Teaching Accessibility in Computer Science and Related Disciplines: A Systematic Literature Review and Narrative Synthesis Protocol

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ABSTRACT

Background: Imperatives for digital inclusion mean there is growing demand for graduates with the knowledge and skills to produce digital services that are accessible to disabled people and older populations. Accessibility is mandated by a body of laws that constitute digital disability rights, and internet use among disabled people is increasing (ONS, 2019). However, a lack of progress in the delivery of accessible mobile web-based services, tools and resources mean disabled and older people face persistent digital barriers. There is a pressing need to develop accessibility capacity in the digital workforce. To this end, this systematic literature review seeks to establish what is empirically known about the effective teaching and learning of digital accessibility through the lens of pedagogy.

Methods/Design: The review will consider research (1999-2019), which focuses on the teaching and learning of digital accessibility in higher education and the workplace. The focus is on how pedagogy is enacted - the pedagogic practice of teaching—rather than curriculum development or other activities that relate to planning or governance. Two databases will be searched, using identified keywords. To identify further papers, backward- and forward- citation analysis is used. Researchers will work iteratively with the data, to ensure no loss of context through data extraction. A narrative synthesis of the findings will be presented.

Discussion: The review will collate literature on the pedagogy of accessibility education, reporting on *how* the teaching or learning of digital accessibility is effectively undertaken. It will identify the empirical basis for accessibility pedagogy.

Keywords: accessibility, assistive technology, computer science education, digital accessibility, pedagogy, teaching, learning

1. Background

This systematic literature review and narrative synthesis is conducted in the initial phase of 'Teaching Accessibility in the Digital Skill Set' (http://teachingaccessibility.ac.uk), a 4-year UKRI funded research project investigating accessibility education in computer science and related disciplines. The review builds upon an initial scoping review previously

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conducted by the PI (Lewthwaite & Sloan, 2016). Scoping work identified a lack of pedagogic culture in accessibility education and a pressing need for cross-case empirical research. A lack of pedagogic culture can be identified as a lack of debate and cross-citation, and a fragmented literature, characterised by small studies and individual reflective accounts of teaching a single course or cohort (Earley, 2014; Kilburn, Nind, & Wiles, 2014). This deficit in pedagogic culture means that accessibility teachers, trainers and educators cannot inform their pedagogic practice by calling upon a substantial body of resources. Instead, educators are reliant on trial-and-error, immediate peers, technical know-how and procedures (e.g., informed by Web Standards [WCAG] guidelines), rather than pedagogic knowledge that is informed by theory or research. Given that accessibility is foundational in the digital skill set, this is troubling. There is a pressing need to develop the pedagogies—the learning theories and teaching approaches and strategies—appropriate to accessibility, so that the education process is effective and scalable.

Accessibility education is important. In the UK and other 'digital first' economies, digital technologies increasingly mediate social interactions, communication and the functions of the State. From applying for a drivers' licence, passport, school place or doctors' appointment, to welfare benefits, banking and tax returns, society is reliant on digital platforms. However, for disabled and older people who use assistive technologies or need adaptations (e.g., increased font size, high contrast, voice control), there has been no guarantee that digital services will work. The accessibility of online digital tools and services is mandated in a body of laws that constitute digital disability rights, including the UN Convention on the Rights of Disabled People (UNCRDP, 2017) and Directive (EU) 2016/2102 on the accessibility of the websites and mobile applications of public sector bodies, alongside national legislation (Lewthwaite & James, 2020). Yet there remains a lack of progress in the delivery of digital accessibility of mobile and web-based services, digital tools and resources (see House of Commons Work and Pensions Committee, 2018). As a result, disabled people continue to face persistent digital barriers.

Along with the social cost and a trajectory of growing demand, the business case for accessibility has demonstrated the need for graduate skills. In industry, the accessibility skills gap has been identified as a pressing strategic need (PEAT, 2018; TeachAccess Initiative[2]). Grassroots demand for courses and learning materials is also strong among developer communities. The introductory FutureLearn Digital Accessibility MOOC[3] received 10,000+ registrations from over 150 countries across three iterations.

Despite such moves, there remains a lack of detailed understanding of the teaching and learning characteristics (the pedagogies) of accessibility education and how digital accessibility can be effectively taught in different contexts to meet the needs of diverse learners. The pedagogic challenges reflect a rapidly changing technological context, lack of formal curriculum and struggles for visibility beyond a sub-group of Human Computer Interaction. Many learners self-teach and are reliant on Web Standards guidance that are functional, but complex and difficult to work with (especially for novice learners). Contrary to inclusive practices, they encounter one-size-fits-all teaching. This review shifts the focus from a limiting 'what works' discourse to that of a learning ecology inclusive of evidence-based practice.

This review will deliver an in-depth investigation of the pedagogy of accessibility education, establishing what pedagogic content knowledge (PCK) (Shulman, 1986) is evidenced in research. It will identify the current state of pedagogical culture in the field, by

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[2] http://teachaccess.org

[3] https://www.futurelearn.com/courses/digital-accessibility

mapping the literature, identifying emergent issues and giving consideration to citation and publishing practices.

1.1 Existing reviews

Within their thematic scoping review, Lewthwaite & Sloan (2016) make an initial exploration of the pedagogy of accessibility teaching, which provides the grounds for this review. They identify a perceived lack of pedagogical culture, expressed in a small body of educational research, lack of cross-citation, cross-case research and debate. They also note potentially distinct PCK visible in the research corpus, expressed as a unique mix of theoretical understanding, procedural knowledge and technical competence at the intersection between a teacher's general pedagogical know-how (how to teach) and the content particular to a discipline (what to teach). Pedagogic themes scoped include the use of project-based and problem-based learning, tool-based approaches, the use of learning by doing and experiential approaches, amongst others.

Nishchyk & Chen (2018) provide a systematic review of literature and practices using the ACM (Association for Computing Machinery) Digital Library and Orio, a Nordic academic library Search Engine. The review concerns the integration of Universal Design and accessibility into computer science curricula in Europe. Their reporting on the literature is brief, concerning curriculum integration and its geographies. They establish that Universal Design and Accessibility are 'mostly integrated into other courses' (p.59) beyond that of computer science.

Lastly, during the later stages of writing this protocol, Baker, El-Glaly & Shinohara (2020) published a systematic review on accessibility in computing education. The review also uses the ACM library and outlines the nature of digital accessibility teaching in computer science curriculum/education, with a particular focus on which courses cover accessibility, the topics that are covered and the assessment approaches that are used. Whilst the paper does give an indication of pedagogies as enacted (i.e. lectures, reading, projects, simulated disability), as with Lewthwaite & Sloan (2016), these are listed rather than discussed. The review provides a quantitative analysis of the teaching of accessibility, reporting the frequencies of different pedagogies used, and the coverage of accessibility concepts within courses. Baker, El-Glaly & Shinohara's (2020) locus is on what teaching is taking place, from a form and content perspective, rather than assessing quality, what is being researched and the specific pedagogic themes arising.

In contrast, our protocol represents a systematic search, qualitative examination and synthesis of pedagogy in accessibility education research. This is methodologically distinct. It has a specific remit and will take a narrative and thematic approach towards the literature, seeing value in recognising the distinct ways through which pedagogies are enacted and developed in varying contexts. These are arguably overlooked by quantitative approaches, which, in the context of educational research can lead to charges of reductionism (MacLure, 2007; Hammersley, 2020). Further, the review will also take a more grassroots approach towards accessibility pedagogy, focussing on the nuances of how pedagogy is enacted at the instructor level (bottom-up) as opposed to strategic attention to instrumentation, i.e. through curricula and course design (top-down). In addition, methodological development for example, backward- and forward- citation analysis, and an assessment of research quality sets this review apart from prior reviews.

In short, we anticipate that this review will complement and supplement previous work, as it serves a different end. A focus on strategic development of the curriculum, types and locations of accessibility education are valuable to the field, as they seek to urgently assist the mapping and scaling of accessibility skills and capacity, in terms or 'what' and 'where'

teaching can take place (Baker, El-Glaly, & Shinohara, 2020; Nishchyk & Chen, 2018). In turn, our work seeks to address 'how' accessibility can be taught and establish what is empirically known, in order to establish a baseline of evidence that teachers can work with in the development of their own teaching and in-class pedagogic practices. Systematic literature reviews of accessibility in computer science education are scarce.

1.2 Review questions

The review asks: What pedagogies are evidenced in educational research into the teaching and learning of digital accessibility in the computer sciences and associated disciplines?

2. Methods/Design

2.1 Rationale

The review seeks to inform and evidence accessibility pedagogy. It aims to map developments in pedagogical culture in the teaching of digital accessibility by engaging and synthesising literature spanning computer sciences and related technical disciplines (e.g., engineering). It is anticipated that by highlighting and synthesising this literature, pedagogic culture will be further spurred in the field.

As discussed (1.2), previous reviews have gravitated towards the curricular and strategic aspects of accessibility teaching, the groundwork necessary for strategic work to build capacity. In pedagogic research terms, this attention to 'pedagogy as planned' (Nind, Curtin, & Hall, 2016) neglects two key aspects, 'pedagogy as enacted' – how teaching is actually articulated in a particular context, and 'pedagogy as understood' – the learner experience. Our review focusses on research into 'pedagogy as enacted' and 'pedagogy as understood' (Nind, Curtin, & Hall, 2016), to promote evidence-informed development in the field. It seeks to more fully recognise the socio-cultural facets of teaching and education as it is practiced, in research that evidences an effective pedagogical repertoire in this field. This is important, since many teachers of accessibility in industry, the public and third sector do not come from educational backgrounds. These teachers may demonstrate strong and up-to-date content knowledge (a knowledge of accessibility strategy, cutting-edge principles and techniques) but do not necessarily have the pedagogic knowledge required to facilitate or scale excellent learning experiences. Meanwhile, in academia where pedagogic knowledge may be more developed, research suggests instructors perceive a lack of the necessary content knowledge (Shinohara, Kawas, Ko, & Ladner, 2018) to sufficiently develop student expertise. At the same time, where pedagogic knowledge is developed, it may be developed in a very tacit way, making it hard to recognise and share. This 'invisible pedagogy' (Bernstein, 1975) limits the potential for teachers and learners to optimise ongoing learning and engagement, a factor exacerbated by disciplinary cultures and terminology. A focus on 'pedagogy as enacted' brings pedagogic content knowledge to the fore. In primary research, dialogic, collaborative methods are particularly salient here, to democratise the research process and establish community knowledge and collective understandings in an inclusive way (Seale, Nind, & Parsons, 2014).

For this reason, this systematic literature review and narrative analysis aligns with the principles of open social science and Cumulative Literature Review (CLR; Vaganay, 2019), which acknowledges protocols, search strings and other research tools as products of research with value to the field. The publication of this protocol seeks to assist future reviewers in the extension of work investigating the accessibility education literature. It may also inform corresponding later reviews and reviews in other areas.

2.2 Study design

A systematic literature review will be conducted, following PRISMA search and screening processes (Moher et al. 2015), a critical quality assessment (Pettigrew & Roberts, 2005) and qualitative, narrative synthesis (Popay et al., 2006). The review seeks research evidence of pedagogic development in the field through a qualitative and thematic, rather than quantitative analysis of the literature, in order to recognise the qualitative (and social) nature of learning.

2.3 Search criteria

The review will consider peer-reviewed primary research studies of quantitative, qualitative or mixed methods design published in English between 1999-2019. It will include journal papers, conference proceedings and other peer-reviewed research focussed on the teaching and learning of digital accessibility in higher education and workplace education. Incorporating peer-reviewed conference papers recognises the status of academic conferences within technical sciences, as the preeminent location for research publication on accessibility and computer science education. Initial searches around teaching accessibility indicate the dominance of conference papers, and more specifically, key annual international conferences associated with Special Interest Groups (SIGs) such as the (North American) Special Interest Group in Computer Science Education (SIGCSE) and its international counterpart, the Innovation and Technology in Computer Science Education (ITiCSE), identifying conferences as an established source of information exchange providing up-to-date developments in the field.

The inclusion and recognition of this 'grey literature' is essential to capturing and cataloguing the full range of evidence on how digital accessibility is taught and learned in computing and related sciences.

2.4 Search strategy

A comprehensive search of two key bibliographic research databases will be conducted[4].
1. Web of Science
2. Scopus

The search strategy is structured to establish two domains of interest: Accessibility and Education, which are then intersected (sift 1). Resulting returns are then hand searched by two researchers (sift 2). The search terms were developed and tested in both Web of Science and Scopus, ahead of final application, and in light of prior reviews in the field (Lewthwaite & Sloan, 2016). The review search will involve the use of relevant titles, abstracts and keywords, published between January 1999 and December 2019.

2.4.1 Domain 1: Accessibility

Accessibility as a domain will be established using terms including 'accessibility' (accessib*) and near terms, alongside 'universal design', 'design for all' and 'WCAG' (the common abbreviation of Web Content Accessibility Guidelines).

(TITLE-ABS-KEY (accessib*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) AND (TITLE (accessib*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE (wcag*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE

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[4] Search strings quoted are based on Scopus search.

("design for all") AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE ("universal design") AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998)

2.4.2 Domain 2: Education

Education as a domain will be established using search terms incorporating 'teaching' and 'learning' to 'curriculum', 'pedagogy' and 'course', and near neighbours, using the wildcard (*) operator. For example, teach, teacher, teachers, teaching are all captured through "teach*".

(TITLE-ABS-KEY (teach*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE-ABS-KEY (learn*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE-ABS-KEY (educat*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE-ABS-KEY (pedagog*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE-ABS-KEY (training) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE-ABS-KEY (curricul*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998) OR (TITLE-ABS-KEY (course*) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1998)

Once intersected, these domains will return all journal articles and conference proceedings discussing accessibility and education. These results will be further refined by Language (English) and Subject Area, modified slightly per database. Subject areas 'limited to', included computer sciences, engineering, materials science, and intersecting interdisciplinary and multidisciplinary fields: e.g., social sciences, psychology, economics.

This first sift was completed 1st July 2019, and repeated 1st Feb 2020 to incorporate additional papers published to the end of 2019.

Trial searches immediately identified a key methodological concern in the searching of the literature. The core domains of this search: Accessibility and Education are combined in two distinct fields.

1. In the teaching and learning of digital accessibility (how learners in technical disciplines gain knowledge of accessibility principles, strategies and techniques for the purpose of building tools, environments and services to be used by disabled people - the focus of this review).
2. In the development of accessible teaching and learning (how education as a whole can be developed to include disabled learners).

Given this overlap, and a small intersecting literature (teaching accessibility in inclusive and accessible ways) the second sift will require hand-sorting by researchers of titles and abstracts, to exclude irrelevant studies, prior to shortlisted papers being exported to Endnote (v X9).

2.4 Information sources

The review will comprehensively search two databases Web of Science and Scopus. Search will be supplemented using backwards- and forwards- citation analysis of selected papers within these databases and Google Scholar. This will identify additional primary research material.

2.5 Study selection / data collection

2.5.1 Screening primary studies

Following the second sift, all identified records will be collated and added to Endnote (v. X9) and duplicates removed. A substantial part of the literature is published in conference proceedings. Within this, there is a convention of publishing short papers and early works that detail emergent or indicative findings ahead of subsequent full papers. These early studies will be removed in favour of full papers.

Once duplicates have been removed, backwards and forwards citation analysis will be completed on all selected studies (checking for wider literature, through cited and citing works), via Scopus, Web of Science and using further citation tracking through Google Scholar. This will allow for inclusion of high-quality primary research sources (e.g., theses) not presently listed in mainstream research databases.

Across the process, a search log will be kept and updated to ensure that all search activities and articles captured are fully and transparently accounted for. This search log will also act as a reference, to indicate the effectiveness of these activities (for example, reporting the differences in database search returns). Where articles cannot be accessed through databases or other means, corresponding authors will be contacted to obtain copies.

2.5.2 Inclusion/exclusion criteria

The computer science and technical education literature reviewed will only include papers that have a substantive pedagogic focus (in terms of teaching and learning practices), and deal explicitly with digital accessibility. To anticipate neighbouring and related literatures that focus on tools, non-digital accessibility, and content-focussed curriculum design, explicit selection criteria will be applied (Table 1), which will be reviewed and refined where necessary.

Table 1. Inclusion / exclusion criteria.

Focus of Paper	Not Selected	Considered for Selection
Tool/Resource Development	1. The focus is on the development of a tool/resource without reference to using it in a teaching or training environment. 2. A tool/resource is used in a teaching or training environment without consideration of how it relates to teaching methods.	1. Presents a rationale for developing a tool/resource for teaching and/or the implications of developing the tool/resource is addressed (with evidence). 2. The tool/resource is used (or "tested" or "trialled") in a teaching or training environment with stated implications for teaching methods.
Curriculum/Course Design	1. Course/curriculum content is presented without significant information about how content is delivered (i.e. teaching methods).	1. Even though the focus is on the development and design of the course/curriculum, significant information is provided about the teaching methods.
Integration of Accessibility in Courses/Curricula	1. The integration of accessibility is addressed as an aspect of course/curriculum design with insignificant information about teaching methods.	1. How accessibility is integrated into a course/curriculum is addressed with clear implications on teaching methods.
Accessibility of a Course/Curriculum	1. The course/curriculum is not primarily about digital accessibility. 2. The course/curriculum is primarily about digital accessibility, but there is insignificant information about teaching methods.	1. The course/curriculum is primarily about digital accessibility, and there is significant information about teaching methods. 2. The inclusion of students arising from making the course/curriculum more accessible is significant to the teaching methods and/or resources.
Accessibility (including in the Built Environment).	1. May include digital accessibility, but not significantly.	1. May include accessibility in the built environment but the main focus in on digital accessibility.
Related Concepts/Approaches (e.g., 'Usability', 'Design for All')	1. There is insufficient consideration given to digital accessibility and its relationship with the concept/approach.	1. It is clear how digital accessibility relates to the concept/approach and it is addressed significantly.

2.6 Data extraction and presentation

Data to be extracted from eligible studies will include author, country of study, year of publication, study objective, type of teaching (level), course, discipline, research/design, methodology, explicit pedagogy and the teaching and learning approaches and interventions that the studies cover. The type of study will be keyworded using the EPPI Centre keywording strategy (v. 0.97).

Table 2. Draft data extraction tool.

#	Paper	Source	Type of Study / Focus	Data	Pedagogy	Comments	Recommendation
1							
2							

#	Number, for internal reference (ordered alphabetically by lead author).
PAPER	Indicating author(s), year and title.
SOURCE	Indicating the conference or journal etc. Useful for indicating recurring sources.
TYPE OF STUDY/ FOCUS	Brief summary of what the paper is about, keyworded, inclusive of description of intervention.
DATA	Brief summary of methods of data collection and analysis used.
PEDAGOGY	Outline of the main pedagogic theories and approaches used in the study.
COMMENT	Any other useful references to key content in the paper e.g., from literature reviews and discussion sections.
RECOMMENDATION	Decision on including or excluding the paper or further reading, with a summary of the reasons for the decision, assessing quality criteria inclusive of: study design, sample, measurement tools, data analysis method and outcome data).

The draft data extraction tool will be modified and revised as necessary during the process of extracting data from each included paper.

Quality assessment will focus on the appropriateness of the study methodology in addressing the research questions and objectives including the study design; recruitment, participant selection, data collection and analysis methods, reporting of findings and the exploration of study limitations. The quality assessment (Critical Assessment) (Pettigrew & Roberts, 2005) will be carried out independently by two researchers (Sarah Lewthwaite and Andy Coverdale) and any discrepancy resolved through discussion.

We plan to work iteratively with the data, to ensure no loss of context through 'data extraction' (removing important context from the papers selected). This is done to distinguish what is distinct about the teaching of accessibility in light of diverse contexts. Thus, whilst data will be extracted and keyworded for summary, categorisation and reference purposes,

reviewers will work with both summaries and full papers. Common threads, trends, themes and sub themes will be identified and synthesised. As the studies to be included are likely to employ diverse methods, within divergent contexts (in terms of classroom, student groups [the study population], study level, location, course content) data will be synthesised thematically, with contextual data extracted for comparison, analysis and presentation in the final report. A narrative summary of the overall findings will be provided, exploring the key pedagogic themes that are present in the literature.

3. Discussion

This systematic literature review will provide insight into the evidence base for pedagogic development in computer science and related disciplines in higher education and the workplace. The review will develop insights into the pedagogic content knowledge expressed in educational research into digital accessibility, and also identify substantive gaps. This is done to distinguish what is known, and distinct about the teaching of accessibility and assist the development of pedagogical culture in this field.

Declarations

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