Requirements Engineering (2024) 29:143–176
https://doi.org/10.1007/s00766-023-00409-8

ORIGINAL ARTICLE

Understanding the integration of accessibility requirements in the development process of information systems: a systematic literature review

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Received: 14 February 2023 / Accepted: 15 December 2023 / Published online: 27 January 2024

Abstract
People with disabilities (PwD) are frequently excluded from certain activities due to the lack of accessible information. In this area, information systems can help PwD by allowing access to a range of information about the accessibility of spaces, facilities, and products. There has been an increase in technologies that promote accessibility, but there are few literature studies which analyse how these technologies were developed to ensure access for all. To address this gap, this study aims to explore the integration of accessibility requirements in the processes of developing information systems. To achieve this aim, a systematic literature review was conducted using the PRISMA reporting guidelines. To conduct the review, a search was carried out for primary studies in four well-established databases—SCOPUS, Web of Science, IEEE, and ACM. A snowball search to find additional studies was also performed. Based on this, 34 papers were obtained to conduct the study. In general, the studies published on this topic are relatively recent, with healthcare and education being the two major areas where accessibility in information systems is most addressed. The integration of accessibility seems to be primarily applied during the requirement assessment and testing phases, involving potential users in the process. The results obtained within this systematic literature review raise awareness about the integration of accessibility for the success of solutions, which are oriented towards the accessible market. Additionally, the different practical and theoretical contributions can help future practitioners and technology developers establish guidelines that promote the integration of accessibility, thus achieving a more accessible and inclusive society.

Keywords Accessibility · Information systems · People with disabilities (PwD) · Development process · Systematic literature review

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1 Introduction and background

1.1 Background

It is estimated that over a billion people (about 15% of the world's population) live with some form of disability [1]. Moreover, although products and services have become more accessible nowadays, there are still several members of our society who face constraints in their use, especially people with disabilities (PwD). On that basis, accessibility can be perceived as a concept that removes physical and communication/information barriers for PwD [2]. As explained by Rucci and Porto [3], PwD encompasses not only people with particular types of disabilities (physical, hearing, visual, cognitive) but also other people with specific accessibility requirements such as senior citizens and people with temporary limitations. In that sense, the market composed by PwD

is also designated as the accessible market [4] and presents tremendous economic potential [5]. In studies in areas such as healthcare [6], tourism [7], and transportation [8], it can be seen that accessibility is more than a niche market. To achieve this market's potential, technologies have been increasingly responsible for improving products and services for accessibility [9]. In this sense, technology can be understood as any device, networking component, application, or system that, when contextualized in a systemic way, allows interaction with the digital world [10]. Within these various technologies, information and communication technologies (ICTs) are amongst the most important. In summary, ICTs refer to equipment and systems that are able to collect and send information in an electronic format [11]. As mentioned by Zysman et al., [12], this technology allows people and organizations to interact in the digital world. For this reason, ICTs emerge as responsible for integrating information systems (IS) in their different aspects, to ensure that information and knowledge are disseminated and communicated [13]. According to Alter [14], IS can be defined from an organizational viewpoint as a conjunction of procedures, information, people, and technologies, aimed at achieving the objectives of an organization.

With the emergence of new technological platforms and digital processes, IS have become crucial in different sectors [15]. Some examples are tourism IS [16] and health IS [17], both providing benefits in information exchange between different users in their respective areas. In these areas, digital activities have increased, which also caused the amount of data to increase exponentially. IS provide effective treatment of data and improved information management by helping to distinguish what information is essential and which is not relevant [18]. In summary, with technological growth [13], the management of information has become essential, which makes IS stand out as a crucial tool.

In the field of accessibility, information and access to it are seen as crucial factors for improving accessibility conditions [19]. In that sense, IS can contribute to a more inclusive community by providing accessible information about the accessibility level of spaces, facilities, and products in diverse areas. For this to happen there is a need to address accessibility requirements. These requirements can be defined as making information and overall design understandable and straightforward enough for the majority of users (including PwD) to utilize without needing to make any adjustments, but also supporting users that need adaptability [20]. Due to the importance of accessibility requirements, there have been attempts to structure and systemize them. In that regard, the World Wide Web Consortium (W3C) produced the Web Content Accessibility Guidelines (WCAG) [21], which state different guidelines to make sure web technologies are accessible to PwD. Due to their importance, WCAG 2.0 received ISO/IEC approval in 2012 to become a global accessibility standard [22]. Significantly, following WCAG 2.0 can make sure accessibility requirements are addressed when developing an accessible technological solution, as found in previous studies [23–25].

As expected, people with greater accessibility requirements also require more specific, detailed, and personalized information [26]. However, as found by Waschke [27], technologies tend to ignore accessibility requirements, with these findings being confirmed in different research areas. Authors in the areas of education [28], healthcare [29], social sciences [30], and tourism [31] have reported the need to reinforce information about some accessibility factors and deliver information accessibly. In this area, the difficulty in providing information according to needs may lead to the inability to use a specific function of technology, or in some cases prevent the users from using the technology entirely. As a consequence, technologies fail to appeal to PwD, possible business opportunities are ignored and this considerable potential of this market is wasted [32, 33]. The quality of this information is an equally important criterion. Inconsistent or contradictory information can lead PwD to be disappointed and frustrated [26]. The accuracy and quality of information are therefore fundamental since more complaints can lower loyalty and overall satisfaction [34].

1.2 Rationale for conducting the systematic literature review

The urgency of IS in the accessible market is clear. These systems aim to eliminate information problems by displaying accurate, quality information. To accomplish truly accessible technologies, it is essential to encourage the active integration of accessibility requirements during IS development processes. That can be achieved with more user-centred design (UCD) [35], where the users (PwD) are an active part of the methodological process. UCD methodologies can be defined as iterative design processes, where the focus is on users' requirements, at every phase of development [36]. That being the case, UCD approaches take on particular importance for developing solutions for the accessibility market, which is usually composed of users with very distinct requirements [37, 38]. Hence, it is necessary to use methodologies which can actually listen to the users and address their particular needs. However, published studies have yet to explore this assimilation between accessibility and IS methodologies. For this reason, there is a clear need for a systematic literature review (SLR) that addresses these important aspects of methodology integration.

From a methodological point of view, accessibility requirements can be included in different phases of the development of IS. Jain and Suman [39] outlined five typical phases of a global software development cycle in which IS can be included. These five phases are: (i) requirement analysis

(gathering requirements to build the technological solution); (ii) system design (designing the solution according to the gathered requirements); (iii) coding (developing the solution using the correct tools); (iv) system testing (testing the system and obtaining feedback to improve the solution); and (v) system integration (integrating the solution into a real-life context). Each phase has different contexts, so it is necessary to study how accessibility can be applied in each one.

There has been a worldwide effort to create IS that encompass accessibility [40]. In Europe, the European Assistive Technology Information Network (EASTIN) search engine [41] aims to aggregate and share accessible information from different websites belonging to European countries. In other countries, similar platforms exist. The USA created AbleData [42], and Australia developed the National Equipment Database [43]. Despite the existence of these systems, few details are available concerning their development. In addition, it is also important to address the fact that legislation concerning accessible technology already exists. The European Union released the European Accessibility Act (Directive 2019/882) [44], requiring products and services to be accessible for PwD. This act covers products and services associated with IS, which enforces the need to comply with users' accessibility requirements. The integration of accessibility requirements can make sure that a solution developed for PwD can be perceived as an accessible and adapted product.

1.3 Objectives

To address the gap that exists in terms of assimilating accessibility within development of IS, this study aims to investigate and answer the following research question:

How is accessibility integrated during the development process of IS?

The response to this question will be obtained using an SLR process [45]. First, to confirm the gap, a pre-research study was performed on the topic, which involved using research queries in some databases (Scopus, Web of Science, IEEE, and ACM) and checking already published studies. The conclusion reached was that although some studies [46–48] report the importance of integrating accessibility in the development of information systems, no literature review studies are known about how exactly it can be done. In fact, the present SLR intends to show some evidence of the creation of IS that take accessibility requirements into consideration. To accomplish this goal, a detailed literature review of studies reporting the integration of accessibility in the process of developing IS was performed. To conduct and guide the analysis, specific sub-research questions were formulated supported by the 5W1H method (Fig. 1).

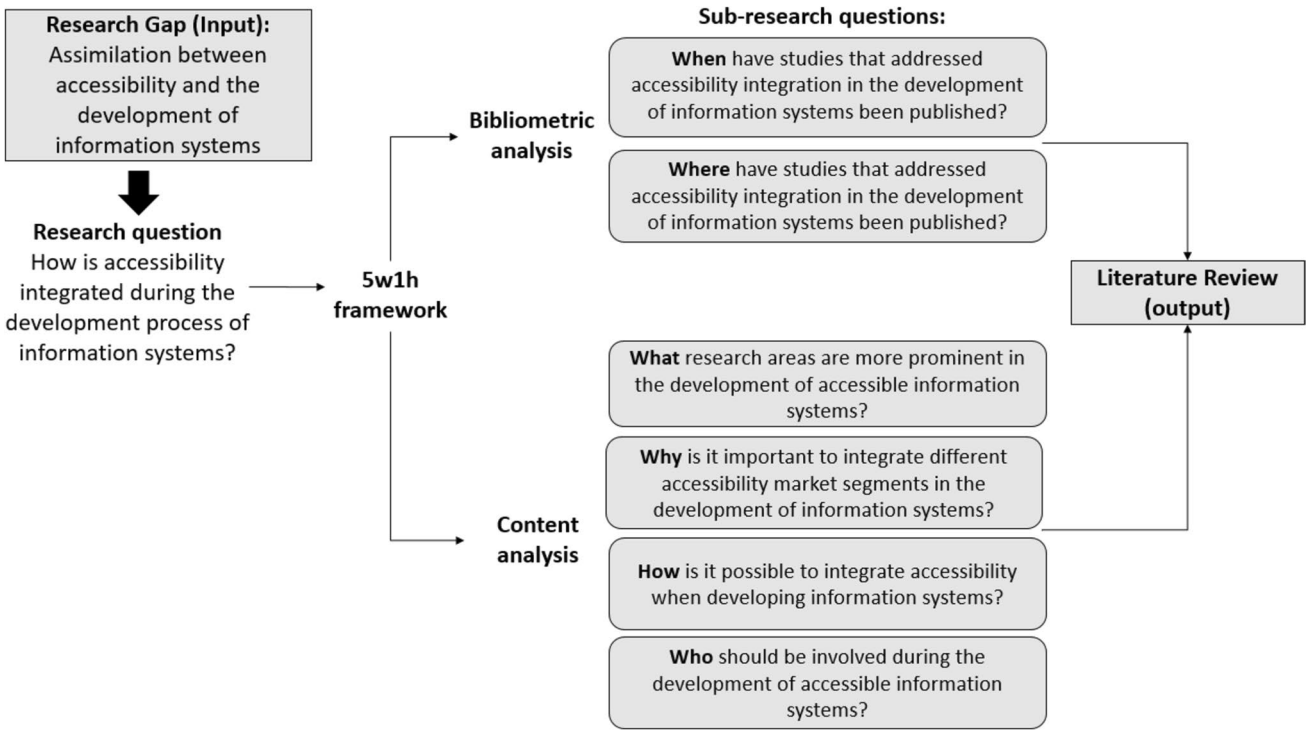

Fig. 1 Application of the 5W1H framework

The 5W1H framework takes previous models used in the development of IS into consideration [49, 50] and depicts the questions "when, where, what, why, how, who", and the order in which they will be addressed. Within the framework, it was important to identify the group of sub-research questions that lead only to bibliometric analysis and those that are more specific to content analysis, which requires a detailed reading of the papers. The two large quadrants, in Fig. 1, indicate that "when" and "where" address bibliometric factors, while "what", "why", "how", and "who" correlate to content factors.

1.4 Structure of the paper

The study is composed of four parts. The first part presents an introduction to the topic, analysing the importance of integrating accessibility in the development of IS and displaying the research questions. In the second part, the methodology is described, highlighting all the steps in the SLR process, and describing how the studies were selected and later analysed. The third part depicts the findings of this study. The number of publications over time is explored, as well as sources, research areas, and accessibility market segments. After this, the content of the papers is detailed. The phases of IS development in which accessibility was addressed are analysed, as well as exactly how accessibility requirements were integrated. In like manner, the main methodologies applied in building accessible IS are identified and the involvement of users is scrutinized. Thus, a clear review of the state of accessibility integration in IS development is provided. The last section contains the main conclusions, limitations, and possible topics for future research, based on the gaps identified.

2 Methodology

2.1 Document selection

To investigate how accessibility is integrated into the development process of IS and to understand the state of the art on this topic, an SLR was carried out. The *PRISMA 2020* (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology [51, 52] represented in Fig. 2

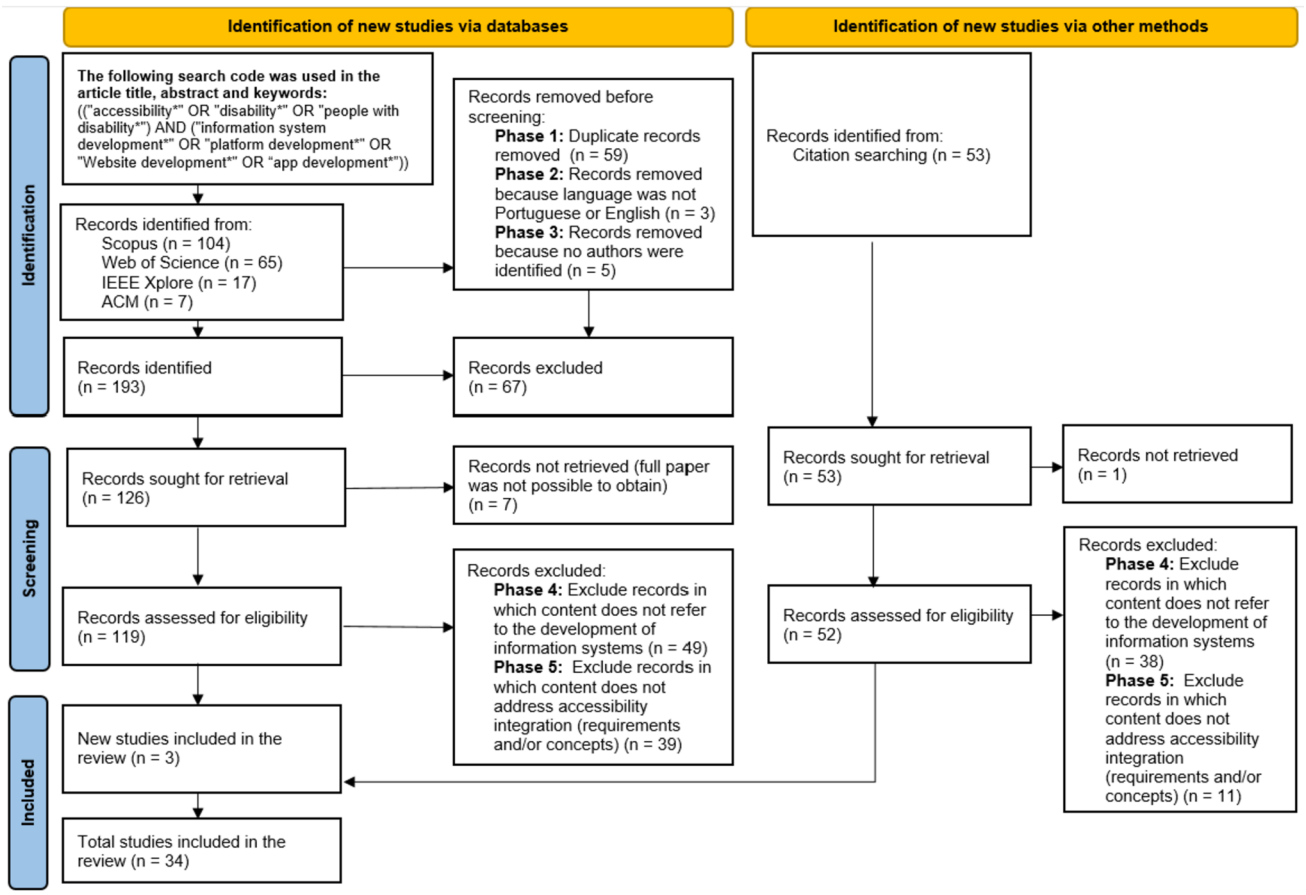

Fig. 2 Flow diagram (PRISMA 2020) for paper selection

was used. *PRISMA 2020* was released in 2021 and employs some improvements over the older version (*PRISMA 2009*) [53, 54]. This approach allowed the identification of a set of scientific documents to be considered in the final analysis. To guide the analysis, as mentioned before (Fig. 1), specific research questions were established based on the 5W1H method.

To find the relevant documents, four important databases—SCOPUS, Web of Science, IEEE Xplore and ACM—that aggregate important research studies in the field of IS were used. These databases were selected due to their scientific value, overall reliability, and relevance in the field of accessibility. The selection results were returned based on a detailed research query applied to documents' titles, abstracts, and keywords in June 2022, without restrictions on either time or subject. The search query used crossed two broad areas relevant to the research (accessibility and software development processes), involving the following terms: (("accessibility*" OR "disability*" OR "people with disability*") AND ("information system development*" OR "platform development*" OR "website development*" OR "app development*")). The main objective of this query was to cover the integration of accessibility in the development process of specific types of IS. Based on this, 104 records were obtained from the SCOPUS database, 65 from the Web of Science database, 17 from IEEE Xplore, and 7 from ACM (Fig. 2).

The 193 studies obtained were then subjected to six verification phases. Each verification phase had specific inclusion and exclusion criteria used to determine whether studies were eligible for the systematic literature review or not. The exclusion criteria are described in Table 1. The first three exclusion phases occurred during the identification stage and exclusion criteria are related to bibliometric factors. Exclusion phases 4 and 5 occurred during the screening stage and checked whether the content of the papers was adequate for the SLR.

In the first exclusion phase, 59 repetitions were detected and categorized as redundant. Secondly, because of translation constraints, only papers in English and Portuguese were included in the analysis. Based on this second exclusion phase, three papers (two in Chinese and one in Persian) were excluded. In the third exclusion phase, five studies with no author identification were taken out, to maintain scientific coherence. Based on the first three exclusion phases, 67 papers were removed.

Therefore, 126 reports were sought for retrieval. When the full paper was not available in the selected sources, an effort was made to obtain the full paper by other means. These included contacting the original authors directly. However, despite all efforts it was not possible to obtain seven papers. These seven were not available in open access and since the full papers were not attainable, it was necessary to remove them from the analysis.

Afterwards, in the screening phase, studies not related to the scope of this research were removed, based on the exclusion criteria of phases 4 and 5. This complex screening was performed by analysing the remaining 119 documents. When the title and abstract did not present enough information, the full paper was read and analysed. This crucial screening stage allowed us to distinguish accessibility in terms of accessibility needs, and accessibility in terms of availability, which is not within the scope. It is important to note that some articles were excluded because authors showed concern about accessibility issues but did not incorporate any accessibility standard as part of the development of IS solutions. Hence, a total of 88 documents were excluded.

To make sure that the scope was well analysed, additional citation searches were carried out, applying the snowballing effect [55]. When carrying out this snowballing effect, the primary studies obtained through the database-driven search were used as a start set. A total of 53 were identified; however, it was not possible to obtain one paper. The remaining 52 newly identified studies were subjected to verification phases 4 and 5 with the respective exclusion criteria. It was observed that three new studies fulfilled the criteria and could be integrated into the analysis. In the end, 34 papers were included in the conducted SLR. The selected 34 papers are listed in appendix, with data regarding: (i) author(s); (ii) year of publication; (iii) title of the paper; (iv) source; (v)

Table 1 Exclusion criteria in each screening phase

Phases	Exclusion criteria
Identification stage	
Phase 1	Exclude records that were duplicated on the databases
Phase 2	Exclude records not in English or Portuguese
Phase 3	Exclude records that do not specify the original authors
Screening stage	
Phase 4	Exclude records in which content does not refer to the development of information systems
Phase 5	Exclude records in which content does not address accessibility integration (requirements and/or concepts)

research area; (vi) purpose of the study; and (vii) segment of the accessible market analysed.

2.2 Document analysis

Based on the 5W1H method presented in Fig. 1, the 34 documents were scrutinized. Upon obtaining the articles, a categorization of several factors was performed: (i) distribution over time; (ii) arrangement by source (journals and proceedings); (iii) disposition by research context/accessibility area where the studies were performed; and (iv) by accessible market segment targeted in the paper. After identifying these factors, a content analysis of the selected documents was also performed for an in-depth understanding of the process of accessibility integration in the development of IS. Information was gathered about what accessibility requirements were addressed, in which IS development phase was accessibility incorporated, and the methods on exactly how accessibility was integrated. After this, a more detailed analysis was performed when accessibility integration involved potential users. The methods used to incorporate potential users were explored in an attempt to extrapolate more knowledge from IS development methodologies. Lastly, it is important to mention that no automatic tools were used to analyse the studies. Human reviewers conducted both bibliometric and content analysis. All three authors/researchers were involved in the search for the primary studies and the extraction of the data found in these studies. Likewise, all researchers participated in the elaboration of the inclusion/exclusion criteria. As a result, no potential conflicts arose between systematic reviewers during the selection and data extraction processes.

3 Findings and discussion

The results will be presented and discussed following the approach defined in the methodology (Fig. 1). Essentially, the findings are divided into two types: bibliometric analysis and content analysis. The intention of the bibliometric analysis was to build indicators on the dynamics and evolution of scientific information related to the integration of accessibility in IS development. On the other hand, the focus of the content analysis was on obtaining a clear perspective by analysing the frequency of occurrence of certain themes. As expected, to perform a correct content analysis, a detailed reading of the papers was required. Both analyses were based on the 34 selected papers.

3.1 Bibliometric analysis

3.1.1 Year of publication

The evolution of the number of published papers is represented in Fig. 3. It is possible to understand how the topic of accessibility integration in IS development has gained more focus in recent years. The first detected published study is dated 2004. Until 2018, a great variation of published studies was registered, oscillating between one and three studies per year and with no studies detected in 2005, 2006, 2008, 2009, and 2015. However, after 2018, the number of studies published tended to increase, with most published papers being detected in 2021 (nine papers).

These results can be explained by an increasing interest in developing more accessible solutions, which may show the existence of greater sensitivity to this issue. In addition, in more recent years, there has been a collective effort for international entities to provide accessible conditions for all (people both with and without disabilities). Moreover, accessibility-related software has improved [56], which provides more opportunities for developers to integrate accessibility conditions within new technologies. It is also important to point out that changes have taken place in terms of legislation, especially with the introduction of the European Accessibility Act in 2019 [44]. Finally, an argument can be made about the increasing relevance of the accessibility market. Once supply agents started to grasp the potential of

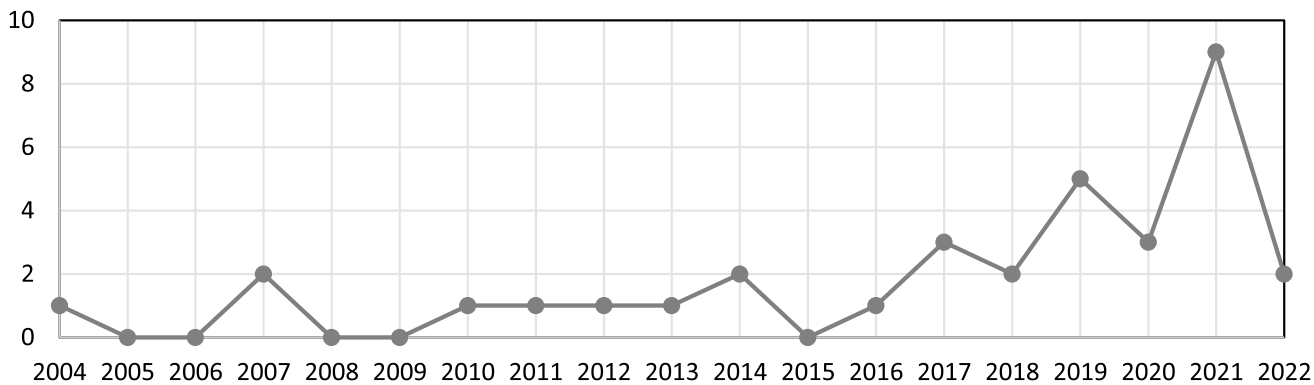

Fig. 3 Number of papers published by year

the accessibility market [5], the integration of accessibility requirements consequently became more relevant.

3.1.2 Arrangement by source

As can be seen in Table 2, there is a great balance between publications in journals (50%) and proceedings (50%). In terms of journals, publications in journals related to technology development in different research areas are more prominent (e.g. *Assistive Technologies Baltic Journal of Modern Computing*, *International Journal on Electrical Engineering and Informatics*, *JMIR Rehabilitation*).

In terms of conference proceedings, publications were mostly in the fields of computer sciences, technology accessibility, and human–computer interaction. The fact that there is a great number of conference proceedings could indicate that the authors intend to first present an accessible technology prototype and collect feedback so that further improvements to that technology can be added before a final version.

3.2 Content analysis

3.2.1 Research area

As depicted in Fig. 4, accessible IS conceptualization has been an important topic in diverse research areas. In addition, the area of research is directly connected to the purpose of each study, as it is explained in the context in which IS were conceptualized. This factor may indicate that the topic of accessibility integration in IS is highly multidisciplinary. The areas of healthcare, with 32%, and education with 26%, are the most represented. Notwithstanding, the

Table 2 Sources of the published studies and subject areas

	Source	Number of studies
Proceedings	ASSETS—International ACM SIGACCESS conference on computers and accessibility	3
	People and computers: engage—Annual conference of the British-HCI-Group	1
	CW—International conference on cyberworlds	1
	ACM Symposium on applied computing	1
	AICT—Applied information and communication technologies, international scientific conference	1
	LISA—Annual conference on Long Island systems, applications and technology	1
	IEEE—International conference on software analysis, evolution and reengineering	1
	ACAI—International conference on advances in computing and artificial intelligence	1
	DAMT—International conference on digital arts, media and technology	1
	SIGDOC—International conference on the design of communication: building coalitions worldwide	1
	LACLO—Latin American conference on learning technologies	1
	LNCS—Lecture notes in computer Science	1
	CISTI—Iberian conference on information systems and technologies	1
	ICCCUBEA—International conference on computing, communication, control and automation	1
	HICSS—Hawaii international conference on system sciences	1
Journals	Assistive technology	2
	Journal of special education technology	2
	Baltic journal of modern computing	1
	Gerontology	1
	International journal of environmental research and public health	1
	International journal on electrical engineering and informatics	1
	Internet interventions	1
	JMIR Formative research	1
	JMIR human factors,	1
	JMIR mHealth and uHealth	1
	JMIR Rehabilitation and assistive technologies	1
	Journal of medical internet research	1
	Journal of physics	1
	Psychiatric rehabilitation journal	1
	Universal access in the information society	1

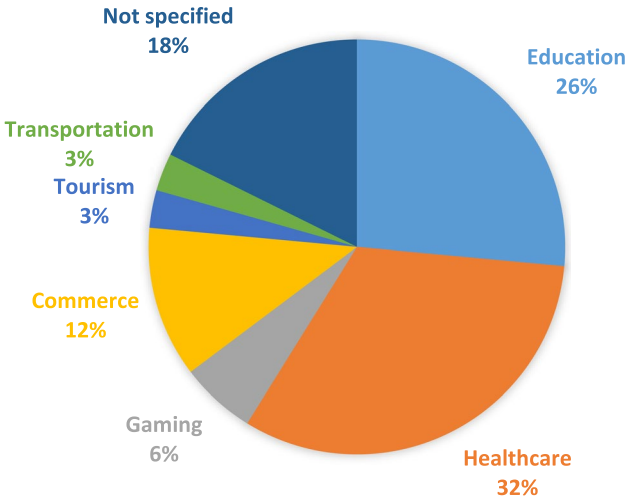

Fig. 4 Distribution of papers by research area

topic also seems relevant to commerce, gaming, and transportation. Surprisingly, despite tourism and transportation being important research areas for the implementation of IS [57, 58], only one study in each one of these academic fields was identified.

The high percentage of studies in healthcare may be due to the fact that disability is often studied from a health perspective. In addition, ensuring access to clinical information is regarded as a priority [59], which can also explain the importance of information systems. Furthermore, a growing presence of health information systems that support patients with different disabilities is reported [60]. Similarly, in education, there has been exponential growth in the use of information technologies for improving teaching methods. Technologies have the potential to improve teaching performance with students with disabilities [61], and therefore, there is a need to build accessible teaching tools. This can be done by integrating accessibility requirements during the conceptualization process of those teaching tools.

3.2.2 Accessible markets segments analysed

The diversity observed in the accessibility market [4], can lead to different user requirements that IS should fulfil. The lack of accessibility components in a given technology can possibly prevent its use by PwD, especially by people with visual or cognitive disabilities, and also people with some specific physical impairments [62]. Figure 5 illustrates the accessible market segments that have been focused on the diverse papers analysed. It can be seen that eight papers (23% of total studies) were written for the general accessible market, with authors targeting every segment. In contrast, 26 papers (77% of total studies) targeted specific group segments, with some papers analysing more than just one segment.

Cognitive disabilities are the most studied individual group, with 13 studies (38% of total studies), followed by people with visual disabilities (32% of total studies), mobility disabilities (18% of total studies), and hearing disabilities, with just one paper (3% of total studies). The special concern with people with cognitive disabilities is probably related to the fact that many studies take place in the education research area. Since cognitive disabilities are associated with learning disabilities, education-related IS must address this particular group of PwD. On the other hand, fulfilling

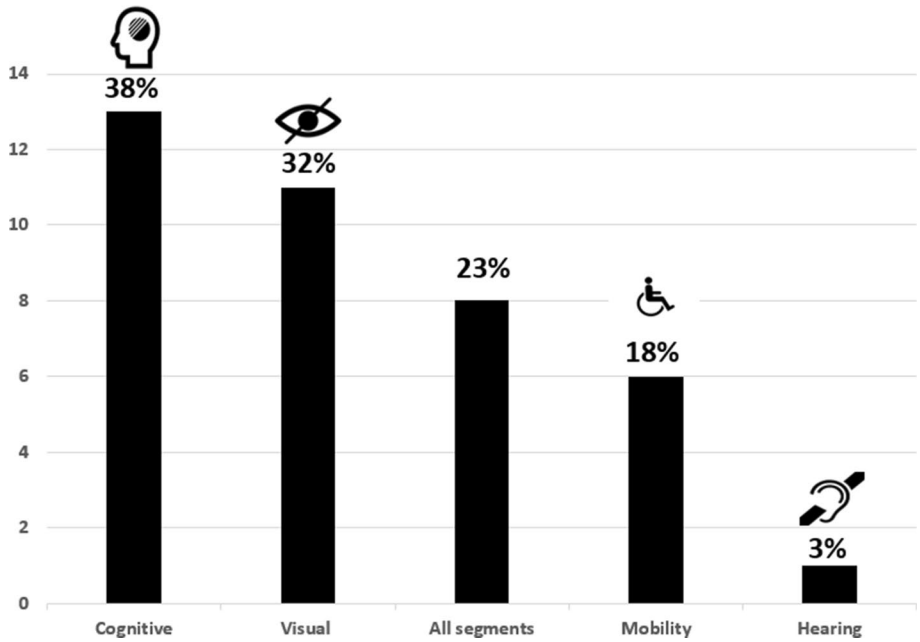

Fig. 5 Number of papers addressing each accessible market segment

accessibility requirements for users with visual disabilities can be a challenging and complex issue, which also justifies the need for more studies that pay attention to this type of segment.

This variety in terms of the accessibility market segments analysed can also be connected to the diversity of the accessibility requirements. The accessibility requirements of users with visual disabilities are different from the accessibility requirements of users with hearing disabilities. Therefore, during the development of IS, developers should take this diversity into consideration. This justifies the need for IS with different features, equally adjusted to all PwD. Moreover, integration of accessibility requirements can be the key to making sure final solutions are indeed accessible and usable by all accessibility market segments.

3.2.3 Accessibility integration in the development of an IS

In this section, the intention is to provide further knowledge on the content of the 34 selected studies by depicting three crucial factors. In summary, the articles were analysed in detail to gather information about: (i) the accessibility requirements addressed, (ii) the development phases in which accessibility was taken into consideration; and (iii) how exactly accessibility was integrated. By scrutinizing these factors, it will be possible to obtain a clear idea of the state of the literature concerning the inclusion of accessibility requirements in the conception of IS.

With the objective of providing more context on accessibility integration, an effort was made to provide a summary of requirements that were collected in the studies analysed. To achieve this goal, WCAG 2.0 was used as a standard to ascertain which accessibility requirements were addressed by the authors. On this basis, WCAG 2.0 success criteria are essential for evaluating compliance levels of web technologies concerning accessibility requirements. Essentially, the WCAG is composed of four general principles (perceivable, operable, understandable, and robust) structured into 12 guidelines, which can be translated into actual accessibility requirements. To help this conversion, the description of how to meet each guideline, available in the disclosure WCAG 2.0 document, was carefully read [21]. Table 3 illustrates this conversion and depicts a summary of what accessibility requirements were addressed in each study. It should be made clear that each and every WCAG 2.0 success criterion and respective accessibility requirement is crucial. However, it is difficult for IS to integrate all types of accessibility requirements because doing so might result in system inefficiencies and highly complex development processes.

In terms of the accessibility requirements addressed, the most important aspects were making sure the system was adaptable, functional through keyboards, easy to navigate, and compatible with assistive technologies. This is in accordance with previous findings, especially in terms of the accessible market segments analysed. Since people with cognitive disabilities were the most studied group, it makes sense to make sure the development of IS addresses navigability and adaptability. This is because these factors heavily influence how the users operate the system. In terms of seizure disorders, it is important for IS to avoid visual or audio flickering as mentioned by Vitols [63]. Moreover, as found in the model-driven approach by Rieger [64], system functionalities must help users identify when their input is needed (e.g. insertion of personal data).

After identifying what accessibility requirements were present during the development of IS, it is important to look at where accessibility was implemented. Across the identified papers, it can be seen that accessibility was integrated into different development phases of IS. As mentioned before, according to the global software development cycle [39], there are five typical development phases. Table 4 depicts the development phases in which accessibility was incorporated across the different studies analysed.

It can be seen that requirement analysis and system testing are the development phases where accessibility was mostly incorporated. Conversely, system integration and coding are the least discussed phases. Due to this fact, it can be speculated that authors seem to attribute particular importance to discussing accessibility requirements at the start of the development process and during testing procedures. Despite the lack of data in terms of successful implementation, it can be speculated that accessibility requirements should be introduced during development phases instead of very late phases such as implementation. Notwithstanding, some papers address accessibility in several phases. This can be seen especially in the study by Bulao et al. [13], with accessibility being included in four of the five development phases. This factor can signify that accessibility integration is part of a continuous development process.

The phase where authors most seek to integrate accessibility is the testing stage (68% of total studies). The integration of users in the testing phase is indeed important when developing an accessible technology [47]. Through the application of user testing methods, it can be determined if a solution fulfils the different user's requirements and important feedback can be gathered that can be used to further improve the obtained solution.

More detailed interpretations can also be made. The requirement engineering phase is commonly a stage where the scope of the solution is carefully analysed. The study of the diverse users and characteristics of the surrounding market usually leads to the determination of concrete accessibility requirements [65–67]. As addressed before, the development of IS should follow a UCD methodology. As such, it is important to understand users' requirements, from the very beginning of the development process. It should also be

Table 3 The accessibility requirements addressed

WCAG 2.0			Studies that address each accessibility requirement
Principle	Guidelines	Accessibility requirement	
Perceivable	1.1 Text alternatives	Provision of text alternatives for any non-text content	Mascetti et al. [76], Ponciano et al. [79], Rieger et al. [64], Carreon et al. [78], Ghidini et al. [77]
	1.2 Time-based media	Provision of alternatives for time-based media (audio and video content)	Mascetti et al. [76], Carreon et al. [78]
	1.3 Adaptable	The content is presented with a simple layout and without losing information or structure	Rattan et al. [70], van Kessel et al. [93], Shamsujjoha et al. [86], Mascetti et al. [76], Ponciano et al. [79], Rieger et al. [64], Joddrell and Astell [73], Yu et al. [84], Patil and Deshmukh [80], Chakraborty et al. [87], Yamagata et al. [95], Vitols [63]
	1.4 Distinguishable	The content is easy to see and hear making the foreground distinguishable from the background	Mascetti et al. [76], Edelberg and Verhulsdonck [68], Ponciano et al. [79], Rieger et al. [64], Arnhold et al. [74], Ghidini et al. [77]
Operable	2.1 Keyboard accessible navigable	All functionalities are available from a keyboard	Rattan et al. [70], Shamsujjoha et al. [86], Rieger et al. [64], Yu et al. [84], Chakraborty et al. [87], Arnhold et al. [74], Laksmiwati and Akbar [65], Manhas [96], Vitols [63], Ghidini et al. [77]
	2.2 Enough time	Users have enough time to read and use content	Frost et al. [88], Rieger et al. [64], Patil and Deshmukh [80]
	2.3Seizures	The content does not cause seizures	Vitols [63]
	2.4 Navigable	It is easy for users to navigate, find content, and determine where they are	Edelberg and Verhulsdonck [68], Siyam and Abdallah [66], Ponciano et al. [79], Carreon et al. [78], Mayordomo-Martínez et al. [85], Patil and Deshmukh [80], Yu et al. [84], Chakraborty et al. [87], Yamagata et al. [95], Vitols [63]
Understandable	3.1 Readable	Text content is readable and understandable	Edelberg and Verhulsdonck [68], Shamsujjoha et al. [86], Patil and Deshmukh [80], Mascetti et al. [76], Rieger et al. [64]
	3.2 Predictable	Content appears and operates in predictable ways	Mascetti et al. [76], Ponciano et al. [79], Rieger et al. [64], Patil and Deshmukh [80], Nicholson et al. [67]
	3.3 Input assistance	Users have assistance when avoiding and correcting mistakes	Rieger et al. [64]
Robust	4.1 Compatible	Compatibility with assistive technologies	Rattan et al. [70], Herbuela et al. [92], Mascetti et al. [76], Ponciano et al. [79], Rieger et al. [64], Patil and Deshmukh [80], Joddrell and Astell [73], Jones et al. [97], Arnhold et al. [74], Lee et al. [83], Ghidini et al. [77]

Table 4 The development phase in which accessibility was integrated

Phase	Studies that address accessibility factors	Total number of studies	% of total studies
Requirement analysis	Bulao et al. [13], Petrenko et al. [75], Edelberg and Verhulsdonck [68], Herbuela et al. [92], Siyam and Abdallah [66], Frost et al. [88], Mayordomo-Martínez et al. [85], Yu et al. [84], Yamagata et al. [95], Laksmiwati and Akbar [65], Manhas [96], Jones et al. [97], Arnhold et al. [74], Shamsujjoha et al. [86], Nicholson et al. [67], Ghidini et al. [77], Livingstone-Lee et al. [72], Vitols [63]	18	53
System design	Bulao et al. [13], Edelberg and Verhulsdonck [68], Rattan et al. [70], Mackare et al. [71], Mascetti et al. [76], Ponciano et al. [79], Arnhold et al. [74], Harrison and Petrie [91], Law and McKay [94], Patil and Deshmukh [80], Carreon et al. [78], Rieger et al. [64], Mascetti et al. [98]	13	38
Coding	Petrenko et al. [75], Mascetti et al. [76], Rieger et al. [64], Patil and Deshmukh [80], Cantù et al. [69], Chakraborty et al. [87], Lee et al. [83]	7	21
System testing	Bulao et al. [13], Petrenko et al. [75], Edelberg and Verhulsdonck [68], Herbuela et al. [92], van Kessel et al. [93], Siyam and Abdallah [66], Frost et al. [88], Mascetti et al. [98], Joddrell and Astell [73], Mayordomo-Martínez et al. [85], Yu et al. [84], Cantù et al. [69], Correa De Lima et al. [81], Chakraborty et al. [87], Yamagata et al. [95], Laksmiwati and Akbar [65], Manhas [96], Harrison and Petrie [91], Law and McKay [94], Lee et al. [83], Jones et al. [97], Ghidini et al. [77], Arnhold et al. [74]	23	68
System integration	Bulao et al. [13], Siyam and Abdallah [66], Frost et al. [88], Herbuela et al. [92], Rattan et al. [70], Mackare et al. [71]	6	18

highlighted that system design and coding seem to be periods where authors seek to debate the different ways to create the solution and make sure it answers users' needs [68, 69]. Concerning coding, some authors refer to the languages PHP and MySQL [13], as these seem to allow accessibility specifications. It is also important to note that the authors also do not seem to include much accessibility in the systems integration point. This is mainly because the stage is more oriented to explaining how the solution comes to fruition and becomes an actual technology [70, 71].

After learning where accessibility was a point of interest, it is necessary to ascertain how accessibility requirements were indeed integrated. Table 5 depicts a more detailed look at how accessibility has been employed in the conceptualization of IS. Overall, the results highlight that there are essentially four methods in terms of integrating accessibility

Table 5 Forms of integrating accessibility requirements across the development of IS

How accessibility requirements were integrated	Studies	% of total studies
Using documentation/literature about accessibility concepts	Petrenko et al. [75], Shamsujjoha et al. [86], Rieger et al. [64], Mayordomo-Martínez et al. [85], Livingstone-Lee et al. [72], Arnhold et al. [74], Laksmiwati and Akbar [65], Manhas [96], Vitols [63]	29
Accessibility tools	Mascetti et al. [76], Edelberg and Verhulsdonck [68], Rattan et al. [70], Mackare et al. [71], Ponciano et al. [79], Carreon et al. [78], Rieger et al. [64], Patil and Deshmukh [80], Mascetti et al. [98], Joddrell and Astell [73], Yu et al. [84], Cantù et al. [69], Correa De Lima et al. [81], Yamagata et al. [95], Vitols [63], Lee et al. [83]	47
Prototype building	Bulao et al. [13], Petrenko et al. [75], Edelberg and Verhulsdonck [68], Herbuela et al. [92], van Kessel et al. [93], Siyam and Abdallah [66], Ponciano et al. [79], Frost et al. [88], Mascetti et al. [98], Joddrell and Astell [73], Mayordomo-Martínez et al. [85], Yu et al. [84], Patil and Deshmukh [80], Cantù et al. [69], Correa De Lima et al. [81], Jones et al. [97], Yamagata et al. [95], Laksmiwati and Akbar [65], Ghidini et al. [77], Lee et al. [83]	59
Users' involvement	Bulao et al. [13], Herbuela et al. [92], Petrenko et al. [75], van Kessel et al. [93], Shamsujjoha et al. [86], Siyam and Abdallah [66], Edelberg and Verhulsdonck [68], Frost et al. [88], Mascetti et al. [98], Joddrell and Astell [73], Mayordomo-Martínez et al. [85], Yu et al. [84], Cantù et al. [69], Correa De Lima et al. [81], Chakraborty et al. [87], Jones et al. [97], Nicholson et al. [67], Ghidini et al. [77], Arnhold et al. [74], Yamagata et al. [95], Laksmiwati and Akbar [65], Harrison and Petrie [91], Law and McKay [94], Lee et al. [83]	71

requirements. Even so, extended investigation and discussion of results demonstrated that most studies apply more than one method to address accessibility features. Once again, this implies that accessibility integration is not static, but rather a continuous process.

Some authors review documentation to better understand how to implement accessibility requirements. The review process was mainly achieved by consulting accessibility legislation and available literature. For example, Livingstone-Lee et al. [72] investigated prior research concerning the difficulties people with cognitive disabilities encounter when using public transit. The authors were interested in following available standards and rulesets to help this population use transportation. This resulted in the gathering of different requirements that should be used to develop transit apps for this specific market of PwD. Other studies performed literature reviews on specific areas to analyse previous solutions and discern what accessibility components were missing [73–75]. In terms of legislation, Vitol [63] determined problems that PwD face and, based on current regulations, developed design guidelines for IS developers. Overall, it can be observed that literature still plays a role in addressing accessibility. By consulting legislation or previous documentation is possible to have an initial idea of PwD requirements. This is even more important when rulesets such as the European Accessibility Act (Directive 2019/882) [44] have become an obligation. It could be important to analyse this particular ruleset and retrieve information related to accessibility requirements that must be present in IS.

It is also important to address the integration of already existing accessibility solutions. Alongside the 15 papers that integrated accessibility solutions, great diversity was found. These solutions included: screen readers [63, 76]; accessibility plugins and design tools [68], voice commands [77], augmented reality [78], assistive visual/audio feedback tools [73], text to speech [79], face recognition [80] and application of focus assistance tools [81]. The idea of integrating assistive technologies within IS is that it helps foster a more efficient user experience for PwD. Since technology exists, it should be made available to the users. Moreover, due to the diversity of functionalities that these accessibility tools bring to the table, IS can hope to help more than just one accessibility segment. For this reason, implementation of these existing accessibility solutions within IS can be seen as a very important step in assuring accessible conditions to different types of users.

The building of a prototype was found in 20 papers (59% of total studies). To ascertain whether IS solutions can actually serve the accessibility market, functional prototypes are usually developed [82]. Some diversity was found in terms of prototype creation. Some authors opted to create fully functional prototypes. For example, Lee [83] discussed the development of a prototype of a multi-user online edutainment platform to provide immersive and engaging experiences. Other authors opted to create smaller solutions capable of evaluating particular accessibility issues. This was the case of the study by Laksmiwati and Akbar [65], which simply assembled an interface of a device for people with physical limitations to be implemented in a rehabilitation institute. This is similar to the study by Ghidini et al. [77], in which a prototype of a calendar app for blind users was created based on voice commands and control with simple gestures. One aspect that the different papers have in common is the fact the authors wanted to test possible solutions before implementing them. This could signify that accessibility is not easy to implement, so there needs to be room for trial-and-error experiments. As found in several papers [13, 69, 84, 85], authors used prototypes to gather a first impression from the users about the IS and pinpoint needed improvements. To a certain degree, prototypes can be seen as another way to materialize users' accessibility requirements. Due to this reason, prototypes seem to be a crucial part of making sure accessibility requirements are implemented.

Since the IS solutions are being developed for a very specific market (PwD), it is necessary to address very specific accessibility requirements. In order to obtain an actual functional solution, it may be important to integrate users' points of view. To achieve this goal, it may become essential to apply a UCD approach [60] and ascertain how users can be an integral part of the IS development process. Users' participation was the most applied accessibility integration method, with 74% of total studies involving users in the IS development process. This demonstrates the correlation that exists between accessibility integration and the application of UCD methodologies.

3.2.4 User involvement methods

The aim was also to explore how potential users were part of the accessibility integration process, and so Table 6 was created. The purpose was to ascertain the type of users and their respective methods of involvement. A total of four main user involvement methods were identified: (i) application of questionnaires; (ii) focus-group/think-aloud sessions to foster discussion; (iii) interviews with the different users; and (iv) usability testing.

Some authors gathered accessibility requirements directly from PwD. This was achieved mainly via questionnaires [84, 86–88]. However, involvement procedures are not always easy [89] and users' engagement methods must be correctly prepared for the accessibility market. Thus the preparation of materials (e.g. questionnaires, interview scripts, focus-group questions) and their respective application should be given proper thought. It is necessary to ensure accessible conditions so that PwD can properly speak their mind. Ensuring accessibility conditions helps developers understand users'

Table 6 Studies that integrated users' involvement across the development of IS

Methods	Users		
	PwD	Experts	Caregivers
Interview	Shamsujjoha et al. [86], Frost et al. [88], Yu et al. [84], Chakraborty et al. [87], Ghidini et al. [77]	Bulao et al. [13], Shamsujjoha et al. [86], Siyam and Abdallah [66], Frost et al. [88], Laksmiwati and Akbar [65]	Petrenko et al. [75], Shamsujjoha et al. [86], Siyam and Abdallah [66], Frost et al. [88], Laksmiwati and Akbar [65]
% of total studies	15	15	15
Focus-Group	Frost et al. [88], Yu et al. [84], Nicholson et al. [67], Harrison and Petrie [91]	Siyam and Abdallah [66], Frost et al. [88], Harrison and Petrie [91]	Petrenko et al. [75], Siyam and Abdallah [66], Frost et al. [88]
% of total studies	12	8	8
Questionnaire	Bulao et al. [13], Shamsujjoha et al. [86], Correa De Lima et al. [81], Chakraborty et al. [87], Nicholson et al. [67], Arnhold et al. [74]	Bulao et al. [13], Shamsujjoha et al. [86], Siyam and Abdallah [66], Arnhold et al. [74]	Shamsujjoha et al. [86], Siyam and Abdallah [66]
% of total studies	18	12	6
Usability testing	Bulao et al. [13], Petrenko et al. [75], Edelberg and Verhulsdonck [68], Herbuela et al. [92], van Kessel et al. [93], Frost et al. [88], Joddrell and Astell [73], Mayordomo-Martínez et al. [85], Yu et al. [84], Cantù et al. [69], Correa De Lima et al. [81], Jones et al. [97], Chakraborty et al. [87], Ghidini et al. [77], Arnhold et al. [74], Yamagata et al. [95], Harrison and Petrie [91], Lee et al. [83]	Bulao et al. [13], Petrenko et al. [75], Herbuela et al. [92], Siyam and Abdallah [66], van Kessel et al. [93], Frost et al. [88], Mascetti et al. [98], Arnhold et al. [74], Harrison and Petrie [91], Law and McKay [94]	Herbuela et al. [92], Petrenko et al. [75], Siyam and Abdallah [66]
% of total studies	53	29	8

requirements and how to create IS which are capable of addressing those needs.

By analysing the number of studies that applied each method, there is a clear predominance of studies that perform usability tests. These tests can be described as an evaluation of how a set of users use a given software solution [90]. In that sense, 53% of studies apply usability testing with PwD. It should be noted that to perform usability tests, some authors [75] allowed PwD to interact with the IS and then analysed this interaction. For this analysis, some studies opted for applying usability scales [74], while others opted for task performance evaluation [91]. There are also some cases in which usability tests were complemented with questionnaires [81].

The great use of usability testing shows the importance of design centred on the PwD. The users' input can be a very important part of validating a technological solution since they can provide important feedback about accessibility features and consequently identify the need for improvements. As expected, many of the authors that built a prototype felt the need to test it with users. For that reason, almost every study that built a prototype (Table 5) tested it with actual PwD. The exception is the studies by Herbuela et al. [92] and Chakraborty et al. [87], in which the authors performed usability testing with solutions that already existed in the market.

It is important to note that not only were PwD integrated, but also experts and caregivers. In the context of this work, a caregiver can be interpreted as someone who takes care of a PwD. In the papers analysed, caregivers were either family members [92] or non-family, including health-trained professionals [66]. A distinction should also be made between experts. Some studies took into consideration the expertise of people in a given research area, such as healthcare professionals [93] or education professionals [13]. On the other hand, some authors involved accessibility experts [74, 91] to help with the design of accessibility features within the IS. It can be argued that these users are also an important part of the demand part of the accessibility market, together with PwD. Since caregivers and experts constantly interact with PwD, they are more aware of particular accessibility needs. In addition, in some papers [65, 75], caregivers and experts were also considered end-users, as the system was also being developed for them. For those reasons, it would be important to incorporate their views and opinions on possible accessibility requirements. On this matter, some studies incorporated experts [13, 74, 91, 94] and caregivers [66, 92] during IS development phases, namely requirements analysis and system design (Table 4). For this particular procedure, interviews were the most predominant method.

Usability tests with these non-PwD users were also performed in 10 papers (29% of total studies). It is interesting to note that all studies performing usability testing with caregivers also tested with experts. Once again, usability testing consisted of studying how caregivers and experts interacted with particular IS solutions. The integration of these users may imply that some authors also saw value in obtaining their feedback, especially in relation to the available functionalities of the system. Similarly to their involvement in previous phases, the integration of these users in testing can bring great benefits to the development of accessible IS. The observations of non-PwD users can bring attention to otherwise unconsidered factors such as a basic missing functionality or a simple colour mismatch. By considering distinctive points of view, developers can identify more flaws and apply correction measures. This will make sure that the system is more usable and more accessible.

4 Conclusion, implications, and further work

This study employed an SLR to understand how accessibility can be integrated into the development process of IS. To perform the review, a 5W1H framework (Fig. 1) was applied to guide the analysis. The SLR used a research string in two distinct academic databases, resulting in the analysis of 34 papers after the application of careful selection criteria. The 34 selected studies were carefully examined in terms of bibliometric factors and content analysis.

Based on the bibliometric analysis, it can be concluded that the topic under study was explored within academia between 2004 and 2022, revealing an increasing research tendency in more recent years. In terms of publishing sources, great diversity was observed. Different academic journals and conferences have published content related to the integration of accessibility components in IS. After performing the content analysis, important pieces of evidence were also identified. Concerning research areas, healthcare and education are the areas with most published studies. This could be explained by the growing importance of information technologies in these fields. Regarding accessibility market segments, IS solutions seem to be more oriented towards users with visual and cognitive disabilities. The authors seem to integrate accessibility factors, especially during two IS development phases: requirements analysis and testing phases. This accessibility integration is obtained mainly by involving potential users and creating prototypes while some other practices included literature/

documentation exploration and the use of widespread accessibility solutions. Concerning users' involvement, not only PwD but also experts and caregivers were incorporated into IS development. This engagement was obtained especially via usability testing. Other involvement methods included interviews, questionnaires, and focus groups.

In general, the results of the literature review showed that, even though accessibility is starting to become a more prominent aspect of IS, there is still a long road ahead. There are clear ways to make sure accessibility is present when developing technology. The integration of users in different IS development phases was a crucial aspect, with more than 74% of papers integrating them. Consequently, the pieces of evidence obtained within the review imply that there are great advantages in the application of UCD principles, with users' involvement demonstrating the correlation between accessibility and UCD. Users are a crucial part of IS, so for a solution to be accessible, it is important to listen to the users and incorporate their accessibility requirements. Due to the particularities of PwD requirements, only by focusing on users and developing the IS based on them will it be possible to obtain IS solutions capable of answering their accessibility needs.

As theoretical contributions, this study increases knowledge in an emerging and increasingly important area, which is the development of solutions for PwD. Accessibility has become a concern in recent years, as the accessible market has been gaining attention in business environments. There is a growing need for accessible technology, so it is important to spread awareness on how exactly accessibility can be integrated. Concerning practical contributions, the review helps identify some potential methodologies that can be applied in different research contexts. The accessibility integration methods identified can potentially serve as roadmaps for authors to create frameworks and other methodological approaches which have accessibility as the main concern. Moreover, the review can potentially help spread the need for more accessibility components in information technologies. By increasing the accessibility of technological products, it is possible to thrive in the accessibility market. Given all the growth potential of the accessibility market [33] and the need to create solutions which are accessible to all, one can understand the relevancy of integrating accessibility aspects when developing innovative technologies.

Despite the important insights related to the integration of accessibility in the development process of IS, some limitations may be identified. The conclusions drawn from this work are based only on what is reported in the literature, and thus it is necessary to expand this study into practical applications. Therefore, it will be important to understand the developers' circumstances, and at the same time, try to discover the reasons behind the lack of attention given to accessibility during the IS development process. Some limitations in terms of the SLR conducted should also be addressed, namely related to the data extracted from the primary studies. No automatic tools were used to perform the analysis, which impacted search strategies, data extraction, and synthesis strategies. To tackle these limitations, information obtained from the selected studies was reviewed more than once by all researchers. To accomplish this, a synthesis document (appendix) and a shared database using Microsoft Excel were produced. The documents were thoroughly corrected by all authors, making it possible to convey contributions from all and minimize the chance of errors appearing throughout the SLR.

In terms of identified research gaps, very few studies provide an actual methodology that integrates accessibility in all stages of the development process. There is a clear need for methodologies that are capable of integrating accessibility across all development phases, at the same time providing transversal concepts which can be applied to other research bases. Another interesting aspect is the lack of accessibility integration studies in different research areas. Only six research areas were identified, with some presenting very few studies. Given the need for accessibility technologies in areas such as communication, media, entertainment, security, transportation, and tourism, it is important to expand these types of studies to other research areas. Furthermore, it would be interesting to extract how the success of research was impacted by the phase of the IS life cycle where the requirements were integrated. This could prove beneficial for the research community to know which particular phases should be targeted target in future works. Finally, knowing that technology should be accessible to all, there is a clear need for more actual accessible information technologies. Making sure accessibility is present in the development process of IS is an important step to ensure that everyone can indeed use the final version of a given technology.

Appendix

List of articles included in the systematic literature review.

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
1	Bulao, S., Prongsantia, S., Payakkapong, C., Tawkaew, P	2022	Development of database system prototype to support provision of education for students with disabilities	7th International conference on digital arts, media and technology, DAMT 2022	Education	Present the results of the development and evaluation of the database system prototype to support the provision of education for students with disabilities	All segments, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders
2	Petrenko, C.L.M., Kautz-Turnbull, C.C., Roth, A.R., Parr, J.E., Tapparello, C., Demir, U., Olson, H.C	2022	Initial feasibility of the "Families moving forward connect" mobile health intervention for caregivers of children with fetal alcohol spectrum disorders: Mixed method evaluation within a systematic user-centred design approach	JMIR Formative research, 5 (12)	Healthcare	Develop a mobile solution to improve family access to Fetal alcohol spectrum disorders (FASD) information for caregivers of children with FASD	Cognitive disabilities
3	Mascetti, S., Ducci, M., Cantù, N., Pecis, P., Ahmetovic, D	2021	Developing accessible mobile applications with cross-platform development frameworks	ASSETS 2021—23rd International ACM SIGACCESS conference on computers and accessibility	Not specified	List and explore how developers can integrate screen readers' functionalities	Visual disabilities
4	Edelberg, J., Verhulsdonck, G	2021	Addressing accessibility as advocacy: special needs users in industry web development processes	Proceedings of the 39th ACM International conference on the design of communication: building coalitions. Worldwide, SIGDOC	Commerce	Discusses how accessibility is addressed during the industrial process of developing websites for clients. The authors also introduced a framework for designers in the industry to consider such issues in their work	Visual disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
5	Rattan, H., Agarwal, S., Poovammal, E	2021	Acceleration of web interface generation through voice commands	Journal of Physics: conference Series, 1911 (1)	Not specified	Provide dynamic generation of web pages using voice commands from the user	Visual disabilities Cognitive disabilities
6	Herbuela,M., Karita, T., Furukawa, Y., Wada, Y., Yagi, Y.,Senba, S., Onishi, E.,Saeki, T	2021	Integrating behaviour of children with profound intellectual, multiple, or severe motor disabilities with location and environment data sensors for independent communication and mobility: App	JMIR Rehabilitation and assistive technologies, 8 (2),	Healthcare	Describe the design and development of the ChildSIDE app. The app was pilot-tested among purposively recruited children with profound intellectual, multiple, or severe motor disabilities and their caregivers. another aim of this study was to identify which movements were associated with the children's behaviours by categorizing the movements	Mobility disabilities Cognitive disabilities
7	van Kessel, K., Babbage, D.R., Kersten, P., Drown, J., Sezier, A., Thomas, P.W., Thomas, S	2021	Design considerations for a multiple sclerosis fatigue mobile app MS Energize: A pragmatic iterative approach using usability testing and resonance checks	Internet interventions, 24,	Healthcare	Explore an iterative approach supported by usability testing, to build a mobile application focused on self-management of fatigue for people with multiple scoliosis. The iterative approach included various stages of testing, during which user feedback included comments about the interface, navigation, and content. It was sought to inform incremental app development and continuous improvement	Mobility disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
8	Shamsujjoha, M., Grundy, J., Li, L., Khalajzadeh, H., Lu, Q	2021	Human-centric issues in ehealth app development and usage: a preliminary assessment	Proceedings—2021 IEEE International conference on software analysis, evolution and reengineering, SANER 2021, pp. 506–510	Healthcare	This paper provides an initial assessment of key human factors related to eHealth apps by literature review, existing guidelines analysis, and user studies. Preliminary results suggest that Usability, Accessibility, Reliability, Versatility, and User Experience are essential HCIs for eHealth apps, and need further attention from researchers and practitioners	All segments, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders
9	Siyam, N., Abdallah, S	2021	A pilot study investigating the use of mobile technology for coordinating educational plans in inclusive settings	Journal of special education technology	Education	Study what are the key design principles required to inform the design of a coordination mobile app for special education. This study first follows a participatory design methodology to identify the key design principles required to inform the design of a coordination mobile app for special education. Then, a mobile app (IEP-Connect) is designed and implemented with the aim of facilitating information sharing between different parties involved in the intervention of students with special education needs and disabilities	Cognitive disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
10	Mackare, K., Jansone, A., Mackars, R	2021	E-material formatting application prototype 2.0	Baltic journal of modern computing	Not specified	Screen users are having complaints during and after screen use. Firstly, current recommendations and methodologies for e-material formatting are not appropriate for digital reading. Develop an E-material formatting application, which improves the comfort of using e-material in the learning and study process and decreases near workload by adapting to individual needs. It is based on developed recommendations for user-centric and adaptive educational e-material creation and formatting	Visual disabilities
11	Ponciano V.,Ivan Pires I.,Ribeiro F., Garcia N	2021	Mobile application for Inclusive Tourism	16th Iberian Conference on Information Systems and Technologies (CISTI)	Tourism	Propose to present a mobile application that allows people with disabilities to know if a particular tourist spot is not suitable for their conditions. The proposed mobile application can be considered as a tourist guide for tourists with disabilities. It allows creating a profile adapted for each user to configure specific requirements in more detail. The mobile application allows the community to collaborate in the application through evaluations and comments, allows the choice of an accessible route, and presents recommendations for points of interest and ways. It also enables the presentation of specific information	All disabilities, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
12	Frost, E., Porat, T., Malhotra, P., Picinali, L	2020	A novel auditory-cognitive training app for delaying or preventing the onset of dementia: Participatory design with stakeholders	JMIR Human factors, 7 (3),	Healthcare	This study aims to identify the needs, facilitators, and barriers to designing a novel auditory-cognitive training gaming app. A participatory design approach was used to engage key stakeholders across audiology and cognitive disorder specialties. Two rounds, including paired semi-structured interviews and focus groups, were completed and thematically analysed	Visual disabilities hearing disabilities
13	Carreon, A., Smith, S.J., Rowland, A	2020	Augmented Reality: Creating and Implementing Digital Classroom Supports	Journal of special education technology, 35 (2)	Education	The study intends to aid in the selection of AR uses and offers an in-depth look at the possibilities HP Reveal can have on enhancing traditional methods of student support. It is important that teachers learn how to use the technology and understand how apps such as AR can engage, motivate, and enhance learning for their students with disabilities	Cognitive disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
14	Rieger, C.,Lucrédio, D., Fortes, R.P.M., Kuchen, H., DIas, F., Duarte, L	2020	A model-driven approach to cross-platform development of accessible business apps	Proceedings of the ACM Symposium on applied computing, pp. 984–993	Commerce	In this work, the authors set out to tackle mobile accessibility by easing the development of native mobile apps through a model-driven approach. Model-driven software development automates the creation of software artefacts by applying transformations from high-level representations – often using domain-specific languages – to executable software artefacts	Visual disabilities
15	Mascetti, S., Leontini, G., Bernareggi, C., Ahmetovic, D	2019	Wordmelodies: Supporting children with visual impairment in learning literacy	ASSETS 2019—21st International ACM SIGACCESS conference on computers and accessibility, pp. 642–644	Education	Through participatory design and multiple evaluation iterations with three domain experts, the authors developed WordMelodies, a cross-platform mobile app that supports children with and without VIB in learning basic literacy skills. The app is designed to be entertaining, inclusive, and usable without external assistance. WordMelodies is also aimed at improving children's basic tech interaction skills and teaching the use of common gestures	Visual disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
16	Joddrell, P., Astell, A.J	2019	Implementing Accessibility Settings in Touchscreen Apps for People Living with Dementia	Gerontology, 65 (5), pp. 560–570	Gaming	Examine whether the introduction of accessibility settings for people with dementia in two mainstream gaming apps (Solitaire and Bubble Explode) could improve the user experience. The authors altered the apps and tested the new versions with users with dementia	Cognitive disabilities
17	Martínez, D., De-Gea, J.M., García-Mateos, G., García-Berná, J.A.,	2019	Sustainable accessibility: A mobile app for helping people with disabilities to search accessible shops	International journal of environmental research and public health, 16 (4)	Commerce	Develop an app with accessibility information in an updated, reliable, and friendly about commercial establishments in the city of Murcia, Spain. The app provides people with disabilities with an easy way to search and filter establishments. The results are shown in a graphic, visual, and intuitive way to give the user the power to choose the establishment that is more adequate to their requirements	Mobility disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
18	Yu, D., Parmanto, B., Dicianno, B	2019	An mhealth app for users with dexterity impairments: Accessibility study	JMIR mHealth and uHealth, 7 (1)	Healthcare	This study aims to increase the usability of the iMHere system for users with dexterity impairments by increasing the app's accessibility. To achieve this, accessibility redesign was targeted by focusing on the physical presentation and the navigability of the iMHere apps. Six participants presenting with dexterity impairments were included in the usability study of the original and redesigned apps	Mobility disabilities Cognitive disabilities
19	Patil P., Deshmukh S	2019	Memory Aid Device for Alzheimer's Patient	5th International Conference On Computing, Communication, Control And Automation (ICCUBEA)	Healthcare	Present a device specifically targeted to individuals with Alzheimer's disease, aiding their ability to recognize people using a face recognition model that matches the facial features of a person with stored pictures of known people	Cognitive disabilities
20	Cantù, N., Ducci, M., Ahmetovic, D., Bernareggi, C., Mascetti, S	2018	Mathmelodies 2: A mobile assistive application for people with visual impairments developed with react native	ASSETS 2018—Proceedings of the 20th International ACM SIGACCESS conference on computers and accessibility, pp. 453–455	Education	Report the experience in the development of MathMelodies 2, an application that supports blind or visually impaired children to study mathematics. The authors applied accessibility measures to an initial version of the mobile app	Visual disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
21	Correa De Lima, A., Cruz, N., Cavalheiro, M., Araujo, Q., Batista, E.J	2018	Accesseducation: Educational platform based on CCI principles and web accessibility	Proceedings—13th Latin American conference on learning technologies, LACLO 2018, pp. 277–283	Education	The objective of this paper was to research and prove how an Internet platform for educational purposes called AccessEducation can help children with disabilities in classrooms	All segments, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders
22	Chakraborty, J., Chakraborty, S., Dehlinger, J., Hritz, J	2017	Designing video games for the blind: results of an empirical study	Universal access in the information society, 16 (3), pp. 809–818	Gaming	The goal of this paper was to propose a set of software guidelines as an incremental solution towards inclusive game design. To do so, the accessibility and usability of non-functional software requirements specific to visually impaired gamers were elicited, analysed, and operationalized. The outcomes of this review lead to several tangible conclusions that software engineers can incorporate towards inclusive game design for the visually impaired	Visual disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
23	Nicholson, J., Song, E.A.,Lord, SE	2017	Developing the WorkingWell Mobile App to Promote Job Tenure for Individuals With Serious Mental Illnesses	Psychiatric rehabilitation journal 40 (3), pp.276–282	Healthcare	The objective of this work is to explore users' requirements to build an app that could help people with cognitive disabilities perform better at their jobs. In this study, Individual Placement and Support (IPS) consumers identify challenges in sustaining employment, provide data regarding their use of technology, and suggest technology-based solutions for coping on the job to inform app development	Cognitive disabilities
24	Jones, M; Mueller, J Morris, J	2017	App Factory: A flexible approach to rehabilitation engineering in an era of rapid technology advancement	Assistive technology 29 (2), pp.85–90	Healthcare	Present a flexible and effective approach to research and development in an era of rapid technological advancement. The approach relies on the secondary dispersal of grant funds to commercial developers through a competitive selection. Process creation of a practical model for consumer participation in the development process in order to optimize the usefulness and usability of apps	All segments, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
25	Ghidini E., Almeida W., Mansour I., Silveira M	2016	Developing Apps for Visually Impaired People:	49th Hawaii International Conference on System Sciences (HICSS)	Not specified	Developed a prototype for an electronic calendar that provides interaction via voice commands, keyboard, and touch. This prototype was analysed with potential users and we collected their initial impressions about the benefits of using various forms of interaction	Visual disabilities
26	Lee, S.A., Ronald W.S.,Livingston, N	2014	Transit apps for people with brain injury and other cognitive disabilities: The state of the art	Assistive technology, 26 (4), pp.209–218	Transportation	Investigate prior research concerning the difficulties people with cognitive disabilities encounter when using public transit. The authors were interested in the best ways to help this population use transit and what features were recommended for transit apps	Cognitive disabilities
27	Arnhold, M., Quade, M., Kirch, W	2014	Mobile Applications for Diabetics: A Systematic Review and Expert-Based Usability Evaluation Considering the Special Requirements of Diabetes Patients Age 50 Years or Older	Journal of Medical Internet Research, 16 (4)	Healthcare	Study mobile apps for people with diabetes and determine whether the available applications serve the special needs of diabetes patients aged 50 or older by performing an expert-based usability evaluation	All segments, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
28	Yamagata, C., Coppola, J.F., Kowtko, M., Joyce, S	2013	Mobile app development and usability research to help dementia and Alzheimer patients	9th Annual Conference on Long Island systems, applications and technology, LISAT 2013,	Healthcare	Analyse specially created apps and existing assistive software that can be used to decrease the symptoms and improve cognition of older adults suffering from Alzheimer or other dementia-related diseases. Via service-learning courses, students developed an easy-to-use application for tablets to help older adults with disabilities more readily use the technology. Student programmers produced apps and performed usability tests with dementia patients, as well as met with geriatric facility personnel to produce application software that meets the patients, family, and caregiver needs and expectations	Cognitive disabilities
29	Laksmiwati, H., Akbar, S	2012	Towards on e-multiple handicapped information system (EMHAS) modelling	International journal on electrical engineering and informatics, 4 (1), pp. 92–103	Education	In this paper, the authors discuss how an Enterprise Architecture Planning (EAP) methodology can support the Multiple Handicapped Education Information System. The paper also describes a particular design of a man-computer interface for improving conditions for people with mental and physical disabilities. A prototype of an interface device was designed and implemented in the rehabilitation institute Bale Endah, Jawa Barat	Cognitive disabilities Mobility disabilities

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
30	Manhas, J.S	2011	Educational web sites accessibility design model	Proceedings of the international conference on advances in computing and artificial intelligence, acai 2011, pp. 9–12	Education	This paper introduces the status of educational web accessibility and puts forward the concept of educational web accessibility design	All segments, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders
31	Vitols, G	2010	Design guidelines of web information systems for people with disabilities	AICT2010—applied information and communication technologies, proceedings of the 4th international scientific conference, pp.242–249	Not specified	This paper aimed to determine problems that people with disabilities meet when using Web information systems and develop corresponding design guidelines for information system developers. To reach the aim, the following tasks had been brought forward: (i) Identify web information system user groups with disabilities and problems that these groups meet when using Web information systems; (ii) Analyse existing guidelines and requirements; (iii) Develop guidelines – possible solutions for Web information system developers for solving identified problems	All segments, namely mobility, visual, hearing, speech,cognitive/intellectual, hidden impairment and elders

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
32	Harrison, C.,Petrie, H	2007	Severity of usability and accessibility problems in eCommerce and eGovernment websites	20th Annual conference of the british-hci-group 2007 l people and computers xx—engage, pp.255	Commerce	The authors explored the impact of the severity of usability and accessibility issues in web design. In addition, determining what the most common and most severe problems are assists in prioritizing. To explore these issues a user study of the accessibility and usability of a set of eCommerce and eGovernment websites was conducted. The study compared the severity ratings of problems found in a group of sites by two sets of guidelines (WCAGl.O for accessibility and the Health and Human Services (HHS) guidelines for usability). The tests were performed by experts and by users	Visual disabilities cognitive disabilities
33	Law, C.M., McKay, E	2007	Taking account of the needs of software developers/programmers in universal access evaluations	Lecture notes in computer science, 4554 lncs (part 1), pp. 420–427	Not specified	This paper presents the argument for putting the needs of developers/programmers at the centre of any accessibility evaluation process. The current means of addressing accessibility in large organizations are discussed, and methodological considerations of the project are described	All segments, namely mobility, visual, hearing, speech, cognitive/intellectual, hidden impairment and elders

No	Author(s)	Year of publication	Title of the paper	Source	Research area	Purpose of the study	Segment of the accessible market analysed
34	Lee, A., Lai, K.W., Hung, F.T., Leung, W.L., Lam, K.K., Leung, C.C	2004	Synaesthesia: Multimodal modular edutainment platform development	International conference on cyberworlds, cw 2004, pp. 335–342	Education	This paper discusses the development of a prototype of a multi-user online edutainment platform to provide an immersive and engaging learning and teaching experience. To support learners with physical and mental disabilities, technologies such as intelligent agents and assistive devices are employed. Intelligent agents enable dynamic tracking of the learning pace and suggest modules and interfaces that adaptively scaffold the learning process	Mobility disabilities Cognitive disabilities

Funding Open access funding provided by FCT|FCCN (b-on). This work was financially supported by the Institute of Electronics and Informatics Engineering of Aveiro (UIDB/00127/2020) and by the research unit on Governance, Competitiveness and Public Policy (UI DB/04058/2020) + (UIDP/04058/2020), both funded by national funds through FCT—Fundação para a Ciência e a Tecnologia.

Data availability All the data used in case study of the research are provided inside the paper. Appendix table shows all the related data of the research work.

Declarations

Conflict of interest The authors have no conflicts of interest to disclose.

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