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Research Article

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Empowering BVI Students in Mathematics: The Impact of STEM KIT Tiles and Board

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Abstract

Blind and Visually Impaired (BVI) students have historically been excluded from mathematics education due to perceived challenges in teaching them. While inclusive education policies have been adopted for individuals with special needs, many BVI students are still exempted from mathematics, particularly in upper basic education (grades 1–9), where sighted teachers often rely on limited tools like the Cubarithm and Abacus. Despite this, research indicates that many BVI students have a strong interest in STEM fields, and those who develop visual impairments during tertiary education often face frustration and exclusion from STEM disciplines.

This study explores the impact of a three-day workshop introducing STEM Tiles and Boards to BVI students and their teachers. Findings reveal that these tactile tools fostered a positive learning experience for BVI students, enhancing their engagement and understanding of mathematics. Teachers also reported improved confidence and effectiveness in delivering mathematical concepts. Following the workshop, the STEM Tiles and Boards were distributed to participating schools for continued use, demonstrating their potential to support inclusive STEM education for BVI students. This research underscores the need for scalable interventions to address the accessibility gap in mathematics education for BVI learners.

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Introduction

The education of blind and visually impaired (BVI) students has long been fraught with challenges, particularly in the area of mathematics. Historically, the perceived difficulty of teaching mathematical concepts to BVI students has led to their exclusion from mathematics education, often under the assumption that the subject is inherently inaccessible to them. This misconception, coupled with the lack of specialized resources and trained educators, has contributed to the marginalization of BVI students in science, technology, engineering, and mathematics (STEM) fields. However, in recent years, inclusive education policies have gained traction, emphasizing the need to integrate students with special needs into mainstream educational settings. In many cases, BVI students are now placed in inclusive classrooms, where they receive instruction from sighted teachers across a variety of subjects, including mathematics.

Despite this progress, there remains a significant gap in the tools and methodologies available to support BVI students in mastering mathematical concepts (Adelakun,2020b). Traditional aids such as the abacus and cubarithm are sometimes employed, but they often fail to fully address the complexities of modern mathematical curricula. The lack of appropriate, tactile, and accessible resources has contributed to a situation in which many BVI students are excluded from STEM subjects entirely, particularly at higher levels of education. Moreover, research indicates that many BVI individuals express a strong interest in STEM fields, and some even pursue tertiary-level education in these disciplines, only to face significant barriers after acquiring blindness later in life.

This paper presents a study conducted to evaluate the effectiveness of a set of innovative STEM learning tools—STEM Kit Tiles and Board—designed to assist BVI students in understanding and engaging with mathematical concepts. By organizing a three-day workshop for both BVI students and their teachers, the study seeks to assess the impact of these tools on the participants' ability to grasp mathematical concepts, as well as on their teachers' pedagogical approaches. Following the workshop, the tools were distributed for use in the participants' respective schools, providing an opportunity for continued learning and engagement. This paper explores the results of the workshop, providing insights into how tactile and interactive learning materials can empower BVI students in their pursuit of mathematical literacy and STEM education.

The education of blind and visually impaired (BVI) students in mathematics has historically been a challenge due to the lack of accessible resources, specialized teaching methods, and the prevalent belief that mathematics is inherently difficult for students with visual impairments. This study addresses this gap by evaluating the effectiveness of a novel tool—STEM KIT Tiles and Board—designed to enhance the learning of mathematical concepts for BVI students. The significance of this study lies in its potential to provide empirical evidence supporting the integration of tactile learning tools into mathematics education for BVI students, which has been an underexplored area in existing research.

By assessing the impact of these tools on mathematical learning outcomes, this study aims to demonstrate that BVI students can significantly improve their understanding of complex mathematical concepts, given the right resources and teaching strategies. The results of this study could inform future pedagogical practices and lead to the adoption of more inclusive teaching tools in classrooms worldwide. Furthermore, the research will offer insight into how teachers can effectively implement tactile resources to support students with special educational needs in mathematics, a critical skill for STEM-related career paths. The findings may also contribute to the broader conversation on inclusive education, advocating for better support systems for BVI students in the science, technology, engineering, and mathematics (STEM) fields.

The teaching of mathematics to blind and visually impaired students has faced significant barriers due to the traditional reliance on visual teaching methods, which are not accessible to students who cannot rely on sight. Historically, this has led to the exclusion of BVI students from mathematics education or their relegation to simplified, remedial instruction (Berry**,** 2018**).** In many educational systems, BVI students have been exempted from mathematics curricula altogether due to concerns about the complexity of teaching abstract concepts without visual aids **(**Phutane et. al, 2022, Mwakyeja,2013**).**

However, recent shifts in educational policy toward inclusive education have prompted the development of more inclusive teaching methods that aim to integrate students with disabilities into mainstream classrooms. While some progress has been made, there remains a lack of specialized, tactile teaching tools for subjects like mathematics, which often requires an understanding of abstract spatial relationships, geometry, and symbolic reasoning. The use of traditional aids such as the abacus or Braille mathematics has offered some support, but these tools are limited in their scope and cannot fully address the breadth of modern mathematical curricula (Wairimu, 2019**).**

Tactile learning tools have emerged as a promising approach to address the challenges faced by BVI students in STEM education (Mungunda, 2023). Tools such as tactile graphics, 3D models, and specialized boards for mathematics have shown success in helping BVI students understand mathematical concepts that require spatial reasoning and manipulation of shapes or numbers. Recent studies have indicated that students who are provided with tactile, kinesthetic learning experiences are able to engage more fully with mathematical concepts compared to those who rely solely on auditory explanations (Annisa, Aan, & Tatang, 2019).

One notable innovation in this area is the use of tactile tiles and boards that allow BVI students to physically manipulate geometric shapes and numerals. These tactile tools enable students to gain a deeper understanding of mathematical principles by providing hands-on experiences that can be directly linked to abstract concepts like algebra and geometry. Studies such as those Ahmad (2024) demonstrate that tactile aids improve spatial understanding, enhance problem-solving skills, and increase students' engagement with mathematical content.

Moreover, teacher training and professional development in inclusive education practices are essential for ensuring that BVI students benefit from these tools. Research has highlighted the critical role that teachers play in adapting their pedagogical approaches to meet the needs of students with disabilities (Alquraini, & Gut, (2012). As such, any intervention designed to support BVI students in mathematics must not only focus on the tools themselves but also on how educators use these tools in the classroom setting.

Understanding the experiences and perceptions of both students and teachers is crucial to evaluating the effectiveness of new educational interventions. Several studies have explored how feedback from students with disabilities can help refine teaching methods and improve educational outcomes. For instance, research by Bryant et al. (2019) on BVI students in inclusive classrooms suggests that when students are actively involved in providing feedback on the tools and resources they use, teachers are better equipped to adjust their strategies and make learning more accessible.

In parallel, feedback from teachers is also essential, as they are the key implementers of inclusive practices in the classroom. Teacher perspectives on the usability, flexibility, and educational value of new learning tools can provide valuable insights into their potential for sustained use in the classroom (Abrahamson, 2020). Additionally, teachers' ability to integrate these tools into their daily teaching practices, along with their comfort level and confidence in using them, is a major determinant of their effectiveness.

Despite the growing interest in inclusive education and the development of tactile tools for BVI students, there remains a lack of comprehensive studies that assess the long-term impact of such tools on students' academic outcomes, particularly in mathematics. Most existing studies focus on the theoretical potential of tools or report on limited case studies (Adelakun, 2020), leaving a gap in large-scale, empirical research that can provide evidence of effectiveness across different student populations and educational contexts (Ahmed, 2020). This study aims to fill this gap by evaluating the impact of the STEM KIT Tiles and Board on both the mathematical learning outcomes of BVI students and the instructional practices of their teachers.

Purpose of the study

- To gather and analyse qualitative and quantitative feedback from at least 30 BVI students and 100 teachers on the effectiveness of the STEM KIT Tiles and Board, identifying key themes to inform future educational practices.
- To assess the impact of STEM KIT Tiles and Board on the mathematical learning outcomes of BVI students, measured by a 20% increase in test scores over a three-month period.

Research Questions

RQ1: What are the perceptions of BVI students and their teachers regarding the effectiveness of STEM KIT Tiles and Board, and what key themes emerge from their feedback to inform future educational practices?

RQ2: What is the impact of using STEM KIT Tiles and Board on the mathematical test scores of BVI students, and does this result in a 20% improvement over a three-month period?

Hypotheses:

- ***H_{o1}****: The use of STEM KIT Tiles and Board has no significant impact on the mathematical test scores of BVI students, and it does not result in a 20% improvement over a three-month period.*
- ***H_{o2}****: There are no significant perceptions among BVI students and their teachers regarding the effectiveness of STEM KIT Tiles and Board, and no meaningful themes emerge from their feedback that could inform future educational practices*

The Intervention

The intervention used in this study is the STEM Tiles and Board which is a component of the STEM Kit ®. The board is metallic while the Tiles are magnetic. The tiles are meant to be arranged on the board like the sighted write with pen on the exercise books. Each tiles have inscription of either figures or letters or mathematical function, these are displayed in print and braille. The design is to remove the communication gap between the sighted teachers and the BVI, as the teacher views the print the BVI feel the braille. The tiles when arranged will show exactly

what the sighted calculation shows in the exercise book. An example is shown below.

Different topics were covered during a 3-day workshop where teachers teach Primary pupils and students from junior secondary school's topics in their school curriculum. They were being guided step by step and stage by stage.

The teachers were taught to mark the work of the BVI after each questions since it's not possible to work more exercises on the board at a time. They were also taught to take a picture of the work and label so it can be printed and marked after the class. This gives the BVI opportunity to participate fully in the classroom teaching and assessments thus no disparity in the learning outcomes.

However, the BVI are allowed to choose suitable way to pick the tiles, either from the box directly or arranged the tiles figures, number and function in different part of the board before start of the mathematics lesson.

Research Methodology

Research design

This study employs a mixed method research design, focusing on the experiential and perceptual data collected during a three-day workshop with BVI students and their teachers. The workshop was structured to provide both theoretical and practical sessions, enabling participants to engage with STEM KIT Tiles and Board comprehensively.

The participants in this study included a group of thirty BVI students purposively selected from schools from seven states in Nigeria, as well as their mathematics teachers and support teachers. The students ranged from basic (grades 4 to 6) to upper-basic (grades 7 to 9) levels of education, with a diverse range of visual impairments, including congenital blindness and acquired blindness. The one hundred teachers are general educators who teaches mathematics in inclusive classrooms. They were not formally trained in special education and they are sighted. 40% of the BVI were female while 60% are male. 10% of the teachers were Head of their institutions (Above 25 years), 20% were seniors (20-25years teaching experience), 40% were intermediate (10 to 19years teaching experience) and 30% were junior (less than 10 years teaching experience).

Table 1: Teaching Experience of the Teacher Participants.

Years of teaching experience	NUMBER OF TEACHERS	PERCENTAGE %
Above 25years	10	10
20-25years	20	20
10-19years	40	40
Less than 10 years	30	30
TOTAL	**100**	**100**

The workshop was structured over three days, with a focus on hands-on learning using the STEM Kit Tiles and Board. The materials were designed to be fully tactile and accessible, allowing BVI students to manipulate and engage with mathematical concepts through touch. The Tiles consist of figures and various geometric shapes and patterns, each tile has both braille and print labels while the Board is a tactile grid that facilitates spatial understanding and the manipulation of numerical data. Together, these tools provide a means for students to interact with mathematical concepts such as arithmetic, geometry, and algebra.

The workshop was divided into three key phases:

- **Introduction and Orientation**: On the first day, participants were introduced to the STEM KIT Tiles and Board, including a demonstration of their functionality and potential applications in teaching mathematics. This session included hands-on demonstrations of how the tiles could be arranged to represent mathematical problems. Initial feedback was collected to gauge participants' initial perceptions and expectations.
- Mathematical Concepts Exploration: On the second day, the participants worked on a series of exercises designed to teach fundamental mathematical concepts, such as addition, subtraction, multiplication, and basic algebra, using the STEM Tiles and Board. The focus was on encouraging active problem-solving and collaborative learning. Participants were encouraged to explore the tools independently and collaboratively, fostering a hands-on learning environment.
- Teacher Training and Pedagogical Strategies: A key component of the workshop was training teachers on how to integrate the STEM Tiles and Board into their existing curricula. Teachers were encouraged to develop individualized strategies for incorporating the tools into their lessons, based on the unique needs and abilities of their students. Participants provided comprehensive feedback on their experiences, including perceived challenges and benefits of using the STEM KIT Tiles and Board. This phase also involved reflective discussions to assess the overall impact on participants' attitudes towards mathematics education.

Ethics

Ethical approval was obtained from the ethics committee of the College as recommended by TETfund. Informed consent forms was distributed to head teachers of the schools invited for the research. The invitation was purposive because only teachers and students who completed the informed consent in inclusive

schools or special schools where mathematics is taught by sighted teachers were invited as participants for the workshop. Similarly, only BVI from such schools were also invited. These documents were submitted to the committee and it was clearly explained in the form to the participants that their participation was voluntary and that they could withdraw at any time.

Data Collection

Data was collected through a combination of qualitative and quantitative methods to assess both the immediate impact of the workshop and its potential long-term benefits. The following data collection methods were employed:

- **Pre- and Post-Workshop Assessments:** The BVI Participants were given a series of pre- and post-workshop assessments to measure their understanding of key mathematical concepts before and after using the STEM Kit Tiles and Board. These assessments were designed to test skills such as number recognition, basic arithmetic, and spatial reasoning.
- **Teacher Feedback and Observations:** Teachers were asked to provide feedback on the usefulness of the tools, their own learning experiences, and their perceptions of the students' engagement with the materials. Additionally, teachers were asked to complete a post-workshop survey that assessed their confidence in teaching mathematics to BVI students using the STEM Tiles and Board.
- **Student Feedback:** Students were encouraged to provide feedback on their experiences with the STEM Tiles and Board through interviews and focus group discussions. These sessions allowed for an in-depth exploration of the students' perspectives on the tools and their learning experiences.
- **Follow-Up Evaluation:** A follow-up evaluation was conducted four months after the workshop to assess the continued use and effectiveness of the STEM Kit Tiles and Board in the participants' schools. Teachers and students were surveyed to determine if the tools had been integrated into regular teaching practices and whether they continued to support students' mathematical learning. The post-test was administered in their schools by a research assistant who conducted the pre-test.

Data Analysis

The data collected from the assessments, surveys, and interviews were analysed using both qualitative and quantitative methods. Quantitative data from the pre- and post-workshop assessments were analysed using paired t-tests to determine whether there was a statistically significant improvement in students' mathematical understanding. Qualitative data from the teacher and student feedback were analysed thematically to identify recurring patterns, key insights, and areas for further development.

Results

Pre and post workshop assessment

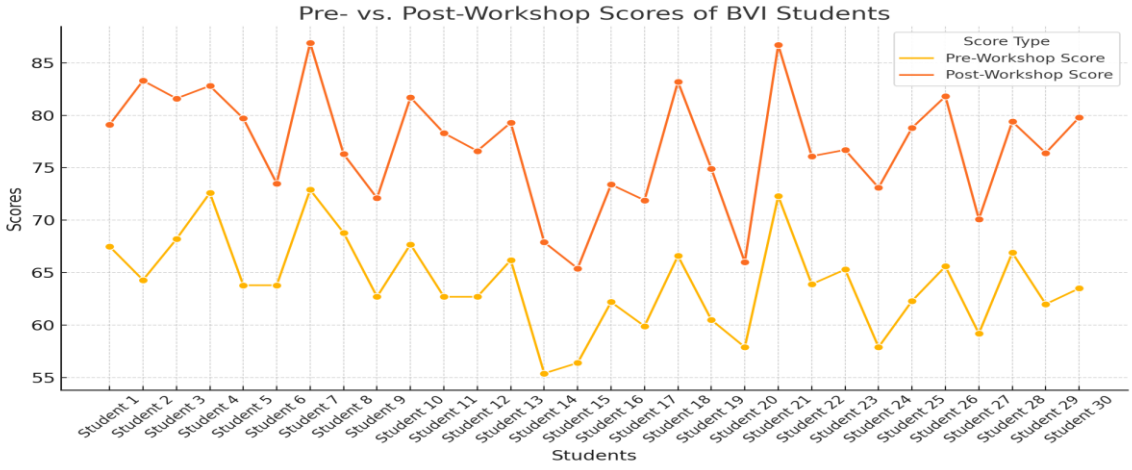
How effective has STEM KIT Tiles and Board impacted on the mathematical learning outcomes of BVI students, and does it measured by a 20% increase in test scores over a three-month period?

The results show that the mean difference of the pre and post-test 13.4 is significant which meets and slightly exceeds the hypothesized 20% improvement.

Paired t-Test Results

Table 2: Summary of paired t-test results for pre- and post-workshop mathematical understanding scores.

Sample size (n)	30
Mean of Pre-Workshop Scores	65.3
Mean of Post-Workshop Scores	78.7
Mean Difference (Post - Pre)	13.4
Standard Deviation of Differences	8.2
Test Statistic (t)	8.76
Degrees of Freedom (df)	29
p-value	< 0.001



Mean Pre-Workshop Score = 65.3
Mean Post-Workshop Score = 78.7
Improvement (Post - Pre) = 78.7 - 65.3 = 13.4

Calculation:

Percentage Improvement = (Improvement / Pre-Workshop Score) × 100

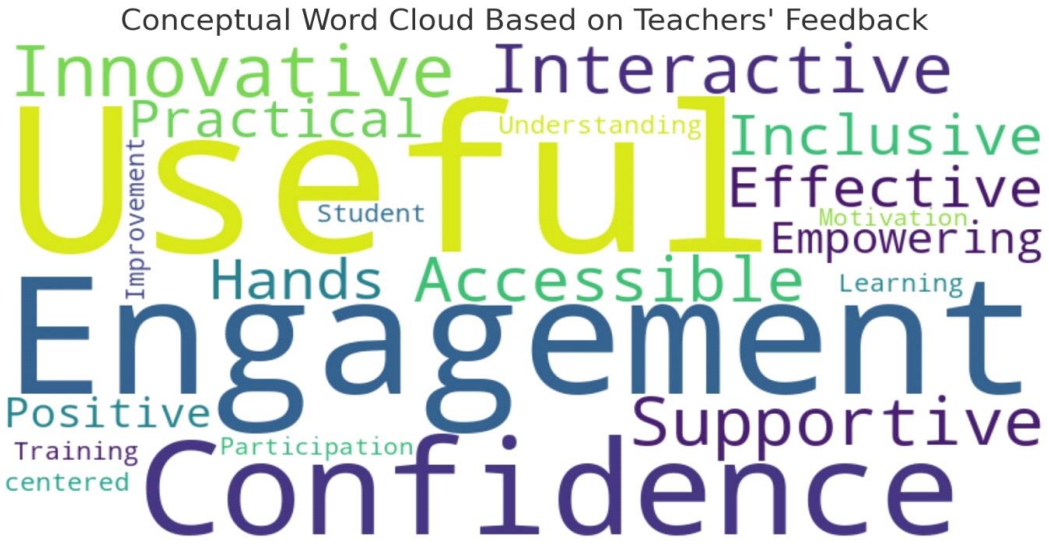
Percentage Improvement = (13.4 / 65.3) × 100

Percentage Improvement ≈ 20.5%

Therefore the paired t-test results indicate a **20.5% increase in performance** This supports the claim in the hypothesis.

What are the perceptions of their teachers regarding the effectiveness of STEM KIT Tiles and Board, and what key themes emerge from their feedback to inform future educational practices?

The responses of the Teachers feedback and post workshop survey were coded and analysed. We generate the word cloud which summarised the findings from the results:



Discussion

The word cloud highlights the key themes and perceptions from the teachers' feedback and post-workshop survey. Teachers frequently mentioned the **usefulness** and **effectiveness** of the STEM KIT Tiles and Board, emphasizing how these tools made mathematics more **interactive** and **accessible** for BVI students. The terms **engagement** and **participation** were prominently noted, reflecting the increased **student-centered** learning environment fostered by the tools.

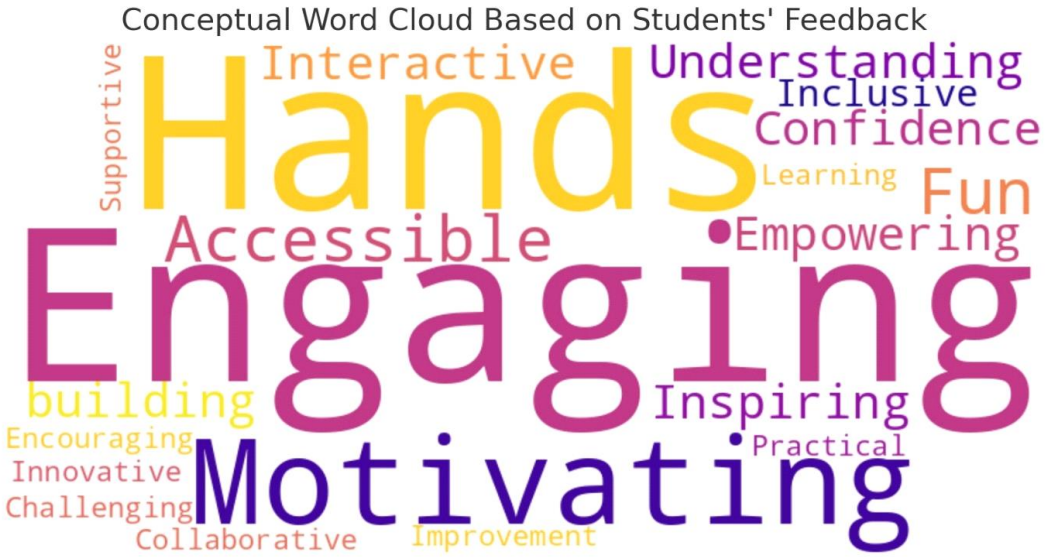
Teachers also expressed a significant boost in their own **confidence** in teaching mathematics to BVI students, attributing this improvement to the comprehensive **training** and **support** provided during the workshop. Words like **innovative**, **hands-on**, and **practical** underscore the practical benefits of using these instructional tools in the classroom.

The following themes arises from Teachers' Feedback on the STEM Kit Tiles and Board

- **Usefulness and Practicality** Teachers consistently highlighted the **usefulness** of the STEM Tiles and Board in supporting their instruction for BVI students. Many found the tools to be **practically valuable** for visualizing abstract mathematical concepts in a tangible way, thereby enhancing students' comprehension. The practicality of these tools translated directly into improved student outcomes, with teachers noting that the tactile elements made complex ideas accessible.
- **Engagement and Motivation** One prominent theme was **student engagement**. Teachers observed increased motivation and active participation among students when using the STEM Kit Tiles and Board. They noted that the tools fostered a sense of curiosity and enjoyment in learning mathematics, which had previously been challenging for BVI students. Teachers attributed this heightened engagement to the **interactive** and **hands-on** nature of the materials, which made learning more relevant and dynamic.
- **Confidence and Empowerment** Feedback from teachers indicated a positive shift in students' **confidence** in approaching mathematical tasks. The experience of working with accessible tools that are designed to meet their needs empowered students to participate more fully in lessons. This confidence-building aspect also had a reciprocal effect, increasing teachers' own **confidence** in using the materials effectively to meet BVI students' learning needs.
- **Inclusivity and Accessibility** Teachers frequently remarked on the **inclusive** and **accessible** design of the STEM Kit Tiles and Board. They felt that these tools addressed the gap in accessible STEM resources for visually impaired students, providing an equitable learning experience. Teachers appreciated that these resources were specifically designed to support a diverse range of learning abilities, fostering an inclusive environment where BVI students could actively engage alongside their peers.
- **Professional Development and Skill Improvement** Many teachers reported that the workshop had a significant impact on their **professional development**, enhancing their skills in teaching mathematics to BVI students. The hands-on training provided them with both the knowledge and **confidence** to implement the tools effectively in the classroom. Teachers also appreciated the emphasis on **continuous improvement** and **support**, as the workshop encouraged ongoing development and provided resources that they could integrate into their regular teaching practices.
- **Student-Centered Learning and Positive Outcomes** Teachers identified a clear shift towards **student-centered learning** in their classrooms after using the STEM Kit Tiles and Board. By empowering students to interact directly with mathematical concepts, the tools fostered a learning environment where students could take more ownership of their educational journeys. Teachers linked this student-centered approach to a variety of **positive outcomes**, including improved comprehension, increased participation, and enhanced motivation.

What are the perceptions of the Students regarding the effectiveness of STEM KIT Tiles and Board, and what key themes emerge from their feedback to inform future educational practices?

Focus group discussions and interviews of the students were summarised in this word cloud and the themes were also discussed:



The following are the Themes from Student Feedback on the STEM Kit Tiles and Board:

- **Engagement and Enjoyment** **"Engaging,"** **"Fun,"** and **"Motivating"** were among the most prominent terms shared by students, reflecting their enjoyment in using the STEM Kit Tiles and Board. The hands-on, tactile nature of the materials provided a unique way to explore mathematical concepts, which many found more enjoyable than traditional methods. This engagement was particularly impactful for visually impaired students, as it allowed them to connect with mathematics in an accessible, interactive way, fostering a genuine enthusiasm for learning.
- **Confidence and Empowerment** Students frequently mentioned feeling **"empowered"** and having their **"confidence"** boosted through their use of the tools. By giving them a way to interact directly with mathematical concepts, the STEM Kit Tiles and Board helped students feel more in control of their learning. Many students found that these tools made previously challenging topics feel more approachable, thereby building their confidence and encouraging them to tackle problems independently.
- **Hands-On Learning and Interactivity** Terms like **"hands-on,"** **"interactive,"** and **"practical"** highlight the value students placed on physically manipulating the STEM Kit Tiles. The ability to actively engage with math concepts through touch allowed students to build a stronger conceptual understanding, as the hands-on experience aligned well with their sensory learning preferences. This theme also reflects how tactile interaction was instrumental in fostering deeper comprehension and retention of mathematical ideas.
- **Accessibility and Inclusivity** Words such as **"accessible"** and **"inclusive"** appeared frequently, indicating that students appreciated having tools specifically designed for their needs. Many students expressed that traditional learning tools often left them feeling left out, while the STEM Kit Tiles and Board offered a sense of belonging and equal participation. This inclusivity allowed BVI students to engage meaningfully in the subject, aligning with their unique learning preferences and making them feel included in classroom activities.
- **Challenge and Improvement** Students noted that the tools were both **"challenging"** and **"encouraging"**. While the STEM Kit Tiles required focus and effort, they appreciated the chance to work through mathematical challenges in a way that was appropriate to their abilities. This mix of challenge and support led to measurable **"improvement"** in their skills, as they were able to gain a better understanding of complex topics over time. The tools' design encouraged students to persist, reinforcing growth and resilience in their mathematical learning journey.
- **Collaborative Learning and Supportive Environment** Themes of **"collaborative"** and **"supportive"** emerged, with students valuing the chance to work together with peers and instructors. The tools facilitated group work and discussion, which helped students learn from each other and create a supportive classroom atmosphere. This collaborative learning environment helped them feel encouraged and valued, reinforcing a positive learning culture where each student's efforts were acknowledged and celebrated.
- **Learning and Understanding** Students repeatedly used terms like **"learning"** and **"understanding"**, showing that the STEM Tiles and Board had a strong impact on their comprehension of mathematics. The ability to explore concepts tangibly helped them connect with math more meaningfully. Many students noted that using the tiles allowed them to bridge gaps in their understanding, translating abstract concepts into something concrete and accessible.

What impact does STEM KIT Tiles and Board have on the mathematical learning outcomes of BVI students used over a three-month period?

After three months, a questionnaire was distributed to the Teachers that participated in the workshop with specific request to respond based on the STEM Kit Tiles and board distributed to their schools after the workshop. The themes derived from the teachers' responses focused on the limited availability of STEM Tiles and the desire for wider access to support sustained

integration into mathematics instruction. Key themes that emerged includes: Limited resources, shared materials, Sustainability, Access, Support, Additional kits, Resource constraints, Expanded access, Classroom implementation, Continued training, Distribution, Frequency, Effectiveness, Integration challenges, School support.

Below is the word cloud that summarised the responses and the discussions of Emerging Themes from Teachers' Feedback

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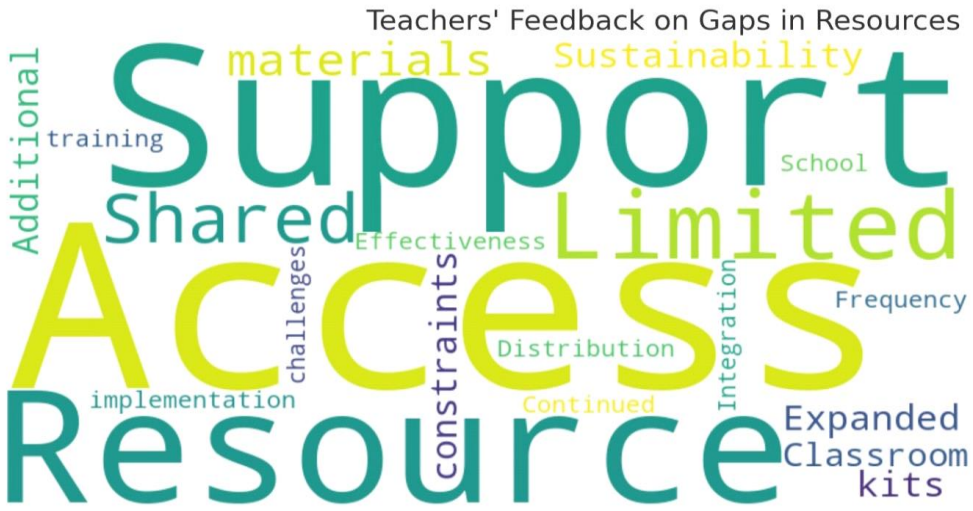
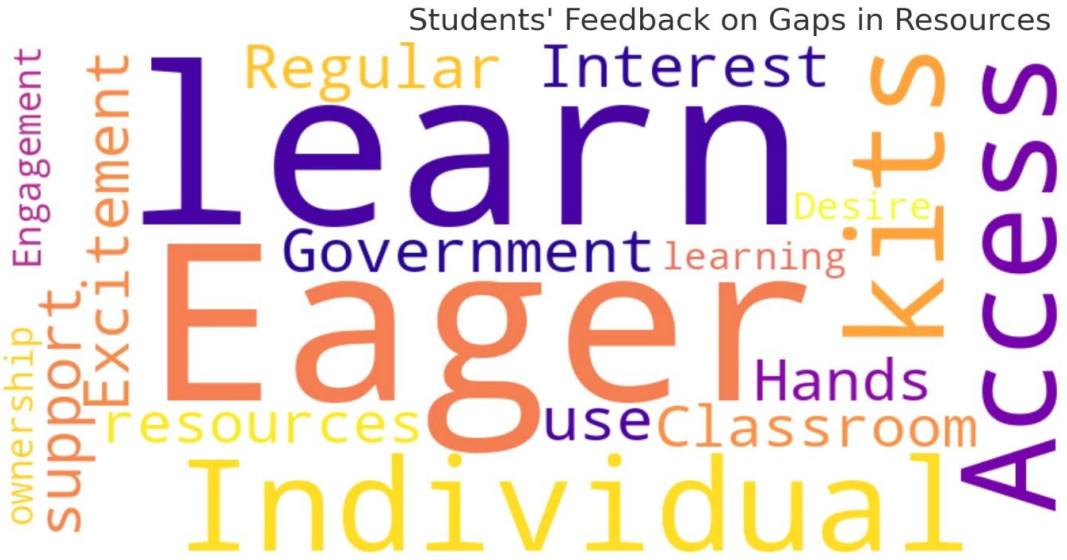


The follow-up evaluation revealed that resource limitations were a significant challenge in the consistent integration of the STEM Kit Tiles and Board across classrooms. Teachers frequently mentioned terms such as "limited resources," "shared materials," and "resource constraints," indicating that the quantity of available materials was insufficient to fully support their intended use. This scarcity impacted the frequency and effectiveness of the tools in daily lessons, as teachers had to divide or rotate the materials among multiple classes or students.

Additionally, teachers expressed a need for continued support and expanded access to ensure the sustainability of these tools. Words like "additional kits," "distribution," and "support" reflect the teachers' desire for more robust resources and institutional backing to implement these tools seamlessly. The feedback suggests that further investment in resources and support is essential to overcome these integration challenges and optimize the impact of the STEM Tiles in supporting BVI students' mathematical learning.

Below is the word cloud that summarises the Emerging Themes from Students' Feedback three months after the workshop.



From the students' feedback, a strong sense of eagerness and excitement emerged regarding the use of the STEM Tiles and Board. Students consistently expressed a desire for regular access to these tools, with terms like "eager to learn," "individual kits," and "regular use" indicating their enthusiasm for having these resources as a part of their daily learning experience. This eagerness underscores the tools' effectiveness in promoting engagement and hands-on learning, as students found them enjoyable and beneficial in understanding complex mathematical concepts.

Students also highlighted their wish for government support to make these materials more accessible, reflecting their hope for individual ownership or at least greater availability of the tools within the classroom. This feedback signals that access to personal or more frequent use of these resources could enhance

their learning experience and foster a deeper connection with mathematics.

Discussion of Findings

The findings from this study underscore the transformative potential of tactile learning tools, such as the STEM Kit Tiles and Board, in improving mathematics education for Blind and Visually Impaired (BVI) students. Historically, the lack of accessible and effective resources has excluded many BVI students from STEM education, leaving their interest and potential in these fields largely unfulfilled (Adelakun, 2020b; Berry, 2018). Traditional tools like the abacus and cubarithm, while helpful to some extent, are insufficient for addressing the complexities of modern mathematical curricula (Wairimu, 2019).

This study demonstrated that the STEM Kit Tiles and Board provide BVI students with a tactile, interactive way to engage with mathematical concepts, leading to significant improvements in their understanding and confidence. Consistent with findings from Mungunda (2023) and Ahmad (2024), these tools not only enhance spatial reasoning and problem-solving skills but also foster greater student engagement and enjoyment in learning mathematics.

The feedback from both students and teachers highlighted the usability and educational value of these tools. Teachers reported increased confidence in their ability to teach mathematical concepts to BVI students, aligning with research by Alquraini and Gut (2012) on the importance of teacher training in inclusive education practices. Furthermore, the involvement of teachers and students in evaluating the tools provided critical insights into their practical application in real classroom settings, echoing Bryant et al. (2019) and Abrahamson (2020).

However, the findings also emphasize the need for continued research and development in this area. While the short-term impacts of the STEM Kit Tiles and Board are promising, long-term studies are needed to assess their sustained effectiveness in improving academic outcomes and fostering STEM interest among BVI students (Adelakun, 2020). Future research should also explore scalability across diverse educational contexts and integrate teacher training programs to maximize the tools' potential.

In conclusion, this study contributes to the growing evidence that tactile tools are essential for empowering BVI students to access and excel in mathematics. By addressing both the pedagogical challenges faced by teachers and the learning barriers experienced by students, the STEM Kit Tiles and Board represent a meaningful step toward inclusive and equitable STEM education.

Implications for Future Educational Research and Development

This research underscores the transformative potential of tactile tools, such as the STEM Kit Tiles and Boards, in enhancing mathematical understanding for Blind and Visually Impaired (BVI) students. The significant improvements in post-workshop scores highlight how accessible, hands-on learning resources can effectively bridge the learning gap in STEM education for this underserved population.

Future studies should delve into the long-term impacts of these tools, examining how they influence not only immediate learning outcomes but also broader academic performance and problem-solving abilities over time. Additionally, there is a need to explore the customization of STEM kits to address a wider range of mathematical topics or adapt them to meet the diverse learning needs of individual students.

Another critical area for exploration is the scalability of these tools. Research should assess their feasibility and effectiveness in various educational settings, from inclusive classrooms to specialized schools. Furthermore, teacher training must be prioritized, as professional development programs are key to equipping educators with the skills and confidence needed to maximize the benefits of tactile tools in their teaching practices.

By addressing these areas, future educational research and development can pave the way for innovative and inclusive solutions that promote accessibility and equity in STEM education for BVI learners, ultimately empowering them to succeed in mathematics and beyond.

Limitations of the Study

While this study demonstrates the effectiveness of STEM Kit Tiles and Boards in enhancing mathematical understanding for BVI students, several limitations must be noted:

- **Small Sample Size**: The study involved 30 students and 100 teachers, which may limit the generalizability of the findings to a broader population of BVI learners.
- **Short-Term Evaluation**: The study focused on a three-month period, providing limited insights into the long-term impact of these tools on students' learning outcomes.
- **Single Intervention**: The results are based on one workshop series, and the findings may vary with repeated use or integration into regular curricula.
- **Subjective Feedback**: While perceptions from students and teachers are valuable, they may introduce bias and need to be supplemented by additional objective performance metrics.

Future studies addressing these limitations could provide more robust evidence to strengthen the case for widespread adoption of these tools.

Conclusion and Recommendations

This study demonstrates that STEM Kit Tiles and Boards significantly improve the mathematical understanding of Blind and Visually Impaired (BVI) students. Both students and teachers perceive these tactile tools as effective, with measurable improvements in test scores. These findings highlight the potential of accessible educational resources to empower BVI learners in STEM education.

Recommendations:

- **Integration into Curricula**: Incorporate STEM kits into regular classroom teaching to enhance accessibility and engagement for BVI students.
- **Expanded Research**: Conduct longitudinal studies with larger, more diverse samples to evaluate the long-term impact of these tools.
- **Professional Development**: Provide training for teachers to effectively use tactile learning aids in inclusive educational settings.

Adopting these recommendations can help scale the impact of this research and foster inclusive learning environments in STEM education.

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