A Systematic Analysis of Accessibility in Computing Education Research

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ABSTRACT

Recent interest in accessibility emphasizes including it in computer science curriculum as key to producing effective computing professionals. Despite a general consensus that teaching accessibility in computing curriculum is good, there exist few tools and resources to support instructors in higher education. To better understand the relationship between accessibility in curriculum and research, we conducted a systematic literature review of papers in computing education. We analyzed the papers for the courses accessibility is covered in, the topics that are covered and pedagogies and assessment approaches that are used. Across this body of work, we found a number of key learning objectives commonly covered in computing education research, though it appeared the research did not evenly cover these objectives throughout curricula, nor did the research systematically investigate how learning objectives were integrated. Based on these results, we offer suggestions for future directions of accessibility education research and curriculum building.

CCS CONCEPTS

CCS → Social and professional topics → Professional topics → Computing education → Model curricula

KEYWORDS

Accessibility; education; learning objectives; assessment; pedagogy; computing

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1 Introduction

Including accessibility in computer science and related fields is extremely important if we wish for the next generation of professionals to be able to create accessible technology. Recent research on teaching accessibility has focused on who is teaching it, revealing a number of institutional and individual motivations that encourage accessibility in higher education [17]. However, the growing body of literature that encapsulates *what* should be taught and *how* it should be taught is a compilation of individual pedagogies (*e.g.*, [4, 8, 13, 20]), curricular suggestions (*e.g.*, [5, 9, 16, 19]), and anecdotal evidence (*e.g.*, [1, 3, 6, 14]). Although quite a comprehensive body of research, it is unclear what aspects of accessibility are systematically covered in computing curricula, and what pedagogies are commonly used. Prior work found that most accessibility computing education literature relies on anecdotal instructor feedback instead of robust evaluation [12].

Meanwhile, the lack of accessibility in curricula is a problem for industry. Only 7.2% of web accessibility practitioners reported learning anything substantial about accessibility in their formal education [21]. Surveys of designers in 2006 and 2009 found that lack of knowledge was the main reason for not implementing inclusive design [22]. Indeed, the TeachAccess consortia [18] was created to aid technology companies to find developers with the skills necessary to create accessible products.

Thus, there is a need to elucidate not just that teaching accessibility is important and that we should include it, but also to understand what elements of accessibility are currently being taught, what needs to be addressed, and how. To summarize and clarify what educational strategies have been studied toward defining research needs moving forward, we conducted a systematic literature review of research papers focusing on teaching accessibility and analyzed them for a number of factors including: what kinds of courses accessibility is taught in, what approaches were used to integrate accessibility, what pedagogies were used, which accessibility-related topics were covered, and how learning objectives were assessed. Our goals were to understand the extent to which computing education research

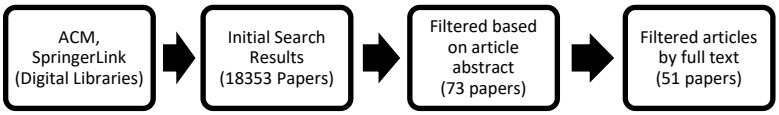

Figure 1. Summary of the phase two of the analysis process.

addresses how accessibility is included in current curricula and what opportunities exist for future research.

Our findings suggest that computing education research has covered a specific category of topics, across similar curricular integration strategies. We also found that topics were reported to vary based on how accessibility was integrated into a given computing course. We also found that the research reported that accessibility topics were more likely to be dropped when covered as an added topic rather than a core component. Further, we found evidence in the literature that accessibility is disproportionately covered in a small number of elective courses as opposed to core courses, and is not often evaluated for learning effectiveness. Thus, our findings suggest that the research indicates that few have investigated the effectiveness of accessibility as part of core computing curriculum requirements.

Based on these results, computing education research should focus on developing effective strategies and materials to center accessibility in core curriculum. Given such a lack of inclusion as a core computing competency, if computing faculty with limited accessibility expertise are inclined at all to include accessibility, they may do so as an addition to a course. Thus, there is a need to focus on ensuring that all topics, particularly the commonly dropped topics, can easily be integrated into a course and that there are good resources for instructors to learn and integrate accessibility into their courses.

2 Methodology

We did a systematic literature review (SLR) [10] to learn how accessibility is taught in computing programs. Our goal was to analyze existing research that investigated the effectiveness of accessibility topics in computing courses to understand the direction of the field, and determine future research opportunities. We asked the following research questions (RQs):

- What courses cover accessibility topics?
- What kind of accessibility concepts were covered and what were the accessibility learning objectives in these computing courses?
- What pedagogies were used in teaching accessibility? What methods were used to evaluate the course objectives?

2.1 Search Strategy

2.1.1 Phase 1: Identifying Search Criteria. We began with pilot searches to identify the best search terms and databases to use. The initial search terms we used included: teaching, curriculum, course, learning outcomes, education, pedagogy, accessibility, inclusive, and universal design. We also compared different versions of those search strings (*e.g.*, universal design *vs.* "universal design", teaching *vs.* teach*). The databases we used in the initial search were: Science Direct, ERIC, Springer Link, IEEE, ASEE, and ACM. Not every search was done on every database as our search terms were evolving as we examined abstracts of relevant articles and identified commonly used language. For these searches, we skimmed through the first few pages of the results to determine relevancy and noted any relevant papers. We eliminated the Science Direct, ERIC, IEEE, and ASEE databases as we found few accessibility papers in the first several pages of results. It is unclear if this is due to a lack of relevant papers or due to poor search rankings burying the existing papers. However, many of the papers found were irrelevant to our research questions (*e.g.*, focusing on accessible pedagogy or using access as in remote access). Additionally, we found that some of the relevant papers were available in other databases (*e.g.*, ACM has some IEEE papers).

2.1.2 Phase 2: Identify Relevant Papers. Based on Phase 1, we identified ACM and SpringerLink as our target databases because they returned the most relevant sources. We used search terms in two categories: (1) accessibility keywords: *accessibility, "universal design", inclusive*; and (2) education keywords: *curriculum, pedagogy, educat*, courses, teach**. For each search, we used one term from each category. For ACM, we required both accessibility-related and education-related terms to be in the abstract. For SpringerLink, the online database does not include the feature of searching the abstract of papers. So, we required both terms and narrowed the categories to require the articles to be within the following categories: Computer Science, User Interfaces and HCI (Human-Computer Interaction), Computers and Education, and English. We performed 15 searches per each database, resulting in 18353 total papers (not unique).

For each result of the searches, one researcher would read the abstract of the article and add it to our library if it mentioned teaching accessibility in computing related courses. We included all papers that had more than just an abstract, resulting in a combination of research papers, experience reports, and posters with short papers. Papers about making education accessible or that were only about tools or interfaces were not included. If there was a question whether the paper fit our criteria, all three researchers would read the abstract and a majority vote would decide. The searches and analysis of the abstracts took place from March 2018 to June 2018.

As a result of our search we found 73 papers[1], with 49 from the ACM Digital Library and 24 from SpringerLink. We then read the

[1] Papers are available at https://www.zotero.org/groups/2324346/accessibility_education_computing_literature_review

Category	Description	Examples
Course	What course did the paper describe	HCI, Intro Programming, Web Design, ...
Program	In what type of program was accessibility added	Undergrad CS, Gen Ed, Workshop, Industry Professional Development, ...
Concepts	The concepts covered in the courses	Accessibility Laws, Accessibility Guidelines, Implementation, ...
Pedagogies	How the concepts were taught in the course	Lectures, Readings, Projects, Simulated Disability, ...
Category	How the concepts were integrated in the course	Topic (e.g. Accessibility Capstone), Theme (e.g. HCI course with projects focused on users with disabilities), Addition (e.g. Web Design w/ added lectures), Other (e.g. hypothetical courses, survey on what should be taught)
Assessment	Did they report on how they measured student learning? If so, how	Yes, No, Pre-post surveys, criteria on rubrics, comparison across classes, ...
Evaluation	Did they report on the success of the interventions? If so, how	Yes, No, Student Surveys, Instructor comments, ...

Table 1. Codes used to categorize papers in the corpus.

full text of the 73 papers. We excluded 22 papers as they were not relevant to our research questions (*e.g.*, did not include details on how accessibility was taught or discussed a tool related to creating/evaluating accessible technology), therefore resulting 51 papers that were included in our analysis.

2.2 Analysis of Accessibility Teaching

With a collection of papers that met our criteria, we read through and coded the papers for a number of characteristics. Initially, all three researchers read a subset of seven papers and collaboratively created an initial codebook to use for analyzing the papers. Once we had decided on the codebook, the remaining papers were split among the researchers, each reading and coding about a third of the remaining papers each. We focused coding on what course in what type of program the paper detailed, which concepts were covered, what pedagogies were used, how the learning was assessed, and the evaluation of the course. We created thematic categorizations inductively based on the data and later compared them to existing suggestions. An example of the codes used are in Table 1.

3 Results

We found a diversity of topics and approaches emerged from our literature review, including common approaches to teaching accessibility, patterns of pedagogies, and assessments that indicated specific learning objectives that are currently being pursued. These results show opportunities for investigating other pedagogical strategies, and organizing systematic assessments to show how learning about accessibility benefits students.

3.1 Course Integration Approaches

Prior literature proposed different approaches for integrating accessibility into the curriculum, either based on the depth of the content [11] or the context of how it is integrated [9]. Our literature review revealed that course implementations took one of three integration approaches: First, when accessibility was the entire **topic** of the course, *i.e.*, a special topics course that is primarily focused on accessibility. Second, when accessibility was a **theme**, *i.e.*, traditional computing courses whose primary learning objectives are not accessibility (*e.g.*, web programming, HCI) that had a semester focus on accessibility, including semester long projects designing for users with disabilities. Third, when accessibility was an **addition** to the course, *i.e.*, as a single module or throughout the course, but treated as just another topic that students needed to know. A few papers did not fit into any of these categories as they did not describe a specific course or module. Some examples of these papers are interviews with instructors, hypothetical courses or educational games/tools. Papers of this type did not provide details of the topics and approaches used in integrating accessibility, or focused on tools to support learning of specific concepts.

Of the 51 papers we analyzed, 17 (33.3%) discussed teaching accessibility as the *topic*, 6 (11.8%) discussed teaching accessibility as the *theme*, and 11 (21.6%) discussed teaching accessibility as an *addition*. An additional 17 papers covered miscellaneous topics.

3.2 Accessibility Knowledge Covered

We coded papers for the specific topics that were covered in each course. We identified the topics that were covered most often and in which courses they tended to be covered.

3.2.1 Derived Learning Objectives. From the corpus, we analyzed all papers that described courses that were implemented (*i.e.*, hypothetical courses were not included). We noted both explicitly stated learning objectives and deduced objectives from course descriptions where appropriate. We summarized the main learning objectives into four main categories:

1) **Awareness of accessibility**, *e.g.*, abilities, laws, ethics
2) **Technical knowledge**, *e.g.*, requirements, guidelines, WCAG, testing
3) **Empathy**, *e.g.*, understating disabilities, inclusive design
4) **Potential endeavors**, *e.g.*, pursuing career in accessibility

Accessibility Knowledge	Topic	Theme	Addition	Total
Universal Design	11 (64.7%)	5 (83.3%)	7 (63.6%)	23 (67.6%)
Accessibility Guidelines	13 (76.5%)	2 (33.3%)	6 (54.5%)	21 (61.8%)
General Disability Knowledge**	12 (70.6%)	4 (66.7%)	2 (18.2%)	18 (52.9%)
Implementation	5 (29.4%)	4 (66.7%)	4 (36.4%)	13 (38.2%)
Testing**	8 (47.1%)	4 (66.7%)	1 (9.1%)	13 (38.2%)
Accessibility Laws	8 (47.1%)	2 (33.3%)	2 (18.2%)	12 (35.3%)
Assistive Technology*	9 (52.9%)	1 (16.7%)	2 (18.2%)	12 (35.3%)
Empathy	5 (29.4%)	2 (33.3%)	1 (9.1%)	8 (23.5%)
Total Papers	**17**	**6**	**11**	**34**

Table 2. The coverage of accessibility concepts based on how accessibility was integrated into the course. **Indicates that the integration approach had a significant effect on whether it was covered (p<.05) and * indicates there was a trend (p<.1)

Although the first three objectives were common across research papers describing course implementation, only a small number of papers included the fourth category.

3.2.2 Concepts Covered By Course Approach. In Table 2, we break down how concepts covered were integrated into courses. The most common topics included were Universal Design, Accessibility Guidelines, and General Disability Knowledge, with each covered in more than 50% of the papers analyzed.

We tested if there were differences in the topics covered based on the integration approaches (as a course *addition*, a *topic*, or a *theme*). We were interested in topics covered less frequently based on an integration approach, as those would make good candidates for areas of future development.

We found integration approach had a significant effect on whether General Disability Knowledge (($\chi^2(2) = 7.91$, $p<.05$), and Testing was taught ($\chi^2(2) = 6.57$, $p<.05$). Additionally, there was a trend that integration approach correlated with whether Assistive Technology was taught (($\chi^2(2) = 4.64$, $p<.1$). These findings indicate that some approaches to teaching accessibility are more conducive to pedagogies or teaching strategies that demand less expertise. Different concepts may require more in-depth support to enable instructors to more thoroughly integrate effective course learning pedagogies. For example, additional training might focus on informing instructors about substantive General Disability Knowledge *and* about which pedagogies improve accessibility learning objectives.

3.3 Distribution of Topics Across the Curriculum

Next we looked at how topics covered varied across types of courses, analyzing papers that discussed adding accessibility into common courses across computing curricula. In this approach to our analysis, all topic courses were not included, nor were any courses geared at industry professionals. However, we included hypothetical courses and papers that holistically discussed approaches to integrating accessibility throughout the curriculum. After culling for how topics were covered, we were left with 21 papers for analysis.

The most common courses that covered accessibility were HCI and related courses (8 papers) and Web Design/ Programming and related courses (7 papers), representing 15 of the 21 papers (71%) analyzed. We note that oftentimes, these courses were electives. Only a few papers reported on accessibility in core courses (*e.g.*, Intro Programming, Data Structures, etc.), and accessibility integration was on a much smaller scale. While HCI (8 papers), Web (7 papers), and software engineering (1 paper) courses included many concepts covered in Table 2, the few papers that reported including accessibility in Intro Programming (2 papers) and Data Structures (1 paper) only covered one or two accessibility concepts and with few details. As core courses are a direct representation of degree requirements, these findings indicate that accessibility is not yet considered core competency in computing in general. In addition to investigating the benefit to adding accessibility as a core competency, more research may be needed on accessibility integration in basic computing courses.

3.4 Pedagogy and Evaluation

To understand how courses are taught and evaluated, we analyzed the 51 papers resulting from the review process with respect to course evaluations. Nineteen papers in our corpus addressed course evaluations using methods such as survey or instructor feedback. Four papers were omitted from analysis on evaluation because they did not cover learning in a course (*e.g.*, described a tool's effectiveness). We here report on our findings analyzing the remaining 15 papers that included course evaluations.

Across the 15 papers, the most frequently used pedagogies were: (1) In-class activities (n=9, 60%), (2) Projects (n= 9, 60%), and (3) Lectures (n=9, 60%). The least used pedagogies were: (1) Research (n=1, 6.7%), and (2) Guest speakers with disabilities (n=2, 13.3%), Table 3. Other papers (n=3, 20%) included pedagogies focused on raising awareness and fostering empathy such as by including simulations, videos, or interactions with people with disabilities.

Pedagogy (Instructional Method)	Topic	Theme	Addition	Total
In-class activities	5 (33.3%)	3 (20%)	1 (6.7%)	9 (60%)
Projects	2 (13.3%)	3 (20%)	4 (26.7%)	9 (60%)
Lectures	5 (33.3%)	1 (6.7%)	3 (20%)	9 (60%)
Assignments	2 (13.3%)	1 (6.7%)	1 (6.7%)	5 (33.3%)
Videos	1 (6.7%)	1 (6.7%)	1 (6.7%)	3 (20%)
Simulated disability	3 (20%)	0 (0%)	0 (0%)	3 (20%)
Interaction with people with disabilities	1 (6.7%)	2 (13.3%)	0 (0%)	3 (20%)
Guest speakers with disabilities	1 (6.7%)	1 (6.7%)	0 (0%)	2 (13.3%)
Research	1 (6.7%)	0 (0%)	0 (0%)	1 (6.7%)

Table 3. Pedagogies used based on course integration approach for courses with evaluation information.

Evaluation is a solid pillar of pedagogy. Hence, we were interested in analyzing how courses involving accessibility were taught and evaluated. Eight out of the 15 papers (53.3%) with evaluation data described Topic courses. Four papers (26.6%) were Addition courses, and 3 papers (20%) were Theme courses. Evaluation strategies included: (1) comparing exams, quizzes and other graded assignments, (2) utilizing pre- and post-course questionnaires, surveys, and student journals, (3) employing third party evaluation, such as by community organizations, particularly when students worked on group projects, and (4) analyzing retention and completion rate. Evaluation strategies typically addressed the four main learning objectives (awareness of accessibility, technical knowledge, empathy, potential endeavors).

We considered that research papers with course evaluations had well-developed courses because evaluations could close the loop on learning outcomes. Our analysis indicated that well-developed accessibility courses with evaluation techniques were most commonly Topic courses (n=8, 53.3%) that were taught using established instructional methods such as experiential learning (e.g., projects) and active learning (e.g., in class activities). All Theme courses with evaluation data employed projects, in-class activities, and lectures as teaching methods. For Addition courses, the most used pedagogies were projects (100%), and lecture (75%). Interestingly, all Addition courses with evaluation data did not use guest speakers with disabilities, simulated disability, or interaction with people with disabilities, whereas these appeared at least once in the other approaches. These are common strategies for courses to support teaching empathy, but often require more knowledge and community contacts than the other instructional methods.

4 Discussion

Our findings corroborate prior research conclusions that teaching accessibility, as a small and less developed epistemology, lacks the pedagogical culture [12] and curricular infrastructure [16, 17] to produce accessibility-minded computing professionals. However, our investigation finds consistency among current teaching strategies and evaluation techniques. These findings indicate that among the few who teach accessibility, roughly the same kinds of topics are covered in similar manners. In contrast to Lewthwaite and Sloan [12], these findings indicate that instructors are learning from one another or that they perceive similar accessibility issues as high priority.

In addition, these findings show research in accessibility is limited in addressing what content instructors cover, and how student learning is assessed. The body of literature we analyzed covered a narrow range of similar topics with limited approaches and pedagogies. Thus, there are opportunities to expand research on what topics are covered and how, in particular, examining how to include accessibility in core programming and computing courses, not just front-end, web-based or elective courses. More work should focus on assessing accessibility knowledge.

4.1 Approaches to Covering Accessibility

Our findings extend Ko and Ladner's suggestions for three levels to accessibility integration in computing curricula [11]: modifying a lecture, adding a lecture, or adding a course. Although their approach similarly has three different levels, our findings suggest an intermediary level not previously considered: using accessibility as a theme in a course. Depending on the size of the department, adding a special topics course centered around accessibility might not be possible. In these situations, accessibility as a theme can be used as a way to gain a deeper dive into accessibility, while still fitting the curriculum offered by the institution. Web Design/Web Programming and Human Computer Interaction were common courses where accessibility could easily be offered as a theme.

While Ko and Ladner [11] focused on depth when looking at adding accessibility into courses, Kawas *et al.* [9] proposed ways to introduce accessibility in the context of the course. These categorizations are not in competition with our distinctions. Rather, we find that Kawas's suggestions provide concrete approaches for someone who is looking to use the addition approach and needs ideas for how the content can be introduced into the curriculum.

4.2 Resources For Instructors Teaching Accessibility

We found that research has investigated how to include accessibility in a small number of similar types of courses. Though there have been suggestions on how to integrate accessibility

throughout the curriculum [5], little research has focused on diverse ways to do so. Additional research may be needed to cover all the primary learning objectives in core courses.

Most core courses in computing curricula lack coverage of accessibility. Our analysis uncovered eight core topics (Universal Design, Accessibility Guidelines, General Disability Knowledge, Implementation, Testing, Accessibility Laws, Assistive Technology, Empathy) that fit within 4 learning objectives (awareness of accessibility, technical knowledge, empathy, potential endeavors), yet most were covered in elective or HCI-related courses. One research opportunity that arises is to investigate how to incorporate these topics and learning objectives in accessibility in required courses.

We expect that most instructors who are new to integrating accessibility into their courses will start by integrating accessibility using the *Addition* approach. However, our analysis of concepts covered by *Addition* courses revealed that certain topics were often dropped, such as General Disability Knowledge. Without General Disability Knowledge students may not understand how interface changes may be needed beyond explicitly stated guidelines, a problematic issue in practice because meeting guidelines is not enough for creating truly accessible software [15]. Thus, we recommend two areas of study to help faculty looking to integrate accessibility in their courses. First, research should focus on how to improve resources (guidelines and testing tools) and second, we need research to understand how different approaches to introducing accessibility content affects student learning.

4.2.1 Improving Guidelines and Tools. Improving the resources for novice instructors is important for providing instructors the resources they need to learn and teach the material. Instructors are often concerned with time when implementing new teaching practices, both the time for them to learn new material and the time it takes to provide for new material in an existing course, as it may limit the number of topics they can cover [7, 9].

During our literature review, we found that multiple instructors attempted to use accessibility tools and guidelines in their courses. However, tools and guidelines can be difficult for novices to understand [2, 6] which was reflected in some studies reporting on instructors' feedback. Resources that are hard to use and understand can negatively affect teaching. Many existing tools require users to be well versed in accessibility to be able to understand the changes that need to be made and to recognize false positives and negatives. As existing accessibility resources are difficult to use, students may struggle to interpret results from the tools and therefore they may struggle to learn the associated material.

4.2.2 Best Practices in Content Introduction. Our analysis also uncovered a research opportunity to study introduction approaches. As *Addition* courses typically had less content that could be fit into the course, it is important that we are strategic with these resources. Instructors may not initially know how to integrate accessibility as many core computing courses do not involve interfaces and therefore the technical implementation of accessibility is not a potential topic.

Kawas *et al.* [9] proposed that we can introduce accessibility content in four different ways: as (1) core topics, (2) examples, (3) context and (4) motivating problems. Most of the papers in our literature review focused on the first approach, introducing accessibility as a core topic in elective courses, though a few used the other approaches suggested (e.g. [19]). However, as few papers reported using the other approaches, we have less information on the efficacy of these approaches. We suggest that further research focus on using different approaches to introducing accessibility, particularly examples, context, or motivating problems.

We believe that having additional understanding of the best ways to introduce the accessibility content will help us create lightweight ways for instructors to include accessibility content throughout the core courses.

Our findings show that current computing education research approaches to teaching accessibility are limited to a small number of topics, integration approaches and evaluation strategies. We suggest that computing education research can expand to investigate how accessibility can be included in core computing curricula requirements, and what other pedagogical strategies might be effective. Our findings also indicate that more work should focus on how to evaluate learning about accessibility.

5 Limitations and Future Work

To gain an understanding of topics covered and approaches used when teaching accessibility, we conducted a literature review of existing research. Though it enables us to understand research on best practices, this approach may not reflect approaches and topics covered in practice. However, we hope these findings complement contributions from Putnam *et al.* [16]. One way to address these limitations may be to conduct a systematic evaluation of publicly available teaching materials to examine differences between approaches and topics covered in the literature from those that are in used in practice.

6 Conclusion

We did a systematic literature review to identify the common topics and approaches covered in computing education literature, specifically focusing on how research seeks to improve ways to integrate accessibility into the computing curriculum. We found four main learning objectives commonly addressed in the research: (1) Accessibility Awareness, (2) Technical Knowledge, and (3) Empathy for People with Disabilities, and (4) Potential Endeavors. Learning objectives were consistent across courses examined, but they tended to be clustered in a small number of elective courses. Meanwhile, the literature offers little information on how to introduce these topics into core courses. Our study highlights two main needs in computing accessibility education. The first need is to create a research roadmap for covering and reinforcing accessibility knowledge with clear learning objectives and evaluation methods across several core and elective courses. Second, to implement this roadmap, we need to create and investigate the efficacy of usable accessibility teaching materials to support instructors.

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