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Research Paper

AI-Powered Assistive Tools for Visually Impaired Students in STEM Education

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ABSTRACT

Background: In the era of inclusivity, it is necessary to adapt to the changing diversity of students' needs. To cater for these, many applications and benefits of artificial intelligence (AI) have been addressed that directly or indirectly enhanced the scenario of education. When the pointer is on students with disabilities, especially those with visual impairment, a great advancement has been recorded from various studies. **Objectives:** To find the challenges faced by visually impaired students in adapting STEM education and to analyze the role and effectiveness of AI-powered assistive tools in developing STEM learning. **Methodology:** A descriptive survey research design has been employed in the present study. The sample size contains 50 visually impaired students, including 38 secondary school students and 12 undergraduate students. Thematic analysis was used to study the qualitative data from semi-structured interviews and open-ended questionnaire items. **Result:** The findings confirm that significant issues to equal involvement involve the unavailability of lab work, diagrams, and symbolic content. The study revealed that AI-powered assistive tools can bring transformative reformation in STEM learning for visually impaired students. However, long-term achievement requires ongoing investment, training, and the appropriate design of an inclusive curriculum. **Conclusion:** The students' individuality, comprehension, and willingness in STEM learning have potentially been enhanced because of the introduction of AI, like voice-assisted tutoring, Braille converters, and smart screen readers. From the study, the maximum number of participants thought these tools are useful, but still there are various problems with affordability, support for local languages, and teacher readiness.

Keywords: *Assistive Technology, Visually Impaired Students, STEM Education, Inclusive Learning, AI in Education*

In today's knowledge-driven culture, STEM education is the cornerstone of innovation and advancement, economic expansion, and social advancement in today's dynamic world. However, visual aids like diagrams, graphs, symbols, simulations, and spatial reasoning are crucially playing a major role in STEM education. Students with visual impairment or disability pose serious difficulties; almost 2.2 billion individuals in world suffer from some vision impairment. According to the World Health Organization (2023), many students are there who want equal access to school, but unfortunately, the exceptional

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learning requirements of visually impaired students in STEM subjects are often ignored by conventional teaching approaches.

Although screen readers, tactile graphics, and Braille textbooks provide some assistance, often get insufficient when it comes to dynamic Science Technology Engineering and Mathematics topics. Similarly, interactive lab simulations, complex mathematical expressions, and real-time data visualizations are still unavailable via. Artificial Intelligence provides helpful strategies that go beyond the limitations of conventional technology. It has newly become a powerful catalyst for educational innovation. According to Luckin et al. (2016) and Al-Azawei, Serenelli, & Lundqvist (2016), AI-powered tools like adaptive Braille converters, voice-interactive learning platforms, smart screen readers, and object recognition software are starting to alter how visually impaired students utilize educational content in multiple formats and in real-time.

Despite these advancements, there is still some uneven application of Artificial Intelligence in inclusive education, especially in STEM subjects. Furthermore, AI technologies are sometimes developed without the concern of the involvement of individuals with impairments, which further leads to usability issues and faults in design. In order to assist visually impaired students effectively, it is imperative to investigate how AI-powered assistive technology might be fairly and systematically included in STEM instruction. This paper will examine the state of AI-based assistive technologies, evaluate how well it works in actual STEM settings, and offer ideas for enhancing accessibility and inclusion in education.

AI-powered assistive technologies have the potential to enhance STEM education for visually impaired students, but their practical application is often vulnerable due to various number of restrictions and moral dilemmas. Making technology affordable and accessible is one of the main challenges. Many radical AI solutions, such as smart screen readers and tactile displays, are costly and frequently out of reach for organizations in low and middle revenue nations. According to Almalki, Zhou, and Wang (2021), underfunded or rural locations lack the necessary infrastructure, consistent internet, compatible hardware, and common promotions for software applications.

A prominent concern is the lack of localized and multilingual AI systems. The majority of tool development in dominant languages, such as English, weakens their efficacy in linguistically diverse areas. STEM topics demand precise translations of technical words that many AI systems fail to deliver (Kheradia & Sharma, 2019).

Teacher readiness is also a challenge; many instructors are not educated to apply AI tools in inclusive classrooms, resulting in incorrect implementation (Papadopoulos et al., 2020). Additionally, errors in AI, such as misidentifying images or interpreting text, might result in false information that severely influences learning (Sawhney, Ahuja, & Bigham, 2020).

In order to explore how AI-powered assistive technology might be merged for visually impaired students in STEM education; this study makes use of two important theoretical models: Universal Design for Learning (UDL) and the Technology Acceptance Model (TAM). The Centre for Applied Special Technology (CAST) created UDL, which supports inclusive teaching techniques by exciting various forms of representation, expression, and participation to satisfy a range of learner requirements (CAST, 2018; Al-Azawei, Serenelli, & Lundqvist, 2016). With the help of intelligent assistive technologies like dynamic Braille displays and voice-interactive simulations, UDL pledges, content that is usually based on visual formats like equations, diagrams, and models can be made available through auditory, tactile, or digital alternatives in STEM contexts. Both educators and students must find AI-powered products beneficial. In order to extend the usability and importance, this paradigm highlights the need of user cantered design, which integrates visually impaired learners in the creation process (Kacorri et al., 2017).

The present study creates a systematic methodology for evaluating the usefulness and competence of AI-based assistive tools in developing an impartial STEM learning environment by administering these tools via the lenses of UDL and TAM.

Statement of the problem

Students with visual impairments still encounter substantial obstacles while trying to join STEM education, despite developments in technology. These days, a lot of educational setups lack flexible content circulation methods and inclusive structure. AI-powered assistive devices are also often underutilized due to poor awareness, exclusive costs, a lack of context-specific changes, and insufficient teacher training. To reduce these obstacles and increase the learning outcomes of visually impaired students in STEM subjects, we must explore how AI may be analytically included into educational frameworks.

Research gaps

Behind the AI's massive promises, still there are a number of unanswered questions. One of the major problems is the limited access of AI to some particular STEM fields, specifically physics and programming areas, where precise grammar and spatial thinking are vital (Kumar et al., 2020). Unavailability of multilingual and localized AI content shows another issue that hampers access in linguistically diverse areas (UNESCO, 2021). Further, poor usability and acceptance result in inadequate involvement of visually impaired people in the allocation of AI technologies. Lack of research on the long-term learning effects and instructional efficacy of AI-powered technologies in formal STEM education settings is also deficient in a larger view.

Objectives of the study

1. To identify the challenges faced by visually impaired students in adapting to STEM education.
2. To analyze the role and effectiveness of AI-powered assistive tools in developing STEM learning.

Research questions

1. What are the challenges faced by visually impaired students in accessing STEM education?
2. How do AI-powered assistive tools enhance the learning experience in STEM subjects?

Significance of the study

By exploring the relationship between AI technology and STEM approachability for visually impaired learners, this study contributes to a systematic discussion on inclusive education. It validates how intelligent assistive technology can alter conventional learning settings into welcoming areas that encourage equitable involvement. Educators, legislators, EdTech developers, and advocacy organizations working for educational justice would get theoretical benefit from the findings. Moreover, by encouraging equitable and inclusive learning chances for all, this study advances the more general Sustainable Development Goals (SDG 4: Quality Education).

REVIEW OF RELATED LITERATURE

Challenges in STEM education for visually impaired students

Visual aids like graphs, diagrams, and symbols are often used in STEM (Science, Technology, Engineering, and Mathematics) courses. For pupils with visual impairments, this can bring serious challenges. According to Sahin and Yorek (2009), scientific ideas commonly call on spatial thinking and abstract reasoning, which are challenging to carry out without the use of visual aids. Due to their visual nature and the shortage of practical substitutes, admittance to visual materials such as geometric diagrams, microscopic photographs, and physics experiment arrangements is restricted (Wiazowski, 2014). Furthermore, the majority of STEM programs shows deficit in the inclusive teaching strategies, which makes it more problematic for students with visual impairments to relate with the material (Kumar et al., 2020).

Evolution of assistive technologies

Historically, touch and sound were the key focus of assistive technologies for visually impaired students. Some of the educational access was made possible by resources including raised-line graphics, Braille texts, and help from human assistants (National Research Council, 2002). Thanks to technological expansions, visually impaired people now have improved access to text thanks to screen readers like JAWS and NVDA and OCR programs like Kurzweil 1000 (Kelly & Smith, 2011). Yet, because STEM topics often involve highly visual or spatial material, these technologies often fail to suit their objectives. Despite attempts made to remove this gap with tactile graphics printers and 3D-printed models, to solve the problems with budgets, production time limits, and interactivity persist (Landau et al., 2003).

Emergence of AI in assistive technologies

The field of assistive technology has seen a transformation to artificial intelligence (AI), which makes it possible for systems to respond, adapt, and diagnose the context. Computer vision is used by AI-powered products like Google's Lookout application and Microsoft's Seeing AI to characterize text, objects, and environments in real-time (Microsoft, 2019). AI is being majorly utilized in inclusive education for voice-activated navigation, intelligent tutoring systems, and real-time sensory interpretation (Almalki et al., 2020). As per the findings of research, AI-based tools outperform conventional techniques in various terms like efficiency, user happiness, and access to difficult content (Chen et al., 2021). Furthermore, these technologies provide personalized experiences that cater to the specific requirements and learning preferences of people with visual impairments.

Studies on AI applications in STEM for the visually impaired

AI with the potential to improve STEM education for visually impaired students is the subject of current research topics. Mostly in case of mathematical problems, chemical formulae, and repairing code support are being added to voice-activated systems such as Google Assistant and Amazon Alexa (Ravikumar et al., 2022). AI-based tactile output systems, such the Tactonom Reader and Touch Graphics' Talking Tactile Tablet, analyse and describe the graphs, equations, and models by uniting computer vision with tactile responses (Petrie et al., 2021).

When it is being utilized with suitable boundaries, real-time object recognition programs such as Seeing AI can recognize mathematical graphs or recognize lab equipment and certain experimental solutions are being established to help visually challenged learners in comprehend data trends by altering real-time graphs into tactile or auditory input (Giudice & Palani, 2019). These technologies have a lot of potential, but they are not widely used in schools in many instances.

Case studies and field insights

The Tactile Graphics with a Voice (TGV) technology was created in the United States by Microsoft Research and the University of Washington, which device helps the students to work with tactile graphics and get real-time audio feedback, through which they learn concepts like biology and geometry (Miele, Landau, & Gilden, 2019). In a similar way, Carnegie Mellon University evaluated contextual screen readers and AI tutors assist blind computer science students in autonomously interpreting code and graphics (Hurst, Kane, & Trowbridge, 2020).

AI and other inexpensive tactile graphic creation are collaborating in India through the Tactograph project, which is headed by Vision Empower and IIT Delhi. Through this approach, textbook knowledge can be instantly converted into embossed diagrams with local language audio commentary. But issues like expenditure and insufficient teacher preparation still exist. Students can now conduct experiments using spoken commands. These resources increased student engagement and interest by offering step-by-step auditory instruction and result interpretation (Papadopoulos, Koustriava, & Kartasidou, 2020).

Even with these satisfied results, there are still implementation issues. Tools' efficiency in a variety of situations is sometimes limited by their inability to support multilingual and region-specific courses. Moreover, a lot of AI systems depend on fast internet and common updates, which are frequently inaccessible in underfunded or remote institutions. Due to their lack of experience and training, educators are also hesitant to use AI tools (Almalki, Zhou, & Wang, 2021).

Hence, the case studies showed that radical potential of AI in inclusive STEM education, while emphasizing the need for continuous professional growth, physical resources support, and contextual alterations to guarantee the long-term and reasonable application of AI in STEM education.

THEORETICAL FRAMEWORK

The role of artificial intelligence in assistive education

Through the concept of individualized, adaptable, and accessible learning experiences being highly in demand, AI is transforming assistive education, mainly for students with some disabilities. AI helps in closing the gap between inclusive teaching approaches and traditional-style visual instruction for visually impaired students. The design of tools that interpret and transform visual content into aural or tactile forms is made conceivable by its accurate proficiencies in real-time object identification, speech processing, and data analysis (Holmes et al., 2019; Bigham et al., 2010).

Computer vision, which introduces programs like Google's Lookout and Microsoft's Seeing AI, is one of the key AI technologies. By initiating visual content like lab settings, diagrams, and graphs available, these tools accelerate STEM learning by offering real-time vocal descriptions of items, text, and surroundings (Bigham et al., 2010). Another key technology is natural language processing (NLP), which makes people to communicate with AI systems via voice instructions through smart assistants like Siri or Alexa. This inspires self-reliant learning and investigation (Zhou, Liu, & Wang, 2021).

To match the pace of students' progress and adapt instructional strategies accordingly, machine learning (ML) further personalizes the content (Luckin et al., 2016). Furthermore, AI advances haptic and perceptible technology by transforming visual data into precise tactile graphics or 3D-printed models that facilitate tactile understanding (Kumar, Pal, & Yadav, 2021). However, there remain barriers to wider adoption that include inadequate infrastructure, inadequate training for prospective teachers, and a lack of active participation from visually impaired users in the design process (Kacorri et al., 2017).

AI-powered tools for visually impaired STEM learners

By making the visual content more approachable, interactive, and user-friendly, AI-powered assistive technologies are revolutionizing STEM education in a way more extensively for visually impaired students. These resources promote self-directed learning among the students and interaction with STEM ideas through a proper blend of digital, tactile, and aural techniques.

Smart screen readers, such as Google's Lookout and Microsoft's Seeing AI, are been proved as revolutionary tools that use computer vision and natural language processing (NLP) for analyzing text, graphs, and scientific symbols and provide vocal feedback in real time (Sawhney et al., 2020). By providing necessary related insights into visual data, such as equations and chemical symbols, these technologies overcame the capabilities of traditional screen readers.

AI-assisted Braille conversion systems, such as MathML Cloud and Liblouis, are the more creative approaches as they use real-time semantic analysis to make complicated STEM data translation into tactile Braille (Kheradia & Sharma, 2019). These techniques enable dynamic Braille displays that enhance accessibility by adapting to different scientific forms OF STEM Education.

Additionally, graph and object identification technologies are becoming more available, enabling students to incorporate graphs and lab apparatus using tactile representations or speech explanations, and also use haptic or aural feedback. Applications such as AI Graph Recognition (AIGR) and Seeing AI's graph-reading function aid in the interpretation of visual data (Kumar, Pal, & Yadav, 2021).

Moreover, the visible significant development is voice-interactive lab simulations. Students can make them involve fully in laboratory activities by conducting experiments with voice instructions and receiving auditory feedback through platforms like Talking Lab Assistants and Virtual Haptic Simulators (Papadopoulos, Koustriava, & Kartasidou, 2020). Furthermore, scientific diagrams or molecules can be transformed into tactile models with audio descriptions using AI-enhanced 3D printing technologies (Abraham, Manogaran, & Marimuthu, 2020). These bring development and encourage more autonomy in STEM education among students and lessen the need for human support.

RESEARCH METHODOLOGY

Research design

A descriptive survey research design has been employed in the present study. The researcher has gathered information from visually impaired students engaged in STEM education by administering semi-structured interviews and questionnaires. It systematically enabled to identify challenges and measures the function and efficacy of AI-powered assistive technologies in enhancing availability and learning outcomes.

Population and Sample

Visually impaired students of Mayurbhanj area pursuing secondary and undergraduate degrees in fields of science, technology, engineering, and mathematics were the study's population. From this, fifty visually impaired pupils were selected by a purposive sampling method. Samples were chosen due to their active involvement in STEM education. The researcher has made sure that their responses appropriately reflected the real difficulties and encounters with AI-powered assistive technology.

Sampling Technique

Purposive sampling has been utilized in the present study to collect in-depth information from a particular group with particular educational needs, as Purposive sampling is appropriate because there isn't numerous visually impaired STEM students compared to students without visual disability, and their inclusion required targeted identification. From Baripada block, 2- degree colleges and one special education secondary school have been selected purposefully.

Sample Size

The sample size contains 50 visually impaired students, including:

- 38 secondary school students
- 12 undergraduate students

It has been considered as an adequate number for exploratory research, balancing probability with the need for sufficient data to generate meaningful investigation.

Variables of the study

- **Dependent variable:** Effectiveness, independence, and engagement are used to gauge the learning outcomes and accessibility experiences of visually impaired STEM students.
- **Independent variable:** Use of AI-driven assistive technologies, such as voice-activated tutors, tactile graphics with voice support, screen readers with STEM add-ons, and a Braille converter.

Tools and techniques for data collection

To gather data for this study, semi-structured interviews and a structured questionnaire have been used. Likert scale and multiple-choice (closed-ended) items in a structured questionnaire have been used to measure the difficulties and efficacy of AI tools. In order to collect students' individual thoughts and experiences, it also included open-ended questions. A smaller set of participants responded in semi-structured interviews to learn more about learning difficulties, availability concerns, and the real-world applications of AI-powered assistive technology.

Procedure of data collection

Depending on the accessibility necessities of the participants, questionnaires have been given electronically and in Braille throughout the first phase. Semi-structured interviews were carried out both in physical and online modes using screen reader assistance during the second phase. In order to ensure correct responses, the researcher guaranteed informed consent, confidentiality, and offered essential direction throughout the procedure.

Data analysis techniques

Thematic analysis was used to study the qualitative data from semi-structured interviews and open-ended questionnaire items. The researcher has coded, recorded, and categorized the answers into themes that represent the complications and experiences of students with visual impairments. The researcher presented the results in an understandable and efficient manner using pie charts and bar charts.

Ethical consideration

The research is based on the following ethical considerations:

- Informed consent was obtained from all participants.
- Data confidentiality and anonymity were strictly maintained.
- Participation was voluntary, and participants had the right to withdraw at any time.
- Findings were reported honestly, without manipulation or distortion of data.

Data Analysis and Interpretation

In order to evaluate the efficacy of AI-Powered Assistive Tools for Visually Impaired Students in STEM Education, the present chapter focuses on the analysis and interpretation of student responses. To gain significant insights, the researcher employed both quantitative and qualitative techniques.

Fifty visually impaired individuals enrolled in secondary and undergraduate STEM courses made up the targeted sample for the study. Semi-structured interviews and structured questionnaires were used to gather information. Thematic coding of qualitative responses and descriptive data, such as frequency, percentage, and mean scores, has been included in the analysis of data gathered.

1. Data analysis and interpretation of research objectives

Objective 1: *To identify the challenges faced by visually impaired students in adapting to STEM education.*

The major obstacle to STEM education, as per the majority of respondents (78%), is the absence of diagrams, graphs, and symbols. Because there were insufficient hands-on or auditory choices, nearly 64% of respondents said that they struggled with laboratory experiments. Additionally, 58% of respondents reported having trouble using digital resources and traditional textbooks that were mismatched with screen readers. Open-ended questions emphasized psychological obstacles such as low self-esteem and social stigma, dependence on peers and teachers, and limited access to practical resources.

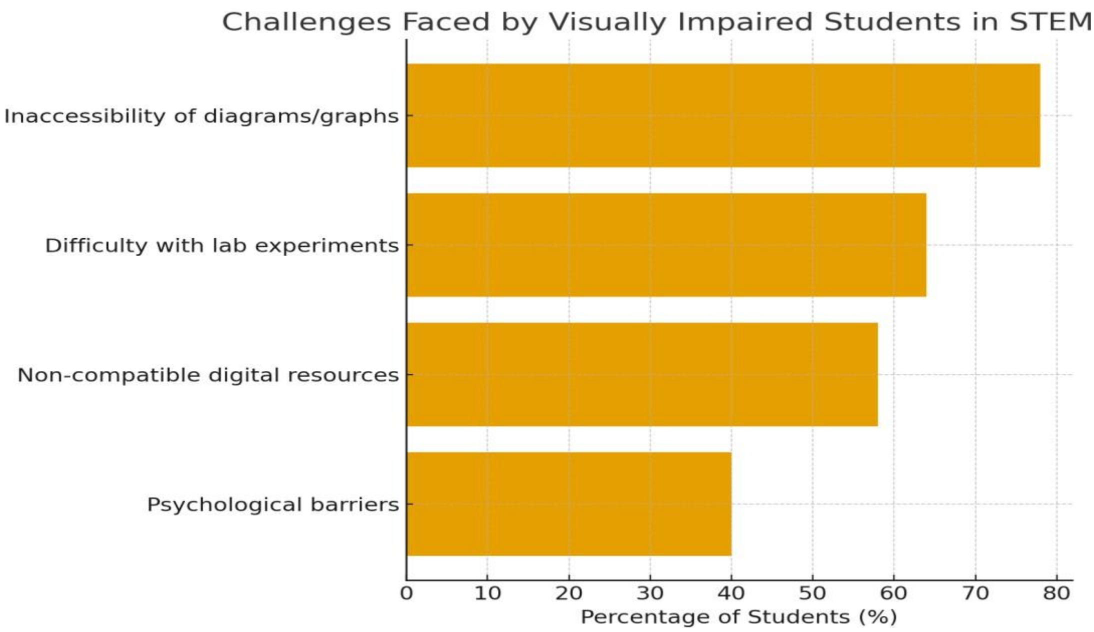

Fig. 1: Descriptive Statistics of the Difficulties Visually Impaired Students Face

Objective 2: *To analyze the role and effectiveness of AI-powered assistive tools in developing STEM learning.*

Out of the 50 participants, 42 (84%) have minimum experience with AI-powered items such as voice-assistive instructors, AI-based Braille translators, and screen readers with STEM add-ons. From these, 67% participants thought that AI technologies are "very effective" at helping them understand difficult science and math concepts, and 21% thought "moderately effective." Due to limited technical support and poor language customisation, only 12% of participants said these tools had a slight effect. Improvements needed in individuality, engagement, and real-time accessibility have been revealed via thematic analysis. However, challenges with affordability (46%) and the lack of assistance in the local language (39%) persisted.

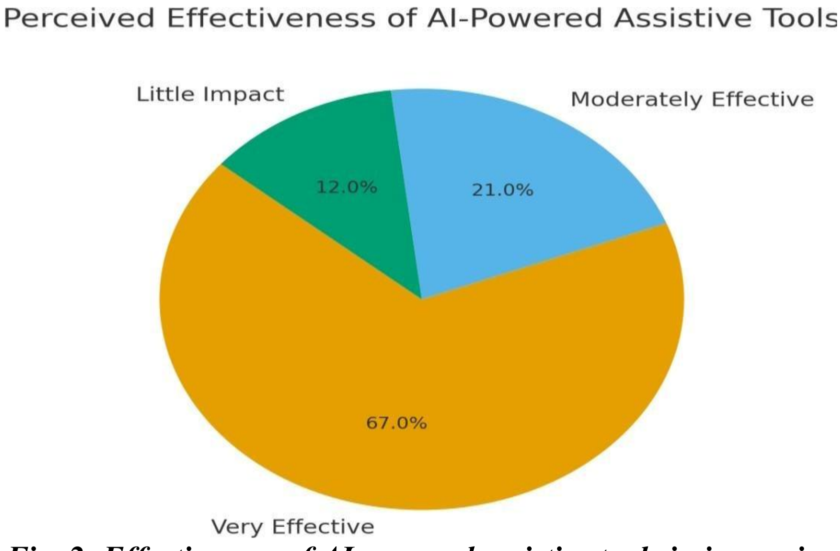

Fig. 2: Effectiveness of AI-powered assistive tools in improving STEM.

Data analysis and interpretation of research questions

RQ 1: *What are the challenges faced by visually impaired students in accessing STEM education?*

As STEM education is primarily a hindrance for visually handicapped students and they have substantial challenges. Access is a challenge, since core concepts frequently rely on graphs, diagrams, symbols, and visual experiments (Sahin & Yorek, 2009). For dynamic or abstract content, conventional tools like tactile graphics and Braille textbooks offer little assistance. According to Wiazowski (2014) and Kumar et al. (2020), many STEM curricula are not designed with inclusive teaching in mind. These difficulties are aggravated by the absence of readily available resources, particular teaching techniques, and suitable teacher preparation. Furthermore, active participation and engagement are restricted by the inability to interact with visual data in real time, specifically during lab trials.

RQ 2: *How do AI-powered assistive tools enhance the learning experience in STEM subjects?*

For visually challenged students studying STEM, AI-powered tools significantly increase accessibility and involvement. Real-time, multimodal content sharing made possible by innovative technologies such as intelligent screen readers (like Seeing AI), AI-enabled Braille converters (like MathML Cloud), and voice-guided lab simulations (Kheradia & Sharma, 2019; Sawhney et al., 2020). The utilization of tactile and aural techniques enables students to actively engage themselves in STEM topics on their own. This helps in understanding in-depth and difficult ideas of data formats, systematic scientific procedures, and equations, AI-powered graph and object recognition systems, data interpretation and laboratory work (Giudice & Palani, 2019).

Moreover, AI enhances learning independence and personalization. Machine learning processes improve comprehension and retention by accepting to each learner's unique learning preferences and requirements. Students can find geographical data and conduct experiments with slight assistance appreciation to voice-interactive tools and tactile feedback systems (Papadopoulos et al., 2020).

Notwithstanding their potential, obstacles still exist. There are still problems with infrastructural preparedness, localized content, teacher preparation, and affordability. For tools to be inclusive, relevant, and usable, visually impaired users must be involved in their creation (Kacorri et al., 2017). It is also necessary to address ethical issues like consent and data privacy (Hussein et al., 2021).

MAJOR FINDINGS

Findings of the study

The findings of the present study are summarized down according to the stated objectives:

Challenges in STEM education:

- Out of all, 78% of participants said they have trouble deciphering graphs, diagrams, and symbolic representations.
- The lack of tactile or auditory alternatives creates challenges for 64% of laboratory-based experimenters.
- From the total responses, 58% have trouble using digital resources and traditional textbooks that aren't compatible with screen readers.
- The dependency on teachers and peers, increased tactile exposure, and diminished confidence as a result of social stigma are all highlighted by qualitative replies.

Effectiveness of AI-powered assistive tools:

- From overall responses, 84% of participants have exposure to AI-powered assistive tools.
- Out of these, 67% responses were "very effective," 21% as "moderately effective," and 12% as "less effective" have been recorded.
- The tools enhance self-reliance, understanding, and interest in STEM education.
- The lack of localized language support (39%) and affordability (46%) continued to be the major challenges.

Results and discussion

The findings highlighted the complicated reality of visually impaired students in STEM education. They face severe challenges due to the visual nature of STEM content, but they also have availability of powerful AI-assisted tools.

The study reveals that the maximum issues for visually impaired learners are graphs, symbols, and hands-on activities (Sahin and Yorek, 2009). While tactile visuals and Braille are helpful tools, they are unable to adequately convey intellectual and dynamic STEM concepts (Wiazowski, 2014). This study validates the findings of Kumar et al. (2020), who highlighted the deficits of existing inclusive prospectuses and the lack of teacher preparation.

AI-powered technologies have a lot of potential to overcome the issues. Smart screen readers, AI-friendly Braille converters, and voice-guided simulations improve accessibility, bring liberation, and stimulate involvement in STEM activities, stated by Kheradia and Sharma (2019) and Sawhney et al. (2020). Most of studies revealed, participants attested to these benefits, mostly in terms of understanding difficult subjects and developing self-assurance in STEM education.

Trending restrictions highlighted systemic problems, the concern expressed by Kacorri and others (2017) and Hussein et al. (2021) that are imitated in issues including pricing, lack of language customization, and insufficient teacher preparation. These difficulties indicate that although AI technologies are beneficial, their effectiveness is uneven in the absence of institutional assistance, regulations, and locally applicable information.

The study revealed that AI-powered assistive tools can bring transformative reformation in STEM learning for visually impaired students. However, long-term achievement requires ongoing investment, training, and the appropriate design of an inclusive curriculum.

Recommendations and future directions

An inclusive methodology is required for the major integration of AI-powered assistance aids in STEM education for visually impaired pupils. Most importantly, inclusive and participatory design must to be given top importance. To safeguard that AI solutions are beneficial, culturally appropriate, and satisfy learners' individual needs, developers must collaborate with educators, accessibility specialists, and visually impaired users (Kacorri et al., 2017). Moreover, teacher preparation is important; teachers need to improve in digital literacy, accessibility standards, professional development and the use of AI in the classroom. AI in classroom use can be enhanced by conducting workshops, certifications, and useful manuals (Almalki, Zhou, & Wang, 2021).

It is important to deal with infrastructure and affordable facilities. To assure the access in places with inadequate resources, these needs promoting collaborations between the public and private segments, providing hardware subsidies, and emerging open-source or offline-compatible solutions (Hussein, Siddiqi, & Ali, 2021). The curriculum placement and localization are critical to be useful in various educational settings. AI should be multilingual and represent the national STEM curriculum (Kheradia & Sharma, 2019). Data security and ethical governance must influence the positioning of AI that contributes towards protecting vulnerable students, clarity in procedures on informed consent, privacy policy, and reasonable use are necessary to make it effective (Hussein et al., 2021).

Last but not least, certifying AI technologies equitably can bring a major shift in STEM education for visually impaired children, where it requires inclusive design, complete teacher training, infrastructure support, localization, and solid ethical principles.

CONCLUSION

The present study focused on the continued challenges as well as the enormous potential of assistive technology determined by AI for visually impaired students in STEM education. The findings confirm that significant issues to equal involvement involve the unavailability of lab work, diagrams, and symbolic content. The students' individuality, comprehension, and willingness in STEM learning have potentially been enhanced because of the introduction of AI, like voice-assisted tutoring, Braille converters, and smart screen readers. From the study, the maximum number of participants thought these tools were useful, but still, there are various problems with affordability, support for local languages, and teacher readiness.

So, AI-powered assistive tools proved to be a hopeful avenue for inclusion, but their success will rely on constant efforts to merge technology with inclusive teaching methods, efficient training programs, and supportive policy implementation. By identifying these systemic gaps, AI can evolve from a simple aid into a driving force for equity in STEM education.

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Conflict of Interest

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