEEE Xplore and ACM Digital Library were searched using targeted keywords such as “Digital Accessibility” AND “Computer Science Education”, “Online learning” OR “Virtual Classrooms” AND “Accessibility”, “Inclusive Education” AND “Computer Science” OR “E-Learning”. The collected data was analyzed using thematic analysis methods to identify recurring themes and to highlight significant gaps in the literature.

Our findings reveal that while there is a growing awareness of the necessity for accessible learning environments, implementation practices vary significantly, often lacking consistency. The review discusses the implications of these findings for future research, and educational practice, emphasizing the need for more systematic approaches to integrate accessibility into the computing curriculum effectively. This synthesis not only contributes to academic discourse but also serves as a guide for improving digital accessibility in computer science education, ultimately aiming to foster an inclusive academic environment for all students.

Introduction/Motivation

Online courses and digital resources have revolutionized education, providing students with unprecedented flexibility and access to educational content [1], [2]. Amidst this digital transformation, a significant challenge endures, one that strikes at the very core of educational equity: ensuring that these digital resources are both accessible and usable for all students, regardless of their abilities or disabilities [3]. In the contemporary educational context, the term “accessibility” extends far beyond physical entry into classrooms; it encompasses the right of every learner, irrespective of their physical or cognitive abilities, to access information, participate in learning activities and interact with educational content. The principle of equitable education mandates that digital learning materials be designed to accommodate the needs of every student, fostering an environment where all learners have equal opportunity to thrive academically [3], [4].

The COVID-19 pandemic forced many instructors to take their teaching online, a realm they had rarely been using regardless of discipline [1], [2], [4]. This sudden shift presented both educators and students with a unique set of challenges and opportunities [1], [2], [4]. Instructors, for example, had to rapidly adapt to digital platforms, mastering new technologies and pedagogical methods to effectively convey course content in a virtual setting [3], [4]. For many, this experience was their first-time teaching online, and they had to learn the intricacies of doing so on the fly [1], [2]. They had to rethink their teaching strategies, assessments, and most importantly the accessibility of their course material. Students, on the other hand, found themselves navigating a digital learning landscape that demanded self-discipline and digital literacy [1], [3]. They had to learn how to stay motivated and engaged in their studies without the support of physical classrooms [1]. They also had to learn how to use new technologies and platforms to access their coursework [1], [3]. This sudden shift to online learning also highlighted the critical importance of digital accessibility, as many students with disabilities faced new barriers to accessing and engaging with course materials. *Digital accessibility*, in the context of education, encompasses the creation and delivery of learning resources and tools that are usable by all students, regardless of their abilities or disabilities [5]. The challenges faced by students and faculty during the height of the pandemic and since reinforces the need to investigate (1) the impact of digital accessibility on existing online curriculum, (2) current efforts by institutions to improve digital accessibility, and (3) the impact of existing digital accessibility tools on the student experience and learning.

Ensuring the accessibility and usability of online course materials is essential for all students to achieve their full academic potential, regardless of their abilities or learning preferences [4]. This need is particularly acute for disabled students, who may face additional challenges in accessing and using online course materials due to a variety of factors [1], [2], [4]. The students within this category include students with visual, auditory, physical, cognitive, and learning disabilities. These challenges can include difficulty accessing materials that are not properly formatted or captioned, using materials that are not compatible with assistive technologies, difficulty navigating course websites that are not designed with accessibility in mind, difficulty understanding materials that are not written in clear and concise style, and difficulty completing assignments that require the use of inaccessible technologies or software [1], [4], [5]. Accessible course materials, as a result, are designed to be compatible with assistive technologies, such as screen readers, text-to-speech software, and alternative keyboards [5], [6]. They are also written in clear and concise language, and they use clear and consistent formatting [5], [6]. Yet, the consistency of implementation of these materials and their overall efficacy is an on-going exploration. These inconsistent practices can make it difficult for disabled students to succeed in online courses and ultimately limit their educational opportunities.

Digital Accessibility in Higher Education Computing Curriculum

The ongoing digital transformation across industries places computer science at the forefront of education's digital evolution. The very skills imparted in computer science programs are essential in enabling students to thrive in an increasingly technology-driven world [7]. Graduates in computer science are often at the cutting edge of technological innovation and societal transformation. Ensuring computer science students' educational experience is accessible has far reaching implications, impacting not only their immediate academic journey but also their future contributions to the workforce and society [8]. Hence, the imperative to ensure accessibility within this curriculum cannot be understated.

The decision to focus on higher education computing curriculum is deliberate, given the distinct and pressing challenges within this field [7]. Computer Science is a discipline known for its complexity, rapid evolution, and pivotal role in modern society [9]. As such, it represents a unique area of study in the context of digital accessibility. The demands of computer science courses, with their intricate coding assignments, data analysis, and complex algorithms, can present a significant hurdle for students with disabilities [10], [11]. For example, students with visual impairments may have difficulty reading and interpreting code, while students with motor impairments may have difficulty using a keyboard or mouse to write code [10]. As a result, all these students may require specific tools and resources tailored to the nuances of the field [10].

Homing in on higher education computing curriculum, this research aligns with the growing emphasis on inclusive practices in STEM (Science, Technology, Engineering, and Mathematics) fields [12]. Historically, STEM disciplines have grappled with, and are still grappling with, issues of diversity and inclusivity [12]. This literature review explores how accessibility is integrated with STEM curricula, thereby contributing to the broader conversation on fostering diversity in education.

Study Overview

Given the continuously evolving landscape of digital accessibility, we conducted a mapping review to identify gaps in the literature, alongside patterns and trends within existing literature. By employing a mapping approach, we can discern recurring themes and key areas of focus in literature, which is essential for gaining a holistic understanding of the field. While mapping reviews do not typically perform a detailed critical appraisal of the quality of individual studies, they serve as valuable tool for researchers, policymakers, and practitioners seeking to gain an overview of a research topic an inform future research directions, policy decisions, or practice recommendations [13]. As the field of digital accessibility in computing education has practical implications for educators, institutions, and policymakers, a mapping review equips us to make informed decisions and recommendations based on comprehensive and evidence-based understanding of the current state of knowledge [14]. With that in mind, this mapping review seeks to address two critical questions within Computing Education:

What are the prevalent digital accessibility challenges in computer science programs?

How do computer science curricula address the need for digital accessibility to enhance the student learning experience?

Methodology

We chose a mapping literature review methodology to identify, analyze, and synthesize the existing literature that focuses on digital accessibility in computing education. By utilizing this methodological approach, we seek to provide an overview of the literature that directly addresses the aspects of digital accessibility used within instructors' pedagogical practices to enhance learning experiences within the context of computing education. To do so we sought to identify, categorize, and summarize a wide range of scholarly publications, including research papers, conference proceedings, and other relevant peer-reviewed sources relevant to digital accessibility in computing education. Given the complexity and multidimensionality of digital accessibility in

computing education, this methodology allows us to cover a wide range of sources, ensuring that we do not overlook any relevant contributions to the field and facilitating the identification of gaps and areas for further investigation [15]. In the context of digital accessibility, where the landscape is continuously evolving, identifying these gaps is crucial.

To conduct our research, we established guidelines for inclusion and exclusion, selected the most suitable databases, and defined highly targeted keywords to ensure comprehensive results. We screened all documents thoroughly, scrutinizing them based on their title, abstract, and full paper review. We then organized and categorized the selected literature to identify and extract patterns, themes, and trends. The following sections describe each of these steps within our research process and give rationale for our methodological approach (Fig 1).

Figure 1: *Steps within Mapping Review Process*

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for this mapping review were designed to ensure the selection of the articles included and ultimately, the findings and discussions in the review reflect current trends and practices, providing a relevant and up-to-date overview of the field (Table 1) [16]. Considering the rapidly evolving nature of technology, this review includes only papers published within the last ten years. Our review was limited to peer-reviewed journal articles, conference papers, and academic book chapters to ensure the quality and credibility of the studies included. The primary topics explored focused on the integration of digital accessibility in higher education computing curricula where the purpose is to make course content accessible to all, as opposed to literature about teaching accessibility topics. Additionally, general studies on online education or computer science that did not focus on accessibility aspects were not considered. Lastly, studies that focus on aspects of accessibility outside the digital domain, such as physical accessibility in classrooms, were not included in the review.

Table 1: *Inclusion and Exclusion Criteria for Literature Review on Digital Accessibility in Higher Education Computing Programs*

	Inclusion Criteria	**Exclusion Criteria**
Date	Includes only literature published within the last ten years (2014 - 2024)	Excludes literature published before 2014
Primary Topic	Includes literature focused on pedagogical practices that employ digital accessibility tool with the purpose of making course content accessible to all	Excludes literature that focused on teaching accessibility topics, general studies on online education or computer science that do not focus on accessibility aspects, and studies that focus on aspects of accessibility outside the digital domain,

		such as physical accessibility in classrooms, were not included in the review
Area of study	Includes literature about computing in higher education	Excludes literature about computing in K-12 education
Type of literature	Includes peer-reviewed journal articles, conference papers, and academic book chapters	Excludes literature that has not been peer-reviewed

Data Sources

For our paper we searched two academic databases, *IEEE Xplore*, and *ACM Digital Library*. We picked these databases primarily because they pertain to the field of computing education. They contain a wide range of publications, such as research papers, conference papers, and scholarly resources. IEEE Xplore is a vital resource in our understanding of electrical engineering and computer science. This database is home to a large collection of technical literature sourced from the Institute of Electrical and Electronic Engineers (IEEE) and the Institution of Engineering and Technology (IET) conferences, journals, and standards. We chose this database because of its extensive collection of technical papers, especially focusing on technological advancements and educational methodologies in computer science. The ACM Digital Library is a database that stores full-text articles and bibliographic literature covering computing and information technology. This database provides access to the complete collection of ACM publications, including journals, conference proceedings, technical magazines, newsletters, and books. It is the single most comprehensive resource for computer science research. We selected this database because it covers computing education research, including education, curriculum design, and digital accessibility in computer science programs.

Keywords and Search Terms

For the search, we carefully selected a set of specific keywords and search terms to ensure a thorough search, capturing a wide range of relevant papers. Core themes searched were *digital accessibility* and *computer science education*. *Digital accessibility* is central to this study, focusing on accessibility in digital and online environments. *Computer science or computing education* refers to the educational context and curricular aspects of computer science. From those core themes we also included the associated terms *online learning* and *inclusive education*. Online learning reflects the shift towards digital education, especially relevant due to impact of COVID-19. Inclusive education encompasses broader educational principles that ensure accessibility for all students. Outside of these terms were the technical and pedagogical aspects of digital accessibility to consider. Keywords like ‘e-learning’, ‘virtual classrooms’, ‘adaptive technologies’, and ‘universal design for learning’ were included to cover the technical and teaching methodologies.

Keywords were combined using Boolean operators (AND, OR) to refine the search. Examples include but are not limited to the following:

- “Digital Accessibility” AND “Computer Science Education”
- “Online learning” OR “Virtual Classrooms” AND “Accessibility”
- “Inclusive Education” AND “Computer Science” OR “E-Learning”

The careful selection and strategic combination of these keywords ensured thorough and effective searches.

Screening and Selection Process

When conducting our search, we initially screened papers for titles that seemed to align with our primary research focus. This step aimed to quickly identify and exclude studies that did not directly pertain to digital accessibility within the context of computer science education. This approach helped to efficiently narrow down the vast array of available literature. Following this preliminary screening, studies were subjected to a more detailed review based on the predefined inclusion and exclusion criteria. This step was important to maintaining the focus and integrity of the review. It involved a thorough examination of each study ensuring its relevance to digital accessibility in computer science education.

Data Extraction and Analysis

Data extraction occurred through a standardized framework established to ensure that we collected the same type of key information from each piece of literature analyzed. Key data points about the study design (objectives, methodologies, and overall findings) were gathered as well as key implications of the studies on digital accessibility computer science education. For the data analysis, a thematic analysis was used to analyze and identify patterns and themes within the data set. This method allowed for a deep understanding of the prevailing approaches and challenges in integrating digital accessibility into computer science education. It also allowed us to identify gaps in the existing literature, such as under-researched areas. Next, we synthesized findings from individual studies. This step was critical within the process because it enabled us to combine the findings of several different studies to draw more well-rounded conclusions regarding the current state of digital accessibility in the field. The results of this synthesis allowed us not only to determine the overall effectiveness of a variety of different approaches and tools, but also to compare educational outcomes.

Findings

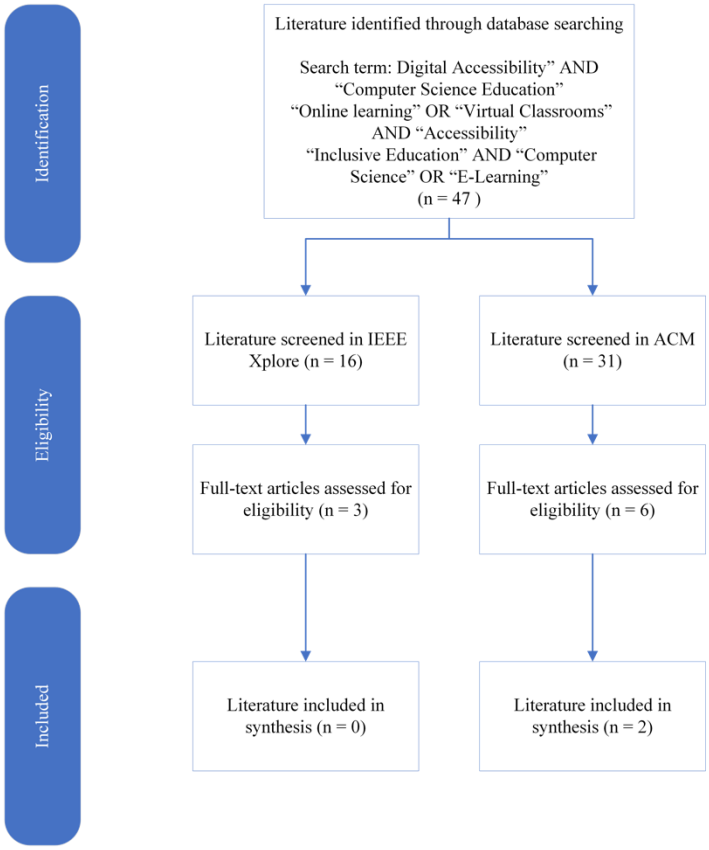
Within the first stage of the mapping review, utilizing the predefined keywords and search terms, we identified 47 papers (Figure 2). Sixteen of those papers were extracted from the IEEE Xplore database and 31 were found in the ACM Digital Library. After initial screening of titles and abstracts 38 of these papers were excluded because they focused on teaching accessibility topics, aspects of accessibility outside the digital domain, such as physical accessibility in classrooms, or were general studies on online education or computer science that did not focus on accessibility aspects. This left nine papers for researchers to examine. Thus, we completed a full text assessment of the nine papers to then synthesize themes across our findings. During this assessment three additional papers were excluded because they did not provide empirical data or theoretical insights that could directly inform the integration of accessibility into computing

curricula. The screening process resulted in the selection of six papers that most closely aligned with our study's goals. These papers provided insight into:

- The existing challenges that educators face in implementing accessible digital environments and
- Effective strategies and tools that have been proposed to overcome these challenges.

Two of these six papers were particularly pivotal as they directly discussed the challenges and utilization of specific digital accessibility tools within computing education. These studies were critical in shaping our understanding of how and if accessibility tools are being integrated into curricula and what barriers remain.

Figure 2: *Flow Diagram of Literature Selection Process for Mapping Review on Digital Accessibility in Computer Science Education*



Prevalent Accessibility Challenges in Computing Education

The initial review of the six papers revealed a broad range of themes related to digital accessibility and pedagogical challenges in computing education, which are summarized in Table 2. These themes include: (1) the integration of accessibility in curriculum, (2) teaching accessibility in design and interaction courses (3) the adoption of inclusive design principles in software development, and (4) the identification of pedagogical challenges. Within the papers that comprise the first three themes, we found that many publications focus on how accessibility

is woven into the computing curriculum to enhance students' ability to create accessible software. For instance, Baker et al. [17], [18] and McHugh et al. [19] discuss various challenges and strategies for accessibility, with McHugh proposing a programming interface for assistive technology as a strategy. Baker et al. specifically examines which courses include accessibility, detail the topics covered, and discuss the assessment methods employed. Furthermore, Lazar et al. [20] provides examples of teaching accessibility in user-centered design and HCI courses, while Garcia et al. [21] emphasize the importance of inclusive design in software development, with Ludi et al. [22] focusing on curriculum implementation.

Table 2: *Themes and Key Findings Accessibility in Computing Education*

Theme	Key Findings	Authors
Integration of Accessibility in Curriculum	Baker et al. [17], [18] and McHugh et al. [19] discuss challenges and strategies for accessibility, with McHugh proposing a programming interface for assistive technology.	Baker et al. (2020), McHugh et al. (2020)
Teaching Accessibility in Design and Interaction Courses	Lazar et al. [20] provide examples of teaching accessibility in user-centered design and HCI courses.	Lazar et al. (2019)
Inclusive Design and Thinking in Software Development	Garcia et al. [21] emphasize the importance of inclusive design in software development, with Ludi et al. [22] focusing on curriculum implementation.	Garcia et al. (2022), Ludi et al. (2018)

Targeted Analysis of Accessibility Tools and Pedagogical Practices

While the above-mentioned themes showcase a growing awareness and incorporation of accessibility features, they take a forward-looking view of digital accessibility in education, by focusing on how future graduates will design accessible digital environments. This focus suggests a lack of literature on why digital education environments are not more accessible right now. Specifically, Lewthwaite et al. [5], [6] touched on the challenges instructors face in making course content accessible to all students, which are summarized in Table 3. They identified four main challenges: (1) a deficiency in pedagogical culture that supports digital accessibility, which is essential for fostering excellence in teaching and learning [5]; (2) the absence of a standardized accessibility curriculum within computer science education; (3) a lack of established best practices for accessibility; and (4) a considerable learning curve for educators adapting content to be fully accessible. These challenges suggest not only variability in implementation but also a critical gap in the standardization of accessible educational practices across the field. Additionally, these challenges have been made even more difficult in the online learning environment, where digital accessibility issues increase considerably. Despite this comprehensive discussion, these two studies demonstrate how little has been researched about the pedagogical practices employed to make digital computing coursework accessible for all students.

Table 3: *Challenges with Accessibility Tools and Pedagogical Practices in Computing Education*

Challenge	Details	Implications
Lack of Pedagogical Culture	Absence of a widespread educational culture that supports digital accessibility, necessary for excellence in teaching and learning.	Necessitates the development of a supportive culture and training programs in digital accessibility.
No Formally Agreed Curriculum	Within computer science education, there is no consensus on a curriculum that integrates accessibility.	Highlights the need for standardized curricula that include accessibility components.
Absence of Predefined Best Practices	No established best practices for implementing accessibility, leading to inconsistencies across discipline.	Calls for the creation of standardized accessibility guidelines and practices in computing education.
Steep Learning Curve for Educators	Educators face significant challenges in adapting course content to be fully accessible, particularly in online environments where digital accessibility issues are amplified.	Urges the development of resources and training to assist educators in enhancing their digital proficiency.

Conclusion and Future Work

This mapping review shows how complex digital accessibility is in computing education. The review synthesized the current literature, revealing efforts to enhance the accessibility of computing curricula to teach accessibility design principles with no practical implementation of accessible course content. The detailed analysis of the two papers by Lewthwaite et al. suggest reasons for why there is limited practical implementation, such as the absence of an accessibility-centric pedagogical culture and a standardized curriculum that integrates digital accessibility effectively. These gaps highlight the need for established pedagogical practices and a more standardized approach to curriculum development. Future studies should continue to seek new ways to integrate digital accessibility practices into computer science education while focusing on practical implementation and effectiveness for student learning experience. Longitudinal studies are also needed to understand the long-term impact of these practices on students with disabilities. As new technology emerges, it will be important to continue to research and ensure that digital accessibility stays up to date. Finally, more studies are needed to broaden the inclusiveness of computing education by exploring how accessibility intersects with other issues of diversity and equity in STEM fields.

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