





## A Systematic Review on Developing Computer Programming Skills for Visually Impaired Students

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### ABSTRACT

Technology and digital-based learning drive contemporary computer skill (CS) education advances. The absence of resources that are easily accessible and tailored to help the development of conceptual understanding in computers may present a number of issues for students who have visual impairments (VI) in the context of CS education. The objective of the research was to provide a concise overview of the existing evidence-based information about CS instruction for students with severe VI. A systematic review was performed to analyze the research papers published between January 2000 and September 2023. A total of 21 articles were extracted and classified into assistive technologies (ATs) and CSs. The study findings highlight the significance of the development of ATs and effective course design for supporting individuals with VI. It can be used by policy makers and educational institutions to present a useful environment for individuals with VI to improve their CSs. In future, the authors need to focus on ATs to enhance the computer programming abilities of students with VI. In addition, they will develop programming platforms and integrated development environments that are easily accessible and can be customized to meet a wide range of learning requirements.

### KEYWORDS

assistive technologies, tactile devices, computer skills, visually impaired, blind students

## INTRODUCTION

The world has seen significant transformation in recent decades due to rapid advancements in information technology, leading to a fundamental shift in the demands on education for the future (Klingenberg et al., 2020). Information communication technology knowledge has emerged as the paramount resource for both social and economic advancement (Tuttle and Carter, 2023). Proficiency in computer and Internet use, a well-rounded education, employment, and strong communication skills have become essential criteria for a high standard of living (Paiva and Gupta, 2020). Therefore, the demand for computers and the Internet is becoming critical for education, work, and everyday tasks. People with visual impairments (VI) may have a difficult time comprehending the visual signals that are supplied by current graphical user interfaces. Even though these innovations have provided several benefits to society, they also present a challenge for such individuals. In addition, individuals with VI have distinctive challenges while using the Internet, with physical access, and acquiring computer skills (CSs) (Terven et al., 2014).

VI cover any vision loss that significantly hinders daily activities and cannot be rectified with corrective devices like glasses or contact lenses (Klingenberg et al., 2020). According to the International Classification of Diseases, they are categorized as poor vision or blindness (Al-Jarf, 2021). Low vision is a condition with partial vision loss, even with corrective measures. On the other hand, blindness is the complete loss of sight or having just a limited field of vision, even with punitive measures (Bhardwaj and Kumar, 2017). VI are categorized into three classifications based on functional vision: poor vision, functional blindness, and complete blindness (Eligi and Mwantimwa, 2017). Individuals with impaired vision rely primarily on their visual sense to engage in reading and writing tasks, sometimes using magnifying equipment for assistance (Komminos et al., 2023). Individuals who are functionally blind can use their limited eyesight for practical purposes (Shafiullah and Akay, 2023). However, they primarily depend on their sense of touch and hearing to acquire knowledge. Individuals with total VI rely on their sense of touch and aural perception

to gain knowledge and perform practical activities (Masal et al., 2023). A mental model refers to the outcome of the cognitive process of constructing visual impressions based on sensory input from the surroundings (Masal et al., 2023). The act of creating a mental representation is often known as “visualizing”, “mentally perceiving”, “auditory imagination”, “imagining tactile sensations”, and so on (Valipoor and De Antonio, 2023). In order to form a mental model, a person engages in cognitive processes such as simulations, reproductions, or reconstructions of previous perceptual encounters or the anticipation of future ones. Visual mental models are primarily relevant to philosophy, psychology, and cognitive science (Sahoo and Choudhury, 2024). These models can be extended to include other senses, such as auditory and olfactory perceptions.

Society, health institutions, and government agencies are increasingly focusing on the conditions of the blind and VI due to the dramatic rise in eye-related conditions and the subsequent decline in human vision (Montenegro-Rueda et al., 2023). Individuals with VI experience a reduced ability to perform various daily living activities due to their lack of vision. Information and communication technology advances provide new opportunities for low-cost, rapid solutions for individuals with VI (Sahoo and Choudhury, 2024). There are 285 million individuals worldwide with VI, with 39 million categorized as blind and 246 million having poor vision. About 90% of blind people live in underdeveloped nations, and 82% of them are aged over 50 years (Klingenberg et al., 2020). In the absence of sufficient measures to address the issue, the growing number of VI will impact future social inequality and quality of life (Klingenberg et al., 2020). These difficulties have led academics to explore new study areas in assistive technologies (ATs), cognitive psychology, computer vision, sensory processing, rehabilitation, and accessibility-inclusive human–computer interaction.

Teaching computer programming to individuals with VI necessitates the use of particular methodologies and tools to cater to their distinct requirements and difficulties. Screen readers, such as job access with speech and nonvisual desktop access, transform text and visual components shown on a screen into spoken words or Braille output. This enables individuals with VI to navigate programming environments, read code, and get aural responses. Similarly, VoiceOver on macOS and iOS offers auditory feedback and keyboard navigation for those with VI. Specialized integrated development environments (IDEs), such as Eclipse with the eclipse accessibility tools framework or Microsoft visual studio with accessibility insights, have specific functionalities tailored for accessibility. These functionalities include keyboard shortcuts, compatibility with screen readers, and high-contrast themes. These inclusive IDEs improve the programming experience for individuals with VI by facilitating code creation and debugging. Audio tutorials, podcasts, and instructional films provide aural explanations of programming principles, coding processes, and software development procedures. Learners with VI may enhance their comprehension of programming concepts and reinforce their learning by using screen readers or audio players to listen to these resources. Peer mentorship programs and support groups provide programmers with VI the chance to engage

with peers, exchange experiences, and share information and resources. Collaborative learning settings provide a feeling of community, support, and reciprocal aid, facilitating the ability of persons with VI to overcome obstacles and develop self-assurance in their programming abilities.

Enhancing the computer programming abilities of individuals with VI may provide a multitude of advantages, affording them the chance to develop personally and professionally, gain empowerment, and experience inclusion. Mastery in computer programming provides access to a diverse array of professional prospects within the technology industry. Visually impaired persons may achieve financial independence and socio-economic well-being by obtaining programming skills, enabling them to pursue jobs in software development, web design, data analysis, and other technology-related professions. Acquiring programming skills enhances cognitive abilities, logical deduction, and critical analysis, all of which are advantageous for personal growth and continuous education. Programming may provide intellectual stimulation and self-fulfillment for visually impaired persons, enhancing their lives and broadening their perspectives. These factors have motivated the authors to investigate the existing tools and technologies for individuals with VI to improve their programming skills.

Recent advancements in rehabilitation engineering, cognitive psychology, computer vision, wearable technologies, multi-sensory adaptations, retinal implants, tactical displays, smart canes, and smartphone-based apps offer new possibilities for enhancing the quality of life of individuals with VI (Montenegro-Rueda et al., 2023). A direct influence on social inclusion is exerted by the fact that ATs make it possible for individuals with VI to access information, support their mobility, promote safety, and improve their quality of life. In this review, the authors intend to evaluate the existing literature on ATs and CSs for individuals with VI. The proposed review focuses on ATs that primarily address mobility, object identification, navigation, access to information on printed artifacts, and social interaction. In addition, the academic course developments for improving the CSs for individuals with VI.

The remaining part of this study is organized as follows: The Review Methodology section offers the methodology of the proposed review. The findings of the study are discussed in the Results and Discussion section. The Conclusions section presents the study contribution and its future direction.

## REVIEW METHODOLOGY

In order to find, evaluate, and synthesize relevant papers on a subject, systematic reviews use a thorough, planned search strategy intending to avoid bias. The authors comprehensively assessed the publications and provided a detailed analysis of the study’s attributes and significant discoveries. Furthermore, the authors evaluated the quality of the research and deliberated potential explanations for the findings.

A search was conducted in the SCOPUS, PubMed, and Web of Science databases using the following search terms: visual impairment, blindness, low vision, computer science,

CSs, AT, learning management system (LMS), and education. The purpose of this search was to locate relevant published publications. One of the authors is an information technology specialist with specialized expertise in information retrieval, which proved beneficial in extracting the relevant research article.

The research included individuals between the ages of 14 and 30 with VI, namely children and young adults. In order to include research on high school and undergraduate individuals, the age range was intentionally broad. However, several research studies included participants beyond the age of 30; nonetheless, the average age of the individuals in each of the included studies was below 30 years. Individuals who have severe VI may have significant difficulties in obtaining information. In certain cases, they may require additional time to complete their secondary education (Yurtay et al., 2015).

We selected English publications published between January 1, 2000, and September 30, 2023, which were peer-reviewed. We discovered a total of 177 abstracts. After examining 108 abstracts, we eliminated articles pertaining to children and young individuals with VI collectively with either comorbidity or multiple impairments. We did not include studies that reported independent data collections for individuals with VI or detailed assessments of teaching techniques and materials in particular circumstances in different countries. We finalized with a total of 77 publications. A total of 34 research articles remained after 43 duplicates were removed from the search. Two of the authors read the remaining 34 papers. In several research articles, initial data gathering was not carried out. Based on the specific criteria for inclusion and exclusion, we determined that 21 articles aligned with the research objective. After assessing the 21 papers, we categorized them into two categories based on their outcomes.

We employed a uniform procedure and reporting template to extract the subsequent information from each publication: publication year, primary author's name, country where the study was conducted, study objective, study design, age and size of the study population, number of individuals with VI and number of individuals with normal vision in each study, definition of VI, and critical findings of each study. We used

the first instance of the article being published online as the reference for the publishing year, compared to the year of the printed version.

## RESULTS AND DISCUSSIONS

We extracted a total of 21 papers related to ATs and CSs. In addition, we classified the articles into ATs and CSs. Figures 1 and 2 present the details of the research articles.

To provide computer science and programming courses for individuals with VI, it is necessary to use a considerate and comprehensive strategy that guarantees accessibility and fosters a favorable learning environment. Various course materials, such as text, audio, and tactile, should be available. All course materials, including handouts, presentations, and homework, should be accessible to students using screen readers or other assistive devices. It is important to have comprehensive written explanations for photos, infographics, and other forms of visual material. This enables those with VI to comprehend the material, even without visual elements. The developers should build a unique evaluation material that does not depend only on visual components (Bhardwaj and Kumar, 2017). A variety of learning styles should be taken into account when designing assessments. For instance, oral presentations, code reviews, and writing assignments should be used. To ensure the accessibility of video information, it is essential to offer precise transcripts and captions. This is crucial for persons who may have challenges accessing audio or video materials. In order to accommodate those who read Braille, the educational centers should offer Braille copies of the course materials. They should create a learning environment by encouraging cooperation and providing assistance from peers. Discussion boards, chat platforms, or other communication tools can be used to promote effective communication.

Table 1 presents the characteristics of the research articles related to ATs. The proliferation of digital learning options poses challenges for students with VI and their instructors (Darrah, 2013; Abdolrahmani et al., 2016; Senjam et al., 2020; Al-Jarf, 2021). Thus, it is essential to understand how individuals with VI may effectively engage with CS instruction and

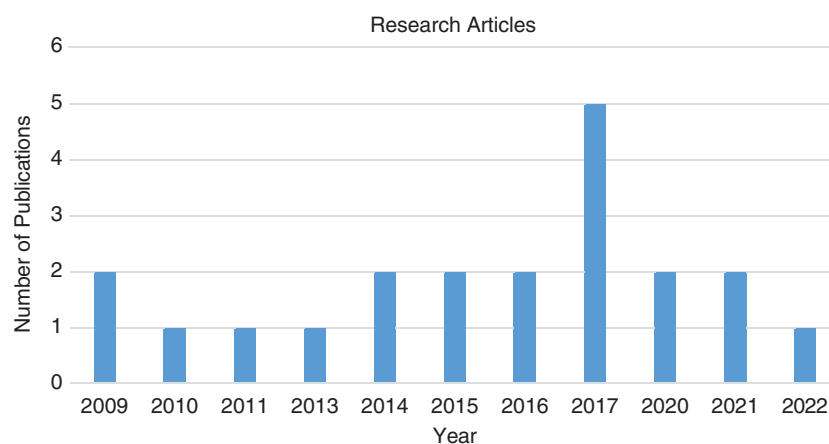
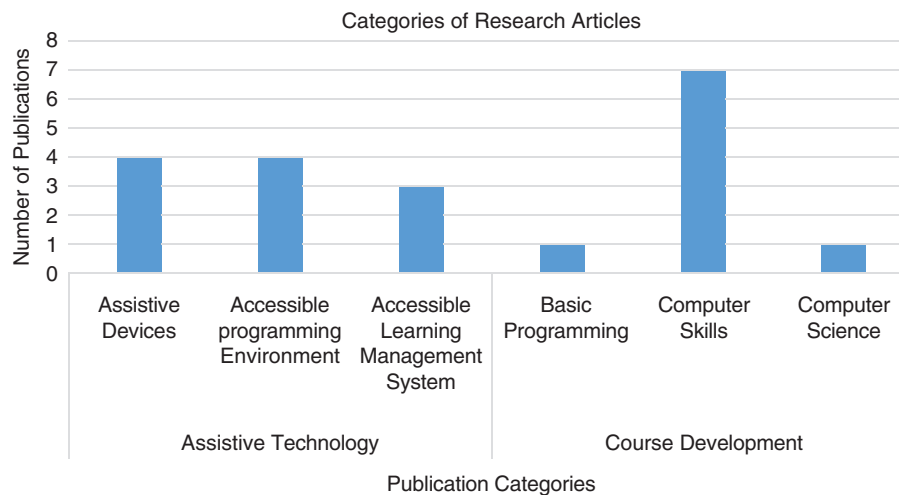


Figure 1: Details of the research articles.



**Figure 2:** Categories of the research articles.

**Table 1:** Characteristics of AT studies.

Authors	Objectives	Methodology	Findings
Abdolahmani et al. (2016)	Investigated the experience of individuals with VI with mobile devices.	Semistructured interviews with eight individuals with VI.	The existing ATs were not user-friendly. The individuals with VI faced challenges in using the mobile devices.
Leo et al. (2017)	Significance of tactile devices.	Designed a programmable tactile display to assess the spatial memory skills.	Tactile displays support the individuals with VI in improving their spatial memory skills.
Ernst et al. (2017)	Identification of the significance of the mobile screen reader.	Exploratory study-based investigation.	The mobile screen reader was useful for the individuals with VI.
Al-Jarf (2021)	Evaluated the role of ATs.	Conducted a case study for analyzing the use of ATs.	Braille sense note taker was supportive for the individuals with VI to perform their academic tasks.
Ajuwon et al. (2016)	Teachers' and students' perceptions on ATs.	Analyzed the data of 165 individuals with VI and 840 teachers.	Demand for innovative models to provide effective teaching environment.
Alves et al. (2009)	Application of ATs in the educational environment.	Conducted a descriptive study among 134 teachers.	Need for effective infrastructure and pedagogical support to teach students with VI.
Bhardwaj and Kumar (2017)	Perceptions of undergraduate students with VI about the digital learning environment.	Qualitative analysis of the responses of 95 students with VI.	Digitized learning environment offered an exceptional environment for students with VI.
Darrah (2013)	Importance of computer haptics in teaching mathematics and science.	Explored the usage of computer haptics tools.	The tool was useful for the students with VI in learning mathematics and science.
Wong and Cohen (2015)	Investigating the role of ATs in teaching students with VI.	Qualitative thematic content analysis of teachers' responses.	Training programs for teachers are necessary to gain knowledge on ATs.
Eligi and Mwantimwa (2017)	Significance of ATs for students with VI.	Conducted a survey among 36 students.	Development of intelligent ATs that address the existing challenges and limitations.
Haneefa and Syamili (2014)	Investigated the use of ICT for students with VI.	Semistructured interviews of 100 students with VI.	Lack of ATs for students with VI to assist them to learn computer science programs.
Senjam et al. (2020)	Awareness and utilization of ATs.	Cross-sectional study of 250 students with VI.	Tactile devices were useful for students with VI.

Abbreviations: ATs, assistive technologies; ICT, information communication technology; VI, visual impairments.

successfully master their age-appropriate curriculum. In the field of computer science, traditional physical textbooks are replaced by digital textbooks (Haneefa and Syamili, 2014; Bhardwaj and Kumar, 2017; Eligi and Mwantimwa, 2017; Leo et al., 2017). The educational resources can be accessed on a computer or a comparable electronic device. According to Wong and Cohen (2015), digital text (e-text) refers to literary elements that are offered in an electronic or digital format. The term "supported e-text" refers to digital text that has been altered or expanded to improve the reader's ability. It enables

the replication of digital text in several formats, including synthetic speech, human-voice audio recordings, video, large print books, and Braille. Alves et al. (2009) highlighted that teachers play a crucial role in fostering students' well-being and generating optimal learning environments. In addition, they can assist students in utilizing resources that improve their remaining eyesight and maintain their visual abilities, consequently promoting their overall health. ATs facilitate the integration of individuals with VI into conventional learning processes and academic settings.

**Table 2:** Characteristics of CSs and ICT studies.

Authors	Objectives	Methodology	Findings
Alotaibi et al. (2020)	Practical challenges in teaching basic programming to students with VI.	Conducted workshops and interviews.	Students faced challenges in understanding abstract concepts, code navigation, and addressing technical issues.
Şimşek et al. (2010)	Identified the challenges encountered by individuals with VI in acquiring ICT skills.	Qualitative descriptive case studies were conducted.	Demand for regularities in developing ICT courses for individuals with VI.
Huang et al. (2015)	E-learning accessibility of individuals with VI.	Experimental study for investigating e-learning accessibility.	No user-friendly environment for individuals with VI.
Bilyalova et al. (2021)	Effectiveness of digital learning environment.	Retrospective analysis of scientific literature and conducting interviews.	Digital educational resources provide an effective learning environment.
Mahajan and Nagendra (2014)	Development of a teaching model.	Designed a model to present IT knowledge and skills.	The low-cost teaching model was useful for individuals with VI.
Arslantas and Gul (2022)	Analysis of the literacy skills of individuals with VI.	Mixed method analysis for evaluating the digital literacy skills.	Lack of effective collaborative and communication in developing digital content.
Armstrong (2009)	Significance of advanced IT education.	Performed a four years pilot project for investigating the academic courses.	Innovative courses to improve CSs.
Stefik et al. (2011)	Building an educational environment.	Developed programming environment and conducted an empirical study.	Significant increase in students' CSs after participating in the programming environment workshop.
Gill et al. (2017)	Explored the adequacies of the learning environment.	Quantitative analysis using a questionnaire.	Demand for a sophisticated e-learning environment.

Abbreviations: CS, computer skill; ICT, information communication technology; VI, visual impairments.

Ernst et al. (2017) outlined the iterative design process of a prototype device called Typhex, which is strategically located to facilitate bend gestures. The authors explored the potential of deformable input devices in enhancing accessibility for individuals with VI. The experiments involved both sighted people and blind participants. The main objective was to compare the usability of bend gestures with touch as the major method of input. Their findings indicated that although the prototype was easily learnable and enjoyable for both groups, it did not enhance the performance of blind users compared to the regularly utilized touch input paradigm.

Ajuwon et al. (2016) emphasized the necessity of creating novel frameworks for service provision and the specific structure for teaching ATs. AT experts have to develop proficiency in collaborating with and offering technological support to students with VI and their educators. They recommended to engage in collaborative consultation with general and special educators, AT professionals, and other relevant stakeholders. Collaborating in this way can greatly benefit learners who have VI by introducing them to the employment of ATs.

Table 2 highlights the significance of the computer science course design and CSs for individuals with VI. To develop courses that are adaptable and support a variety of learning styles, it is essential to implement universal design principles (Alotaibi et al., 2020). It is imperative that all students have access to the various feedback processes, including grading and feedback on assignments (Şimşek et al., 2010). In order to complete coding activities, the students should make use of text editors that are compatible with screen readers. To facilitate navigation for users using screen readers, the educational institutions provide coding environments that include keyboard shortcuts (Huang et al., 2015). To make navigating easier, organize materials using clear headers and a hierarchical framework (Mahajan and Nagendra, 2014). The teachers have to ensure uniformity

in formatting to enhance a consistent and predictable user experience (Armstrong, 2009). They need to utilize collaboration platforms that are accessible and compatible with screen readers and other assistive devices (Stefik et al., 2011). Real-time collaboration and easily accessible chat interfaces are two characteristics that should be utilized. It is important to encourage active engagement by means of joint projects, discussion forums, and activities that incorporate interaction (Gill et al., 2017). Bilyalova et al. (2021) presented the significance of the effective learning environment. The utilization of computer technology enhances the adaptable personal growth of individuals with VI, thereby broadening opportunities for their complete engagement in diverse aspects of social and cultural existence. The proper utilization of specialized digital educational resources and computer ATs offers individuals with VI new opportunities. These include accessing information on electronic media, such as Internet resources, as well as accessing flat-print texts through scanning and recognition. Additionally, electronic information can be transformed into accessible formats, such as relief-point or enlarged font, for easier reading. Individuals with VI can also independently generate various documents on a computer, such as study papers and reports. Arslantas and Gul (2022) suggested that the participants had fundamental abilities in obtaining CSs. However, they were lacking in skills related to information management, efficient teamwork, communication, and digital content creation.

## Challenges and opportunities

ATs are essential in aiding students with VI in enhancing their computer proficiency and getting access to educational opportunities. Figure 1 presents the ATs for assisting individuals with VI to improve their CSs. Screen readers transform

digital text into artificial voice, enabling pupils with VI to perceive and navigate computer information audibly. It facilitates access to diverse digital resources, such as educational texts, Internet articles, and code documentation. Braille displays provide haptic feedback of digital information, enabling users with VI to comprehend text using Braille. It enhances Braille proficiency and promotes interaction with programming languages, mathematical notations, and other forms of nonverbal data. It enlarges the material on the screen, facilitating the perception of details for those with VI. In addition, it improves the clarity and legibility of code, graphs, and other visible components in computer science materials. Voice input/output software enables individuals to engage with a computer by issuing voice instructions and receiving auditory responses. It facilitates functioning without any requirement for manual input and may be used for programming assignments, generating documents, and navigating across systems. Specialized programming environments provide advanced functionalities such as code auto-completion, syntax highlighting, and auditory feedback. It improves the coding experience for students with VI and facilitates fast code authoring and debugging. Tactile graphics and models transform visual data into tactile depictions, such as tactile graphics or 3D-printed models. This technology enables the exploration of visual ideas, charts, and diagrams that are covered in computer science courses. LMS platforms are specifically built to include accessibility features, provide compatibility with screen readers, and enable navigation using a keyboard. It facilitates the accessibility of course materials, assignments, and discussion forums online for students with VI. Figure 3 presents the useful ATs and strategies for improving CSs for individuals with VI.

Advancements in technology and research in ATs for those with VI are progressing. Nevertheless, there have been longstanding obstacles and deficiencies in understanding within this domain. They are developing sophisticated navigation aids for digital settings, particularly in intricate interfaces such as software programs and the Internet. Optimizing spatial perception, delivering effective navigation prompts, and

enhancing user satisfaction in virtual environments can support the VI to improve the learning capability. Developing interactive educational platforms enable visually challenged persons to participate actively in complicated topics, such as computer programming.

The following are to be considered in the future: (i) creating inclusive coding platforms, debugging tools, and collaborative coding environments that may be accessed by methods other than visual interfaces; (ii) enhancing the ability to recognize and identify images and objects in real time; (iii) improving the precision and efficiency of image recognition algorithms to immediately detect objects, text, and sceneries in diverse settings; (iv) advancing Braille display technology by enhancing refresh rates and implementing dynamic tactile feedback; (v) developing Braille displays that can accommodate intricate visuals, mathematical symbols, and interactive elements often seen in contemporary computer interfaces; (vi) enhancing conversational engagements *via* enhancing natural language processing for voice interfaces; (vii) creating sophisticated systems capable of comprehending and reacting to intricate instructions, inquiries, and context in an intuitive manner; (viii) understanding the specific requirements and inclinations of users with VI for tailored and adaptable ATs; (ix) creating systems that adjust to users' preferences, engagement methods, and needs across various jobs and situations; (x) ensuring that ATs are compatible with several devices, operating systems, and software applications; (xi) developing solutions that effortlessly merge with various digital ecosystems and provide uniform accessibility across several platforms; (xii) dealing with concerns over the cost-effectiveness and broad availability of cutting-edge assistive devices; (xiii) creating affordable solutions that may effectively reach a wider audience, including persons in areas with few resources; and (xiv) improving resources and programs to teach persons with VI proficiently using ATs.

Extensive instructional resources and initiatives can enable users to optimize diverse technologies for a wide range of jobs. Scientists, engineers, and supporters persist in their

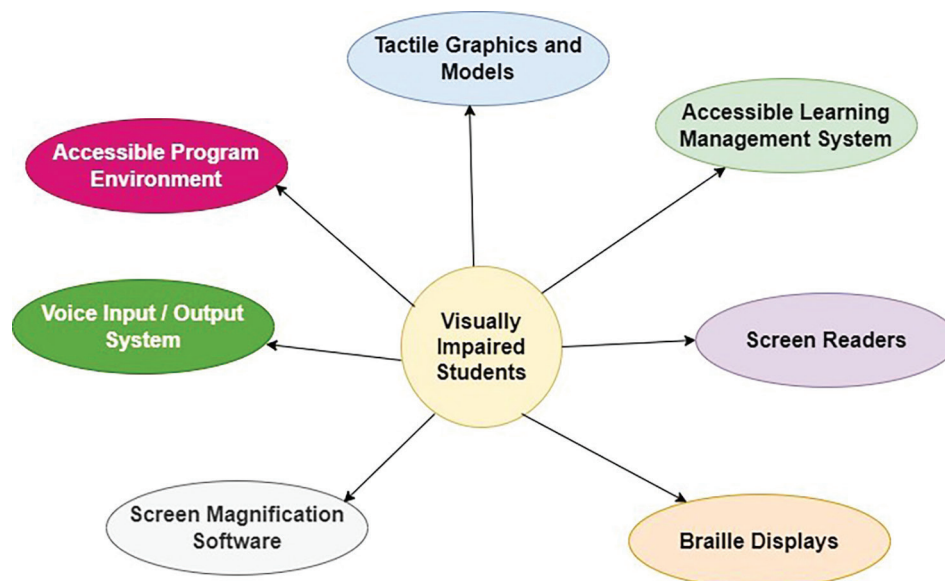


Figure 3: Recent tools and technologies.

efforts to build technological solutions that are more inclusive and accessible for those with VI. The rapid advancement of digital-based learning may be one of the reasons why students with VI may have a wider gap in their digital abilities compared to students who do not have vision loss. Insufficient resources and inadequate education support, particularly in developed countries, may be another contributing factor. Furthermore, the economic conditions and the government's focus on funding the education of individuals with disabilities and enhancing teachers' skills and interests may impact the learning of CSs for individuals with VI. Instructors should have a positive attitude toward their students with VI due to the direct impact on the student's experiences in the classroom. Therefore, instructors are responsible for constructing significant experiences for students with VI. Peer comparisons and instructors' attitudes are critical determinants of whether children with VI have positive or negative experiences.

System developers should assume that ATs are designed with the user's needs and preferences as the central focus. The development process, from the initial prototype design to system testing and continuous improvement, should be guided by a comprehensive understanding of the needs and abilities of users with VI. System functions can only satisfy user expectations under certain circumstances. Individuals have unique methods of acquiring knowledge, experiencing emotions, and interpreting stimuli. AT devices need to acquire knowledge from their users and adjust settings, especially based on user feedback, in order to customize the experience.

The Kingdom of Saudi Arabia has launched a number of programs to aid the health and education of individuals with VI. The government has been actively pursuing inclusive education policies with the goal of providing those with disabilities, such as individuals with VI, equal opportunities to receive high-quality education in regular institutions. Dedicated educational facilities have been built to offer specific assistance and resources for individuals with VI. These centers may provide specialized pedagogical approaches, ATs, and modified curriculum. Persons with VI seeking higher education may be eligible for scholarships and financial assistance provided by the government. This assistance is designed to enhance their ability to obtain university education and vocational training. Partnership with nongovernmental organizations and advocacy groups contributes to the support of the rights and education of persons with VI. These groups frequently collaborate with the government to enact inclusive policies. Ministry of Education, Kingdom of Saudi Arabia, suggests the education institutions to offer effective technologies for teaching disabled individuals. In addition,

online educational platforms, including Coursera, offers CS development programs for individuals with VI. In addition, the university will provide ATs for individuals with VI to learn computer science program effectively.

There may be a great deal of variation across studies that assess treatments to enhance visually impaired students' computer programming abilities in terms of intervention type, duration, intensity, and delivery mechanism. The diversity of procedures poses a challenge in comparing the results across research and reaching solid conclusions on the most efficacious methods. The study may be biased toward positive or substantial outcomes. Several studies assessing treatments aimed at enhancing computer programming abilities in visually impaired students may have deficiencies in control groups or comparative circumstances, rendering it arduous to establish causal connections between interventions and skill enhancements. Attributing changes entirely to the treatments under consideration becomes problematic in the absence of suitable control groups.

## CONCLUSIONS

The authors conducted a systematic review on ATs and CSs for individuals with VI. They extracted 21 research articles which discussed the significance of ATs and CSs. The findings revealed that ATs and well-designed computer science courses are essential in helping visually impaired persons develop and improve their computer abilities. Computer science classes utilize ATs to facilitate access to web resources, code, and documentation. Braille displays are utilized in programming classes to facilitate the reading and understanding of code, grammar, and algorithms. Tactile graphics in computer graphics or design classes facilitate a tangible and experiential approach to comprehending visual concepts. Programming experience for visually impaired persons is enhanced by development environments that incorporate audio signals, accessible interfaces, and keyboard shortcuts. The outcome of this study can be used by the educational institutions and policy makers to support the individuals with VI to develop CSs. In the future, the authors will design tactile devices in order to assist students with VI. They will focus on developing programming platforms and IDEs that provide user interfaces that can be customized to meet a wide range of learning requirements. They will develop a platform for accessible examinations and assignments for visually impaired students, including alternate formats, flexible submission decisions, and additional time.

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