Examining Inclusive Computing Education for Blind Students in India

Akshay Kolgar Nayak
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
anaya001@odu.edu

Yash Prakash
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
yprak001@odu.edu

Md Javedul Ferdous
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
mferd002@odu.edu

Sampath Jayarathna
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
sampath@cs.odu.edu

Hae-Na Lee
Michigan State University
Department of Computer Science and Engineering
East Lansing, Michigan, USA
leehaena@msu.edu

Vikas Ashok
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
vganjigu@odu.edu

ABSTRACT

The growing demand for computer professionals, driven by the expanding Information Technology industry, has led to numerous inclusive computing education efforts. These efforts have even included blind or visually-impaired (BVI) students, who are being increasingly encouraged to pursue education and career in computing, despite the visually-oriented nature of the discipline. Extant literature has predominantly focused on identifying and addressing the accessibility barriers faced by BVI students, to promote more inclusive learning environments. While few studies have also investigated the accessibility of computing eduction from the perspectives of BVI learners and instructors, these have been primarily situated in the Global North contexts; there is still a knowledge gap regarding the teaching and learning experiences of instructors and BVI students respectively in resource-constrained Global South contexts, where accessibility awareness and inclusion efforts are at nascent stages. To fill this gap, we conducted an interview study with 15 participants in India, where we inquired BVI students, instructors, and BVI professionals, regarding their challenges, experiences, and needs pertaining to computing education. The study revealed that BVI students face significant difficulty in comprehending the instructional materials, the instructors often deal with courses not progressing as planned despite meticulous preparation, the students heavily depend on peer learning for grasping computing concepts, and they need additional support for managing the cognitively-burdensome task of simultaneous learning computing concepts and screen readers. Informed by the findings, we offer recommendations to improve computing curricula for BVI students, and discuss self-learning assistive tools to supplement accessible computing education.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in accessibility**; **Accessibility technologies**; *User studies.*

KEYWORDS

Blind, Visually impaired, Computer training

ACM Reference Format:
Akshay Kolgar Nayak, Yash Prakash, Md Javedul Ferdous, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2025. Examining Inclusive Computing Education for Blind Students in India. In *Proceedings of (SIGCSE TS 26).* ACM, New York, NY, USA, 7 pages. https://doi.org/XXXXXXX.XXXXXXX

1 INTRODUCTION

Ubiquitous digitization across industries has intensified global demand for computing talent. As a major hub for offshore Information and Communication Technology (ICT) services, India has expanded its computing education efforts to meet this need [36]. These efforts have included integration of computing fundamentals into school curricula (e.g., through the 'National Education Policy 2020' [27], the multi-lingual 'AI for All' program [28]) as well as expansion of digital education access for diverse demographics, particularly for underrepresented communities. Public-private collaborations, including platforms like FutureSkills Prime [31], Infosys Springboard [15], and IBM's SkillsBuild [14], also play a key role in delivering targeted computing skill development to millions of learners across the country. Despite these initiatives, inclusive efforts to broaden participation of blind and visually impaired (BVI) individuals are still in their incipient stages, with organizations such as the National Association for the Blind (NAB) [32] and government initiatives like Digital India [29], Skill India [30], and Vision-Aid's Project Springboard [43] starting to raise awareness in this regard [21].[1] Therefore, little is known about the experiences and challenges of BVI students and instructors in computing fields (in India); extant research in this regard has predominantly focused on the Global North developed countries where inclusive computing education is relatively mature (e.g., specialized training

[1]As of 2020, India is home to the largest population of people with visual impairments globally, including approximately 70 million individuals with vision impairments and 4.95 million who are blind [18, 38].

SIGCSE TS 26, Feb 18–21, 2025, St. Louis, MO

ACM ISBN 978-1-4503-XXXX-X/18/06
https://doi.org/XXXXXXX.XXXXXXX

and workshops for teachers, accessibility in core curricula) and well-resourced (e.g., Offices of Educational Accessibility in universities [1]), compared to resource-constrained Global South developing countries such as India, where awareness of accessibility and inclusion is limited, even among computer science educators in K–12 and higher education.

To address this knowledge gap, we conducted an interview study with a diverse group of 15 BVI participants from India, which included BVI students (K12 and higher education), computer trainers, and working professionals, to answer the following research questions:

- **RQ1:** What challenges do BVI students face in a developing society such as India regarding computing education?
- **RQ2:** What are the challenges and needs of instructors who teach computing to BVI students?

The study yielded unique insights pertaining to developing societies, notably, the instructors relied on a general curricula that focused on cultivating pre-defined software skills aimed at ensuring "job readiness", rather than providing structured, hands-on computing instruction. Moreover, due to tight funding, most instructors were just volunteering proficient screen reader (SR) users rather than formally trained educators, which consequently limited their ability to explain computing concepts and address students' queries and concerns. Informed by these findings, we finally discuss plausible solutions for enhancing inclusive computing education for BVI students in resource-limited developing countries and beyond.

2 RELATED WORK

Inclusive computing education has increasingly focused on uncovering and removing barriers for students with disabilities, especially BVI students who encounter numerous challenges in traditional computer science courses, which often rely on visual content and tools (e.g. flowcharts and graphs). A seminal work by Mealin and Murphy-Hill [26] highlighted how blind software developers faced significant challenges with IDE accessibility and code navigation which they attributed to a lack of exposure and support for learning development tools. Baker et al. [2, 3] corroborated these findings and highlighted several factors contributing to the incomplete educational experiences of BVI students. These included inaccessible IDEs, non-engaging learning materials, limited teacher preparedness, increased reliance on peer support, the additional burden to master assistive technologies (ATs), and the need to self-teach through trial and error. Consequently, BVI students had less computing exposure compared to their sighted peers. Building on this, Huff et al.[13] found that teachers of BVI students were often forced to adapt or recreate lessons due to inaccessible course materials, faced a high cognitive burden when teaching development tools, and struggled with a lack of accessible and standardized curricula. They also observed that visual-centric tools and pedagogies often alienated blind students, while accessible alternatives like Quorum [39], though promising, still presented usability challenges.

To address these barriers, extant literature has explored a variety of alternative pedagogical approaches and intervention tools to make computing concepts more accessible to BVI students. For instance, AccessCSforAll [22] is an NSF-funded initiative that has adapted the AP Computer Science Principles curriculum to be fully accessible for BVI students by replacing visual programming tools with SR–friendly text-based alternatives like Quorum, and by training Teachers of the Visually Impaired (TVIs) to teach computing through audio and tactile methods. Stefik et al. [40] put this approach into practice by training TVIs to teach the AP Computer Science Principles course using the Quorum programming language, accessible screen-reader tools, and nonvisual teaching methods. Bigham et al. [4] conducted an "Instant Messaging Chatbot" programming workshop for blind high school students, by using an accessible, dialogue-based coding scenario instead of the traditional GUI-centric one, which successfully inspired many participants to pursue Computer Science. In another workshop, Kane and Bigham [19] engaged blind students in programming by having them analyze live Twitter data during crisis events and generate 3D-printed models of the data, allowing students to physically explore their code's output and deepen understanding through tactile feedback. A literature review by Hadwen-Bennett et al. [10] identified four key strategies for making programming accessible to BVI learners: (i) auditory and haptic feedback to convey visual information non-visually, (ii) adapted text-based programming languages designed with accessibility in mind, (iii) accessible block-based environments that support screen reader or keyboard navigation, and (iv) physical artifacts such as tangible programming tools. The review also noted a significant gap in the literature.

As evident, these efforts remain confined to affluent Global North contexts with relatively robust disability support and awareness, creating a notable knowledge gap regarding BVI computing education in resource-constrained Global South contexts. In these developing regions, accessibility adoption is still in its nascent stages, and instructors have fewer resources or training to support inclusive education [23]. Sparse literature concerning BVI individuals in developing countries, particularly India, predominantly focuses on general technology use, assistive technology adoption, voice-based social media engagement, and foundational digital literacy skills [9, 24, 25], with little attention given to their participation in structured computing education or the pedagogical challenges they face in such contexts. Our work aims to fill this gap by triangulating perspectives from: (i) BVI students who navigate computing education firsthand, (ii) computer trainers and instructors who design and deliver instruction to BVI learners, and (iii) working BVI professionals who reflect on the efficacy of their educational experiences in shaping their careers in the ICT industry.

3 METHOD

We conducted semi-structured interviews with a diverse group of BVI participants from India, as described below.

3.1 Participants

We recruited 15 individuals[2] through mailing lists and word-of-mouth referrals from regional workforce development programs (training centers) in India. Selected participants met the following inclusion criteria: (i) prior experience in a computing education program, and (ii) no hearing impairments that could affect their ability to participate in the interview study. Gender representation was approximately balanced, with 7 female and 8 male participants,

[2]Studies with BVI users typically involve between 8 and 20 participants [13, 35].

ID	Age/ Gender	Age of Vision Loss	Occupation	Computer Experience (Years)	Prior Computer or Software training
P1	19/F	Since birth	College Student	2-3	Word, Notepad
P2	47/M	Don't Know	Computer Trainer	10-12	MS-Office, HTML & C Programming, VB script
P3	27/M	Since birth	Computer Trainer	8	MS-Office, Web Navigation, Call Center Training
P4	16/M	Age 7	High School	less than 1	Basic Navigation, Notepad
P5	23/F	Age 10	College Student	5	MS-office, Data Entry, Web Navigation
P6	50/F	Sighted	Computer Teacher	18-20	Programming(C,JAVA,Python, C++)
P7	30/M	Don't Know	Unemployed	3-4	MS-Office, Web Navigation, Data Entry
P8	27/F	Age 15	Unemployed	6-7	Word, Notepad, Excel
P9	32/F	Don't Know	Bank Employee	7	MS-Office, Web Navigation
P10	41/F	Age 20/21	NGO Employee	5-7	Web Navigation, HTML, Notepad, Word
P11	39/M	Don't Know	Computer Trainer	11	MS-Office, Web Navigation
P12	20/F	Since Birth	High School	2	Word, Notepad
P13	27/M	Since Birth	Graduate Student	9	HTML, MS-Office, Web Navigation, Latex
P14	47/M	Since birth	IT Employee	12-14	MS Office, Web Navigation, Python
P15	28/M	Sighted	Computer Teacher	10	Programming (JAVA, Python, C), Web Development

Table 1: Participant demographics. All information was self-reported by the participants.

ranging in age from 16 to 50 years. The participant group included 5 teachers (3 BVI computer trainers and 2 computer teachers from regular K–12 schools), 7 BVI students currently enrolled or completed school (Unemployed) , and 3 working professionals in computing fields. Table 1 provides an overview of self-reported demographic data.

3.2 Interview Design and Procedure

The questionnaire for the semi-structured interviews was developed based on established guidelines in qualitative research [17, 33], and insights from prior studies involving BVI individuals [3, 20]. We designed separate sets of seed questions that aligned with our research questions for each participant group: students, teachers, and working professionals. For BVI students, seed questions were related to learning, e.g., *"What challenges did you face while learning computers and computing subjects?"*, *"How did you learn screen readers?"*. Teachers were asked questions pertaining to instruction, e.g., *"What strategies do you use to teach computing to BVI students?"*, *"What kind of training or resources have you received to support accessible instruction?"*. For working professionals, questions elicited retrospection, e.g., *"What do you wish you had learnt at school?"*, *"Given the computing industry demands, what should be included in the curriculum?"*.

The study began with obtaining informed consent, followed by a basic demographic questionnaire to collect participant background information. Next up was the semi-structured interview which lasted for approximately an hour, allowing for in-depth discussions and rich descriptions of personal experiences. Inspired by Hove and Anda's interview guidelines [11], we also asked follow-up clarification questions for responses that were unique, unclear, evasive, or inconsistent with earlier answers. Each participant received a $35.7 gift card (approximation after conversion from Indian Rupees) upon completion of the interview. All interviews were audio-recorded for data analysis.

3.3 Data Analysis

The annotators transcribed and if needed translated each of the transcripts into English to ensure uniformity in analysis. For analyzing transcribed data, we applied a hybrid thematic analysis method [5, 42] that combined both inductive and deductive coding. First, each researcher inductively analyzed their respective transcripts using open coding [37]. This involved an iterative, line-by-line review of the interview transcripts to uncover themes and patterns in the data. These themes were grounded in the participants' experiences, and in-vivo codes were used to preserve the interviewees' exact wording, capturing the core of their stories. Next, we proceeded to a deductive analysis where we mapped the codes derived from open coding onto established concepts from prior literature that aligned with our research questions. These concepts included self-learning, accessible education, technology adoption, and learning motivation. This process allowed us to examine how participants' learning/teaching experiences either supported or challenged current knowledge. Upon completing both coding phases, all authors collaboratively reviewed, discussed, compared, and assimilated the codes and emergent themes from both the inductive and deductive approaches to reach a consensus.

4 FINDINGS

The analysis revealed six notable themes described next.

4.1 Curriculum Structure

While most participants (11) (had) attended regular schools alongside sighted peers, following the same curriculum with exemptions from visually-oriented *"practical exams"*, the remaining participants (had) only attended specialized schools for the blind, which followed a similar curriculum but included additional accessibility training in ATs. Regardless, all participants indicated that they (had) attended additional *"computer training centers"* (or *cram* schools) for honing their computer skills and knowledge.

The curricula of regular and specialized schools focused mainly on theoretical computer science aligned with foundational concepts, such as explanations of concepts like *"What is a disk?"* or *"What is the full form of USB?"*. The students and teachers typically relied on recorded lectures and, when available, Braille-based textbooks, using similar methods as they did for subjects like history or literature. BVI students were often granted exemptions from practical, hands-on computing activities including exams that typically consisted only of theoretical questions, with no direct interaction with a computer (P13).

The computer training centers followed government-recommended curriculum (KEONICS[3]) tailored to suit IT industry requirements (P3, P2, P11). While they offered practical hands-on training including coding, the curriculum predominantly focused on developing basic skills such as *"Data Entry or Call-center operator,"* which were often considered a *"respectful office job"* for BVIs within their communities (P14,P9,P13). In essence, the curriculum was largely application-specific, focusing heavily on MS Office, particularly Excel, with an emphasis on repetitive routine tasks commonly required in administrative or clerical roles (P14, P11). When asked about teaching 'computing concepts' such as IDEs and coding, the trainers (P2, P3, P11) indicated that these *"advanced concepts"* were taught only if students needed them for specific jobs. In such cases, trainers would teach skills like *"HTML coding or using the Command Prompt"*.

4.2 Instructional Challenges

All computer trainers (P2, P3, P11) at training centers stated that they did not receive formal training in pedagogical methods, and often faced difficulties addressing the diverse learning needs of BVI students. They further mentioned that they were just volunteers, i.e., the centers requested them to teach BVI students, due to their expertise in using screen readers and their proficiency in Office-related software applications and Web browsing. P11 explained,

> *I have studied BA in literature, then I joined as SR trainer here [his training center] to teach computer skills, as there is no money to hire professional teachers. I try to follow the given curriculum and teach what I know from my own experience. If I don't know something and a student wants to learn, I prepare and learn first, then teach them. For me also, no one is there to teach, I somehow manage it.*

The trainers also mentioned that they struggled to customize instruction for students based on their specific visual conditions, age, and technical capability, and linguistic backgrounds. For example, P2 mentioned that if any student struggled with a particular topic for some time, due to time constraint, he would simply instruct that student to engage in peer-learning with other students who have understood the topic or those who speak the same language as the struggling student.

The computer teachers (P6, P15) in regular schools stated that they had received formal pedagogical training, but the training did not discuss much about accessibility and inclusiveness. They further mentioned that this lack of proper specialized training limited their ability to provide personalized support to BVI students. These teachers stated that their standard approach (as instructed by school management) to accommodating BVI students in their class was to simply make exemptions – skipping visually-oriented concepts, avoiding hands-on coding sessions, and theory-only exams without any practical computer tasks.

4.3 Peer-Guided Learning

The BVI students as well as the working BVI professionals stated that they (had) heavily relied on peer learning to grasp computing concepts, because the teachers were often unable to accommodate their individual learning needs. The BVI learners expressed that they often turned to their *"senior"* students who were more familiar with subjects and also proficient in efficiently performing computer tasks with a screen reader.

However, the students mentioned that such peer support was not always consistent. For example, P5 described:

> *"I would sometimes get help, but different people gave me different instructions, which was confusing. One would say, 'Press Ctrl + S to save the file,' while another would tell me to press 'Alt, go to File, and then select Save.' I was like who should I listen to."*

Suggestion of different shortcuts to execute the same tasks caused BVI students to often second-guess themselves and question which approach was the *"right"* one (P1,P5). Additionally, the guidance was naturally limited to the knowledge of their peers, which often restricted their peer learning to routine application-specific tasks without finding much help in programming or using developer tools (P7).

4.4 Self-learning Challenges

When asked about the extent of reliance on online learning sources for their computing education, all BVI students stated that besides the instructor provided subject material, they relied on either Google and YouTube to find manuals and tutorials pertaining to different subjects and concepts. However, most participants mentioned that these tutorials and 'how-to' videos were often inadequate, overly complex, or too generalized to offer context-specific solutions that they were seeking. P13 explained,

> *"The content is full of terms that someone new to this will not understand. It assumes you already know so much, which isn't the case for many of us... It either explains things in a way that doesn't make sense or it doesn't fully cover the exact issue I am dealing with."*

The participants also described difficulties in understanding the complex terminology used in online help manuals. For instance, P4 and P8 noted they were initially unfamiliar with terms like *"ARIA"* or actions such as *"Toggle"* which made it challenging to determine how the explanation in the documentation applied to their specific issues. Additionally, the participants sought a sequential list of actions (e.g., a sequence of keyboard shortcuts) as direct solutions to their problems, but such straightforward instructions were hardly available in the guides (P12). This issue extended to learning

[3]https://www.keonics.in/english/courses

through online tutorial videos as well. P5 described his efforts to learn programming from YouTube videos, but found them difficult to follow:

> *"I tried to use YouTube tutorials, but it's very hard to follow, even if they are accessible. The person gives instructions like click here or check the output, but he doesn't describe what is happening. I need more detailed instructions, like what shortcut to press or what exactly to expect when. Also, sometimes they use terms I don't understand, like terminal, path, or script. Normal people might know these easily, but for me it's confusing without someone explaining slowly."*

When discussing the computer textbooks and lectures used in general education classes, which served as a primary guide for many students, P1 and P13 noted that these materials were largely focused on delivering general theoretical computer education. They seldom included guidance on executing real-world tasks using specific applications, interpreting auditory feedback, or navigating accessibility features. Additionally, the textbooks relied heavily on figures, which were often difficult for BVI students to interpret or relate to without informative alternative descriptions.

4.5 Need for Simultaneous Learning

All BVI participants identified a major challenge in their education: the simultaneous learning of both computing concepts and SR software. This dual learning process was not only time-intensive and cognitively demanding, but also posed a significant barrier before they could progress to any programming-related concepts. P9 described this dichotomy as, *"it was not just about pressing keys"* but rather involved *"remembering where the keys are on the keyboard"*, *"decoding what the SR has said"*, and *"remembering how to respond"* usually recalling from her past experiences.

P7, P1, and P13 had no prior exposure to computers or the structure of a QWERTY keyboard, including the location and meaning of keys and symbols, and required *"a long time"* to familiarize themselves with the keyboard. They also described the complexity of scenarios where they needed to type in their native language (e.g., Hindi (P13)), which required them to not only learn the fundamentals of the SR and the keyboard but also navigate the intricate multilingual keyboard mappings between language characters, a challenge even for sighted users. P1 mentioned,

> *"Learning basic screen reader itself is challenging... It took a long time for me to learn where each key is. If I forget, then someone has to help. While navigating, I need to remember the shortcut, find the key on the keyboard, then understand what the screen reader says. It takes so long to get used to. My mind is always calculating, fixing errors, and it feels very slow. I get so tired and sometimes forget what I was learning in the first place."*

As a result, unlike their sighted peers, the participants spent a significant portion of their education focused on learning SRs, before progressing to learning actual computing concepts and subjects.

4.6 Employment after Education

Some of the BVI participants mentioned that although they graduated with a positive outlook and confidence in their computer skills post-education, they soon experienced professional setbacks. P14 noted, *"I thought that after this education, I would be able to get a job. But once I started working, I realized that what we learned only scratched the surface."* While the education and additional center-provided training ensured basic computer skills and SR knowledge sufficient for tasks such as writing emails, coding algorithms, using MS Office, and developing websites, it did not prepare students for highly competitive industry-level digital tasks that required in-depth coding knowledge, familiarity with developer tools, and the ability to work independently without peer assistance. P14 highlighted this gap:

> *"I had to learn things like analyzing charts and using data science tools, but we were only taught MS Word and Excel at the [training] center. It feels like we are being left behind while everyone else is moving forward... Practically, why would they [software companies] hire someone blind with only the basics and spend money on our training and SR license?... We are competing with sighted people for jobs. So we should learn SR quickly and move to proper coding and development to do tasks on par with the normal population. I think that's the only way... we need something to teach us SR early on and help us get used to 'how to learn on our own' different things, once that is done, we can learn by ourselves."*

After completing their education and additional training, some of the participants returned to their permanent residence (mostly in rural areas, with their family), as they were unable to support themselves for long periods due to the lack of immediate employment opportunities (P7, P8). In such circumstances, participants often lost access to computers, which they claimed led to a decline in their computer proficiency over time (P7, P8, P10).

5 DISCUSSION

Our findings highlight significant gaps in computing education for BVI students in resource-constrained developing countries like India. First (RQ1), K–12 curricula for BVI students focus only on theoretical computer science with no practical components or accessibility support. Even the supplementary training centers tailor their instruction around routine Office-application tasks suited for secretarial or call center jobs. Early K-12 training in accessibility, especially SRs, is absent, making it difficult later for students to focus on core computing concepts while simultaneously learning SRs. Individual learning needs are often unmet, online learning resources are less comprehensible, and peer-learning is inconsistent and often confusing. Second (RQ2), the teachers lack formal accessibility training, and BVI trainers are mostly volunteers with little knowledge of pedagogical preparation. The teachers also have limited time and flexibility to adapt the curriculum for personalizing instruction to BVI students, which often results in the BVI students being left-out of important computing subjects and even exams. To address these challenges, we next discuss plausible solutions that can potentially enhance computing education for BVI students in face of the resource constraints.

5.1 Computing curricula for Global South

Our findings reveal that, unlike computing education in the Global North, computing education in India reflect prevailing societal expectations that confine BVI students to predefined job roles such as transcription, clerical work, or call-center positions, rather than positioning computing as a viable career path. This is observable from the curriculum design, where only fundamental screen reader training is provided alongside computing concepts mostly in the later years of K12 education, thereby erecting learning barriers for BVI students due to the reasons uncovered in our study. We therefore recommend introducing SR learning much early in K12 education, providing BVI students ample time to acquire computer-interaction proficiency before engaging with core computing subjects. While the cognitive demands of auditory interaction can be challenging during early developmental stages [41], curriculum design can draw on research showing that multisensory learning (i.e., combining auditory, tactile, and visual inputs) enhances cognitive development [7]. This approach can foster greater autonomy in computing education for BVI students and help acquire general computer skills, allowing them to confidently delve into advanced computing concepts.

Beside the early introduction of SRs, we also recommend distributing the subject material across multiple K12 grades, in contrast to the status quo where all computing instruction is crammed into the last two K12 grade levels. As the students depend more on self-learning and peer-learning due to the limited inclusive-instruction abilities of teachers and limited availability of other training resources, syllabus distribution across grades will provide BVI students the much needed additional time to not only explore and comprehend the theoretical concepts, but also sufficiently practice and acquire practical computing skills such as coding.

5.2 'Smart' Self-Learning Tools

While a complete overhaul of the curriculum and comprehensive training for computer trainers may take a long time to achieve in resource-constrained developing societies like India, the current computing-education gaps can be partially bridged through affordable and accessible self-learning tools powered by AI techniques such as large language models. Leveraging natural language processing, these tools can generate learning exercises, provide real-time feedback, and personalize instruction and assessment. AI-driven tools are increasing being integrated into K–12 and higher education settings in the Global North [6]. These tools can simulate human-like interactions and support young learners in exploring complex subjects, including mathematics and computational thinking [12, 45]. By expanding their scope to include BVI-specific learning support, these tools will be able to support a more inclusive computing education environment worldwide. Comprehension issues in self-learning via online videos and documentation, as discussed under RQ1, can be also be potentially addressed using Generative-AI tools, given their strong capabilities in language comprehension and translation tasks [44]. This opens up opportunities for multilingual learning assistants that offer real-time guidance to BVI learners in their preferred language – the kind of support that is often not available through conventional teaching methods. Such tools could reduce systemic costs and enhance the accessibility of computing education by eliminating the need for individuals to travel and live in another city to obtain computing education [8].

5.3 Limitations

Our participant pool consisted of BVI individuals from a single region of India, offering insights into localized challenges. However, India's vast diversity in literacy, socioeconomic status, language, education systems, and urbanization [16, 34] suggests that training curricula and learning experiences may vary across states. Additional studies are needed to assess the generalizability of our findings. We included only blind participants, excluding those with moderate residual vision who may rely on a combination of ATs. Their learning needs may differ and warrant future investigation. Our study relied solely on interview data, which may not fully capture ground realities. In future work, we plan to conduct contextual inquiry studies across multiple computer training centers to assess instructional methods and teacher-student interactions in situ.

6 CONCLUSION

This study uncovered the challenges BVI students and teachers face in computing education in India. Curricula were largely application-specific, teachers lacked the pedagogical training to support BVI learners, and peer knowledge was limited, which restricted progression beyond basic tasks. Simultaneous learning of screen readers and computing sunjects was cognitively demanding. As a result, many BVI students abandoned computing careers and settled in clerical or customer service roles. The paper lastly discussed curricula modifications and smart self-learning tools that can potentially address these challenges and needs.

REFERENCES

[1] Rebecca Arzola. 2016. Collaboration between the library and office of student disability services: Document accessibility in higher education. *Digital Library Perspectives* 32, 2 (2016), 117–126.

[2] Catherine M Baker, Cynthia L Bennett, and Richard E Ladner. 2019. Educational experiences of blind programmers. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*. 759–765.

[3] Catherine M Baker, Lauren R Milne, and Richard E Ladner. 2019. Understanding the impact of TVIs on technology use and selection by children with visual impairments. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–13.

[4] Jeffrey P Bigham, Maxwell B Aller, Jeremy T Brudvik, Jessica O Leung, Lindsay A Yazzolino, and Richard E Ladner. 2008. Inspiring blind high school students to pursue computer science with instant messaging chatbots. In *Proceedings of the 39th SIGCSE technical symposium on Computer science education*. 449–453.

[5] Virginia Braun and Victoria Clarke. 2021. Thematic analysis: a practical guide. (2021).

[6] Helen Crompton, Mildred V Jones, and Diane Burke. 2024. Affordances and challenges of artificial intelligence in K-12 education: A systematic review. *Journal of Research on Technology in Education* 56, 3 (2024), 248–268.

[7] Mustafa Gazioğlu and Neslihan Karakuş. 2023. The impact of multisensory learning model-based tale-telling on listening skills and student opinions about it. In *Frontiers in Education*, Vol. 8. Frontiers Media SA, 1137042.

[8] Ashok Goel. 2020. AI-powered learning: making education accessible, affordable, and achievable. *arXiv preprint arXiv:2006.01908* (2020).

[9] Laxmi Gunupudi, Maryam Bandukda, Giulia Barbareschi, Tigmanshu Bhatnagar, Aanchal Singh, Satish Mishra, Amit Prakash, and Catherine Holloway. 2024. Scaffolding Digital Literacy Through Digital Skills Training for Disabled People in the Global South. In *Proceedings of the 26th International ACM SIGACCESS Conference on Computers and Accessibility*. 1–14.

[10] Alex Hadwen-Bennett, Sue Sentance, and Cecily Morrison. 2018. Making programming accessible to learners with visual impairments: a literature review. *International Journal of Computer Science Education in Schools* 2, 2 (2018), 3–13.

[11] Siw Elisabeth Hove and Bente Anda. 2005. Experiences from conducting semi-structured interviews in empirical software engineering research. In *11th IEEE International Software Metrics Symposium (METRICS'05)*. IEEE, 10–pp.

[12] Runke Huang, Yanan Bao, Yinkuo Wang, and Jiameng Wei. 2024. Exploring AI Tools in Early Childhood Education: Usage Patterns, Functions, and Developmental Outcomes. (2024).

[13] Earl W Huff Jr, Kwajo Boateng, Makayla Moster, Paige Rodeghero, and Julian Brinkley. 2021. Exploring the perspectives of teachers of the visually impaired regarding accessible K12 computing education. In *Proceedings of the 52nd acm technical symposium on computer science education*. 156–162.

[14] IBM Corporation. 2020. IBM SkillsBuild: Free Digital Learning Platform. https://skillsbuild.org/ Accessed: 2025-07-03.

[15] Infosys Limited. 2021. Infosys Springboard US: Digital Learning Platform. https://infyspringboard.us.onwingspan.com/web/ Accessed: 2025-07-03.

[16] Niraja Jayal. 2006. *Representing India: Ethnic diversity and the governance of public institutions*. Springer.

[17] Hanna Kallio, Anna-Maija Pietilä, Martin Johnson, and Mari Kangasniemi. 2016. Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *Journal of advanced nursing* 72, 12 (2016), 2954–2965.

[18] Vaishnav Kameswaran and Megh Marathe. 2023. Advocacy as Access Work: How People with Visual Impairments Gain Access to Digital Banking in India. *Proceedings of the ACM on Human-Computer Interaction* 7, CSCW1 (2023), 1–23.

[19] Shaun K Kane and Jeffrey P Bigham. 2014. Tracking@ stemxcomet: teaching programming to blind students via 3D printing, crisis management, and twitter. In *Proceedings of the 45th ACM technical symposium on Computer science education*. 247–252.

[20] Akshay Nayak Kolgar, Yash Prakash, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2025. Insights in Adaptation: Examining Self-reflection Strategies of Job Seekers with Visual Impairments in India. *arXiv preprint arXiv:2506.22741* (2025).

[21] Pawan Kumar and Sunil Kumar. 2022. ICT and employment in India: An analysis of organized sector. *The Indian Journal of Labour Economics* 65, 2 (2022), 373–395.

[22] Richard E Ladner and Andreas Stefik. 2017. AccessCSforall: making computer science accessible to K-12 students in the United States. *ACM SIGACCESS Accessibility and Computing* 118 (2017), 3–8.

[23] Leandro Luque, Leônidas O Brandão, Elisabeti Kira, and Anarosa AF Brandão. 2018. On the inclusion of learners with visual impairment in computing education programs in brazil: practices of educators and perceptions of visually impaired learners. *Journal of the Brazilian Computer Society* 24 (2018), 1–12.

[24] Ted McCarthy, Joyojeet Pal, and Edward Cutrell. 2013. The "voice" has it: screen reader adoption and switching behavior among vision impaired persons in India. *Assistive Technology* 25, 4 (2013), 222–229.

[25] Ted McCarthy, Joyojeet Pal, Tanvi Marballi, and Edward Cutrell. 2012. An analysis of screen reader use in India. In *Proceedings of the Fifth International Conference on Information and Communication Technologies and Development*. 149–158.

[26] Sean Mealin and Emerson Murphy-Hill. 2012. An exploratory study of blind software developers. In *2012 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*. IEEE, 71–74.

[27] Government of India Ministry of Education. 2020. National Education Policy 2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf Accessed: 2025-07-03.

[28] Ministry of Education, Government of India. 2021. AI for All Program – Ministry of Education. https://www.india.gov.in/website-ai-all-program-ministry-education Accessed: 2025-07-03.

[29] Ministry of Electronics and Information Technology, Government of India. 2024. Digital India. https://www.digitalindia.gov.in/

[30] Ministry of Skill Development and Entrepreneurship, Government of India. 2024. Skill India Digital Hub. https://www.skillindiadigital.gov.in/home

[31] NASSCOM and Ministry of Electronics and Information Technology, Government of India. 2020. FutureSkills Prime: A MeitY-NASSCOM Initiative. https://www.futureskillsprime.in/ Accessed: 2025-07-03.

[32] National Association for the Blind, India. 2024. National Association for the Blind, India. https://nabindia.org.in/

[33] Cindy Passmore, Alison E Dobbie, Michael Parchman, and James Tysinger. 2002. Guidelines for constructing a survey. *FAMILY MEDICINE-KANSAS CITY-* 34, 4 (2002), 281–286.

[34] Prabhu Pingali and Anaka Aiyar. 2018. Diversity in Development: Inter-state Differences in the India Growth Story. *World Food Policy* 4, 2 (2018), 57–77.

[35] Yash Prakash, Akshay Kolgar Nayak, Mohan Sunkara, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2024. All in One Place: Ensuring Usable Access to Online Shopping Items for Blind Users. *Proceedings of the ACM on Human-Computer Interaction* 8, EICS (2024), 1–25.

[36] Raghu Raman, Smrithi Venkatasubramanian, Krishnashree Achuthan, and Prema Nedungadi. 2015. Computer science (CS) education in Indian schools: Situation analysis using Darmstadt model. *ACM Transactions on Computing Education (TOCE)* 15, 2 (2015), 1–36.

[37] Johnny Saldaña. 2021. The coding manual for qualitative researchers. (2021).

[38] Fact Sheet. [n. d.]. Visual impairment and blindness. ([n. d.]).

[39] Andreas Stefik and Richard Ladner. 2017. The quorum programming language. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. 641–641.

[40] Andreas M Stefik, Christopher Hundhausen, and Derrick Smith. 2011. On the design of an educational infrastructure for the blind and visually impaired in computer science. In *Proceedings of the 42nd ACM technical symposium on Computer science education*. 571–576.

[41] Stella Timotheou, Ourania Miliou, Yiannis Dimitriadis, Sara Villagrá Sobrino, Nikoleta Giannoutsou, Romina Cachia, Alejandra Martínez Monés, and Andri Ioannou. 2023. Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and information technologies* 28, 6 (2023), 6695–6726.

[42] Mojtaba Vaismoradi, Jacqueline Jones, Hannele Turunen, and Sherrill Snelgrove. 2016. Theme development in qualitative content analysis and thematic analysis. (2016).

[43] Vision-Aid. 2024. Project Springboard. https://visionaid.org/project-springboard/

[44] Shen Wang, Tianlong Xu, Hang Li, Chaoli Zhang, Joleen Liang, Jiliang Tang, Philip S Yu, and Qingsong Wen. 2024. Large language models for education: A survey and outlook. *arXiv preprint arXiv:2403.18105* (2024).

[45] Jeannette M Wing. 2006. Computational thinking. *Commun. ACM* 49, 3 (2006), 33–35.