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Full Length Research Paper

Bridging education gaps: Implementation of Mavis talking pens and books in non-formal learning centers in Northeast Nigeria

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ABSTRACT

The educational crisis in Northeast Nigeria, deepened by conflict, economic challenges, and the COVID-19 pandemic, has significantly hindered access to quality education for millions of children. In response, EdTech solutions such as the Mavis Talking Books and Pens have shown potential in supporting education in conflict-affected and under-resourced areas. This study examines the implementation of the Mavis Talking Books and Pens within non-formal classrooms in Borno state, focusing on out-of-school children aged 9 to 16 who are part of an ongoing non-formal learning initiative. The research aimed to assess the effectiveness of the Mavis tools and identify the conditions necessary for their successful implementation and scalability using a mixed-methods approach involving surveys, focus groups, interviews, and observations with 70 learning facilitators and 350 students across 70 non-formal learning centers. The study found that the Mavis Talking Books and Pens were largely effectively implemented, which appears to lead to student progress, although some inconsistencies in student engagement and classroom management were noted. Challenges included the need for more frequent use, better student-to-pen ratios, and improvements in the learning environment. Facilitators also highlighted the importance of stronger community engagement and addressing external factors affecting student attendance. To overcome these challenges, the study suggests focusing on strengthening support systems, optimizing resource allocation, and enhancing community engagement. These findings offer important insights into how EdTech tools like Mavis Talking Books and Pens can be effectively integrated into non-formal education settings in crisis-affected regions, helping to improve educational outcomes for marginalized children in similar contexts.

Keywords: EdTech, Nigeria, education in emergencies, literacy, numeracy.

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INTRODUCTION

The ongoing educational crisis in Northeast Nigeria, driven by conflict, economic instability, and the COVID-19 pandemic, has left millions of children without access to quality education (Mishra et al., 2023). In this challenging context, EdTech solutions have emerged as a promising way to bridge the gap and support learning in conflict-affected and low-resourced settings. This study focuses on the implementation of Mavis Talking Books and Pens, an innovative EdTech tool designed to enhance literacy and numeracy among out-of-school children in Borno state. To build evidence on how these tools function in non-formal classrooms, the study employed mixed-methods implementation research, focusing on facilitators and students aged 9 to 16 who are part of an ongoing non-formal learning program. This research aimed to identify the conditions critical for the success of the program, including the quality of implementation and its potential for scalability. The findings will inform how EdTech can be

more effectively implemented in similar crisis contexts to improve educational outcomes for disadvantaged learners.

Background

The Northeast Nigeria region faces a poly-crisis that has adversely affected access to quality education. In Borno, Yobe and Adamawa states, the children and youth have borne the brunt of the COVID-19 pandemic, economic crises, and armed conflict with Boko Haram. These crises have had a compounded effect on an already weak education system. There have been direct attacks on schools, resulting in the destruction of physical infrastructure, abductions, killings and displacement of learners and teachers. For example, by 2015, 910 schools had been destroyed, 1500 schools forced to close and more than 950,000 learners forced to drop out due to the violence of Boko Haram (a name that is loosely translated to “Western education is forbidden”) (Mishra et al., 2023). Since 2009, it is estimated that 2300 teachers had lost their lives due to the Boko Haram activities (Sanchi et al., 2022), and thousands more were forced to flee. Moreover, the repurposing of schools to house the internally displaced people (IDPs) and accommodate military forces combating extremist groups has hindered accessibility to continuous education (Mishra et al., 2023). The COVID-19 pandemic also had a devastating impact on the global education system. There was widespread school closure that affected 1.5 billion students and resulted in significant losses in learning years (UNESCO, 2020b). Children from vulnerable and marginalized households were disproportionately impacted as they lacked access to digital resources for continued learning (Tadesse and Muluye, 2020). In Nigeria, the over six months lockdown resulted in a prolonged absence from school, loss of livelihood, and consequently psychological and mental breakdown among the learners and parents especially in vulnerable regions such as the Northeast (Okagbue et al., 2023).

Nigeria is the most populated country in Africa. According to the World Bank 2021 report, there was a 23% increase in the school-age population between 2011 and 2021. This growth created a demand for education provision to a government that was already struggling (Mishra et al., 2023). UNICEF (2023) reported a 2.5% reduction in Nigeria’s GDP, equating to a cumulative loss of approximately $100 billion over ten years due to the protracted crisis in the Northeast. The economic hardships propagated by the ongoing conflicts and the pandemic resulted in job losses, reduced income and financial strain on households, thus forcing parents to prioritize basic needs such as food over education, hence increasing the number of school dropouts. In 2021, as more than 37 million Nigerian children started the new school year, at least one million were left behind — afraid to return to school due to insecurity and lack of resources (UNICEF, 2021).

Nigeria has the highest out-of-school population in the world. Prior to COVID-19, 10.5 million school-age children were out of school (Eze et al., 2021). The number has drastically increased to 19.7 million (UNESCO, 2022). Due to the frequent learning disruptions, and shortage of qualified teachers and learning material, even the children who remain in school cannot achieve minimum proficiency in math and reading (Mishra et al., 2023). The International Rescue Committee’s (IRC) 2018 Education in Emergencies (EiE) assessment of children aged 9 to 14 in Borno and Yobe reported more than 50% of learners scored zero across all early grade reading assessment (EGRA) areas, and on average could understand only 10% of what they read.

When children miss years of schooling due to ongoing conflict and insecurity, they face greater risk of violence, exploitation, and other long-term effects on their health, education, and economic prosperity. The longer children are out of school, the less likely they are to return (Eze et al., 2021). Without ensuring children in humanitarian contexts have education opportunities, the global community will not feasibly meet Sustainable Development Goals (SDGs) 1 and 4, commitments to eradicating poverty and ensuring inclusive and equitable education at all levels. If we fail to act, globally by 2030, approximately 420 million children will not be on track to gain early developmental skills, and 825 million will not be able to acquire secondary-level education skills (UNICEF, 2020). As the education crises grow in scale, duration, and impact, so does the need to find innovative approaches to education that are more effective, equitable, and sustainable.

EdTech in emergencies, conflict, and low-resourced settings: Opportunities and challenges

EdTech programs have demonstrated considerable promise in enhancing education within conflict zones and low-resourced settings, offering innovative solutions to persistent challenges. The Ahlan Simsim initiative, developed by Sesame Workshop and the IRC, exemplifies this potential. By integrating multimedia content with messaging platforms like WhatsApp, Ahlan Simsim supports early childhood development in Jordan and Lebanon. This approach enhances literacy, numeracy, social-emotional skills, and motor skills, showcasing how EdTech can address educational needs even in challenging environments (*Ahlan Simsim*, 2023). Similarly, messaging apps such as WhatsApp and SMS have proven effective in maintaining educational networks and fostering resilience during school closures, as evidenced by the Rapid Evidence Review (Jordan and Mitchell, 2020).

The Rumie Initiative further highlights the importance of offline educational resources, which ensure that learning materials are accessible despite limited internet connectivity (Tauson and Stannard, 2018). Another example, the One Laptop per Child (OLPC) initiative, underscores the significance of conducting needs assessments and involving local stakeholders to ensure the relevance and effectiveness of EdTech solutions (McIntyre et al., 2021). However, these programs also encounter notable challenges. Accessibility remains a significant issue, particularly in low and middle-income countries (LMICs) where internet infrastructure and digital device availability are limited. The Ahlan Simsim initiative, for instance, faced limitations with its audio-only formats, revealing the need for more engaging, multimodal content (Ahlan Simsim, n.d.).

Sustainability is another critical challenge. Many EdTech initiatives rely heavily on external funding and struggle with maintaining long-term viability. The OLPC initiative faced difficulties due to inadequate planning and insufficient local context consideration. Successful programs must involve thorough needs assessments and actively engage with community stakeholders to ensure their sustainability and relevance (McIntyre et al., 2021). Teacher training and support are also essential for effective technology integration. The Integrating ICT initiative in Ghana highlighted the importance of training teachers to use digital tools and create digital content, yet many programs continue to struggle with inadequate training and policy inconsistencies (Burns, 2023).

Open-source software (OSS) presents another avenue for EdTech but comes with its own set of challenges, including insufficient funding, limited access to technology, and a lack of technical expertise. A 2023 survey on EiE found that successful OSS implementation requires technical training, advocacy, and strong data protection measures (Shankar et al., 2023). Overall, successful EdTech programs are those that are adaptable, inclusive, and well-integrated into existing educational frameworks. They leverage local insights, provide robust support systems, and address both academic and non-academic aspects of learning. Collaboration with local educators, communities, and governments is crucial for ensuring relevance and sustainability. Additionally, addressing barriers such as inadequate teacher training and policy inconsistencies is vital. By focusing on adaptability, stakeholder engagement, and comprehensive support systems, EdTech programs can enhance educational outcomes and create sustainable, impactful solutions.

Mavis talking books and pens

Teachers and learners in crisis contexts are always innovators by necessity. During the COVID-19 pandemic, the need to support both of these groups with tools and content through technology was starkly highlighted. As it became obvious that existing solutions were struggling to fill the gap, the IRC set out to support local innovators to introduce and develop new ones. The goal of these new solutions is to achieve measurable learning improvements in literacy and numeracy among disadvantaged children in the schools of Northern Nigeria.

The IRC, in partnership with four other organizations, implemented a five-year project targeting more than 200,000 out-of-school children and youths aged 9 to 16 years living in Borno, Adamawa, and Yobe states of Northeast Nigeria. The project provided non-formal education programming to ensure out-of-school children and youths gain foundational literacy, numeracy, and social and emotional learning skills needed to progress to higher levels of education, training, and engagement in the workforce. The project is in its third year and it has directly benefited 1,214 non-formal learning centers across eleven Local Government Areas (LGAs) in Northeast Nigeria – Maiduguri Metropolitan Council (MMC), Jere, Konduga, and Mongono (LGAs in Borno State); Yola North, Yola South, and Gombi (LGAs in Adamawa State); and Bade, Fune, Jakusko, Potiskum, and Damaturu (LGAs in Yobe State).

To complement this project and address the need for access to quality learning materials, the IRC aimed to invest in low-cost, scalable solutions that do not rely heavily on connectivity and power. The International Non-Governmental Organization (INGO) leveraged the existing robust EdTech market in the advantaged areas of Nigeria, which has not yet taken hold in the Northeast. Collaborating with Nigerian innovators, key government and community stakeholders, as well as end-users — children, caretakers, and educators — the INGO identified Mavis as a potential solution. Mavis Talking Books and Pens, developed by Mavis Computer, are Edtech tools designed to enhance learning, especially in rural areas. The system includes a digital pen that can store up to 100 programs and a specially printed book. When the pen touches the book, it reads the corresponding text in audio, including quizzes, songs, games, and multi-language translations. The books cover subjects like Math and English (“Mavis Talking Books”, 2019). Between April 2022 and August 2024, the Mavis Edtech solution was piloted and tested in two LGAs of Borno State – MMC and Konduga. If the solutions have measurable outcomes in feasibility, desirability, and scalability, 4,000 disadvantaged children and 285 teachers/ learning facilitators would directly benefit.

This current research generated evidence regarding how these talking pens and accompanying books function within nonformal classrooms in Nigeria and what conditions are necessary for their successful implementation. Research indicating how well the Mavis talking pens and books are integrated and used within classrooms in low-resourced settings will help determine

whether and how this tool can be used in similar contexts and communities.

The present study

The implementation research study aimed to build evidence about how the Mavis talking pens and accompanying books work and under what conditions in non-formal classrooms linked with the IRC's project in Nigeria by examining how variations in the quality of implementation are critical for the program. This study took place over two months and relied on primary data gathered through surveys, interviews, focus groups, observations, attendance trackers, and learning assessments. Specifically, the study was designed to answer the following research questions:

1. To what extent are learning facilitators able to implement the talking pens/books with high quality?
2. What levels of engagement do we observe among students, and to what extent are the learning facilitators prepared to engage students with the talking pens/books?
3. How helpful were the supports provided to learning facilitators to implement the talking pens/books?
4. How do the talking books and pens benefit teaching and learning, and what are the main challenges?

METHODS

To answer these questions, this study included mixed-methods implementation research to build evidence regarding the ways in which the Mavis talking pens and books function within non-formal classrooms in Borno state in northeast Nigeria and what conditions are critical for the success of the program including quality of implementation. The implementation study focused on facilitators and students ages 9 to 16 who are already participating in the IRC's non-formal learning program and with whom the Mavis talking pens and books have been implemented.

The implementation study tested the design and take up of the talking pens and books. We gathered quantitative data to assess the project quality of implementation and linked these data to qualitative measures assessing participants' perceptions and experiences with the talking pens and books, project acceptability and significance, and logistics.

[1] A National Diploma is more vocational and technical oriented and provides more practical skills in specific fields (mostly non-education fields). The NCE is specifically designed for aspiring educators and is more focused on pedagogical training. A NCE graduate qualifies to teach at the basic education level. Both a National Diploma and a NCE take 2-3 years to complete.

Participants

The learning facilitators (LFs) consisted of 50 females and 20 males, with 44% holding a bachelor's degree and 51% having a National Diploma or Nigerian Certificate of Education (NCE).[1] Among the 70 facilitators, 53% reported Hausa as the language they speak most often, 19% said they speak both English and Hausa most often, and 11% indicated they speak English most often. Additionally, 11% considered Kanuri at least one of their primary languages.

Of the 350 students included in the study, 66% were female and 34% male. Regarding primary languages, 33% of the students indicated Hausa, while 31% reported Kanuri as their primary language. (Table 1)

Instruments

The quantitative data collection included protocols for collecting attendance data; facilitators and student surveys to collect basic background data and participants' experiences with the talking pens and books; and classroom observation tools to rate the quality of the delivery of the talking pens and books. Qualitative data collection involved semi-structured focus groups with facilitators and students to understand perceptions of the program, preferences and engagement towards the talking pens and books and factors that supported/complicated implementation. All data collection instruments were developed by the research team. More details on each of the tools are included below:

Facilitator survey

This instrument collected background information from facilitators such as their gender, age, level of education, years of teaching/facilitating experience, factors facilitating implementation, their perceptions of supports, perceived value of the talking pens and books, perceived changes in the students from using the talking pens and books, and perceived competence in facilitating the talking pens and books.

Student survey

This instrument collected background information from students such as their age, gender, and languages spoken at home. The survey includes questions on their experience with the talking pens and books, motivation to read, and motivation for math scale.

Semi-structured facilitator focus group

The facilitator focus group presented further questions on

experience with the talking pens and books including implementation successes and challenges, preparation to engage students with the talking pens and books, experiences with the supports, change in their ability to facilitate the talking pens and books over time, and change in the students due to the talking pens and books. The focus group encouraged the facilitators to discuss generally including what they have observed with other facilitators and allowed facilitators to agree/disagree with one another and construct a deep discussion that allowed for a better understanding of the implementation of the talking pens and books. It also provided an opportunity to determine who would be valuable to learn from further in an individual interview.

Table 1. Participants by method type and timeline.

	Number of participants involved	Organization
LF survey	70 LFs	All LFs
LF focus groups	36 LFs	*6 focus groups of 5-6 LFs each* - 3 focus groups from MMC and 3 from Jere LGA - In each location, one all-female, one all-male, and one mixed sex (4 females and 2 males to reflect the higher number of females in each local area)
LF individual interviews	20 LFs	10 LFs from MMC and 10 LFs from Jere LGA with a mix of experiences and opinions based on focus group
Student survey	350 students	350 students
Student focus groups	120 students	*20 focus groups of 5-6 students each* - 10 focus groups from MMC and 10 from Jere LGA - In each location, five all-female and five all-male
Observations	All centers/ LFs	All LFs received four observations by two different observers (two observations each). Each observer's observations were combined when calculating scores; therefore n = 140.

Facilitator interview

The facilitator interview included questions on experience with the talking pens and books including implementation successes and challenges, preparation to engage students with the talking pens and books, experiences with the supports, change in their ability to facilitate the talking pens and books over time, and change in the students due to the talking pens and books. It focused on gathering specific examples and in-depth personal experiences related to each of these.

Semi-structured student workshop style focus group

The student workshop style focus group built an interactive environment for students to share opinions regarding their general perceptions of the talking pens and books, the way they feel students have changed over time with the use of the talking pens and books and their experiences with the learning facilitators.

Classroom observation protocol

This tool contains a matrix that was filled out by trained enumerators while conducting a classroom observation that captured the condition of the learning environment, and facilitator and student behavior related to the talking pens and books. It also involved a short interview prior to the learning session that asked pointed questions about the previous two weeks and technical issues that had to be addressed, certain student behaviors, and other challenges or successes in implementing the talking pens and books in the last two weeks.

All data were collected on paper and tablets using CommCare. Surveys, focus groups, classroom observations and interviews were recorded, transcribed

and translated. Data were then transferred to electronic form by the enumerators using Microsoft Word/Excel.

To determine the quality of implementation, we used a scale of 1 to 3, with negative implementation aspects rated as 1 and positive aspects as 3. For instance, questions about positive behavior management with options like "not often," "somewhat often," and "very often," "very often" would be rated as a 3. Conversely, in questions about negative behavior management, "not often" would be rated as a 3. For yes/no questions, a "yes" indicating positive implementation would be rated as a 3, while a "no" would be rated as a 1. This consistent rating system ensures that the average scores for quality implementation and its sub-scores are meaningful for the reader. Although some sub-scores do not have high alpha scores, they remain divided as per the classroom observation protocol. Notably, the overall quality of implementation score has an alpha of 0.85, indicating a strong overall score. (Table 2)

Table 2. Minimum, maximum and mean scores, standard deviation, and Cronbach's alpha for quality of implementation analysis.

Variable	Definition/Metric	Min	Max	Mean / Percentage	SD	Alpha
Quality Implementation	Mean of sub-scores for learning environment quality, pens/books/curriculum quality, facilitator monitoring quality, facilitator positive management, child progress, and child engagement (each described below).	2.05	2.80	2.46	0.15	0.85
	Sub Scores for Quality Implementation					
Learning Environment Quality	Mean score of five questions assessing whether the room was clean, organized, functioning, noisy, and with sufficient chairs and desks. Variables forming the score were on a 3-point scale. A higher score indicates increased learning environment quality.	1	3	2.33	0.43	0.50
Pens, Books, and Curriculum Quality	Mean score of 13 questions assessing whether pens were fully functioning, books were in good condition and corresponded to the lesson, the curriculum was clear to the students, and the ease with which the students engaged with the pens, books, and curriculum. All variables were on a 3-point scale. A higher score indicates increased pen, book, and curriculum quality.	2.54	3	2.96	0.09	0.40
Facilitator Monitoring Quality	Mean score of 10 questions on the classroom observations protocol assessing whether facilitators resolve technical and learning issues, are responsive, and help students find solutions. All variables forming the score were on a 3-point scale. A higher score indicates increased facilitator monitoring quality.	1.8	2.75	2.17	0.23	0.58

Table 2. Continues.

Facilitator Management	Positive	Score of 10 items that assessed the level of positive behavior management used for discipline, off-task behavior, and for encouragement. Answer options were on a 3-point scale. A higher score indicates greater positive management by the facilitator.	1	3	2.17	0.51	0.82
Child Progress		Score of 10 items on technical issues and difficulties experienced by the students such as challenges in understanding instructions or appearing stuck on an activity. It also included items related to raising hands to ask questions. Answer options were on a 3-point scale. A higher score indicates increased progress of children through the content.	2	3	2.58	0.14	0.48
Child Engagement		Score of eight items related to students being engaged or appearing disengaged during the session. Answer options were on a 3-point scale. A higher score indicates higher levels of child engagement.	1.4	3	2.29	0.36	0.59

RESULTS

Quality of implementation of the talking pens and books

Overall, we found that 83.6% of observers noted high overall quality of implementation, with no observations indicating low quality. This suggests that the learning facilitators are well-prepared and supportive of the Mavis pens and books, a finding that is consistent with the qualitative data discussed further. (Figure 1)

However, when examining the different elements of implementation quality, we observe increased variation. The following chart presents these elements in descending order of quality. Overall, (a) the quality of pens, books, and curriculum, and (b) child progress demonstrates overwhelmingly high implementation quality. In contrast, child engagement, the learning environment, and facilitator-positive management show variation, with significant percentages indicating low implementation quality (9, 7 and 19%, respectively) and high percentages indicating medium implementation quality (41, 48 and 48%, respectively). This suggests that these areas, along with facilitator monitoring (where 68% of observers noted medium implementation quality), should be prioritized for improvement as the program continues. (Figure 2)

We can delve deeper into the data to better understand these three weakest points. Regarding child engagement, 90% of observers found students to be very engaged. However, 49% of observers noted at least one student appearing distracted or disengaged. For the learning center environment, 70% of observers indicated that the rooms were not clean, 69% of rooms had non-functional doors or windows, 15% of rooms lacked enough chairs or desks for students, and 11% of rooms were not organized. Finally, regarding facilitator positive behavior management, 49% of observers witnessed positive discipline being used. However, negative discipline occurred in 5% of classes, indicating a need for further improvement. Additionally, positive encouragement was observed in only 52% of classes, a figure that should ideally be 100%. These findings suggest specific areas for targeted improvement as the program progresses.

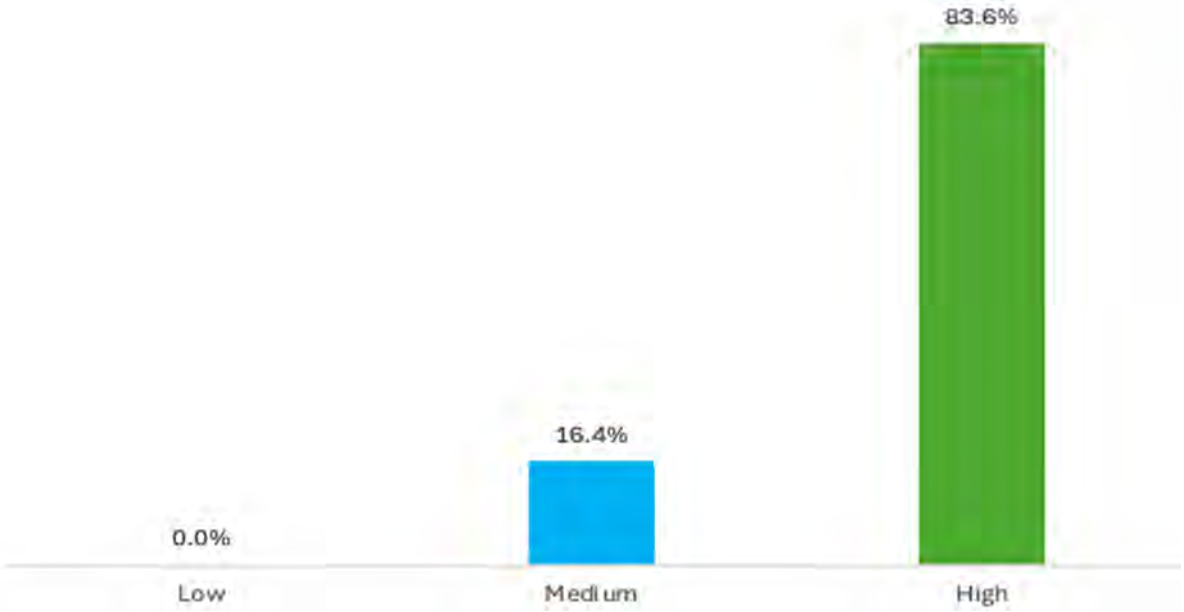

Figure 1. % of observers finding low, medium, and high levels of implementation quality.

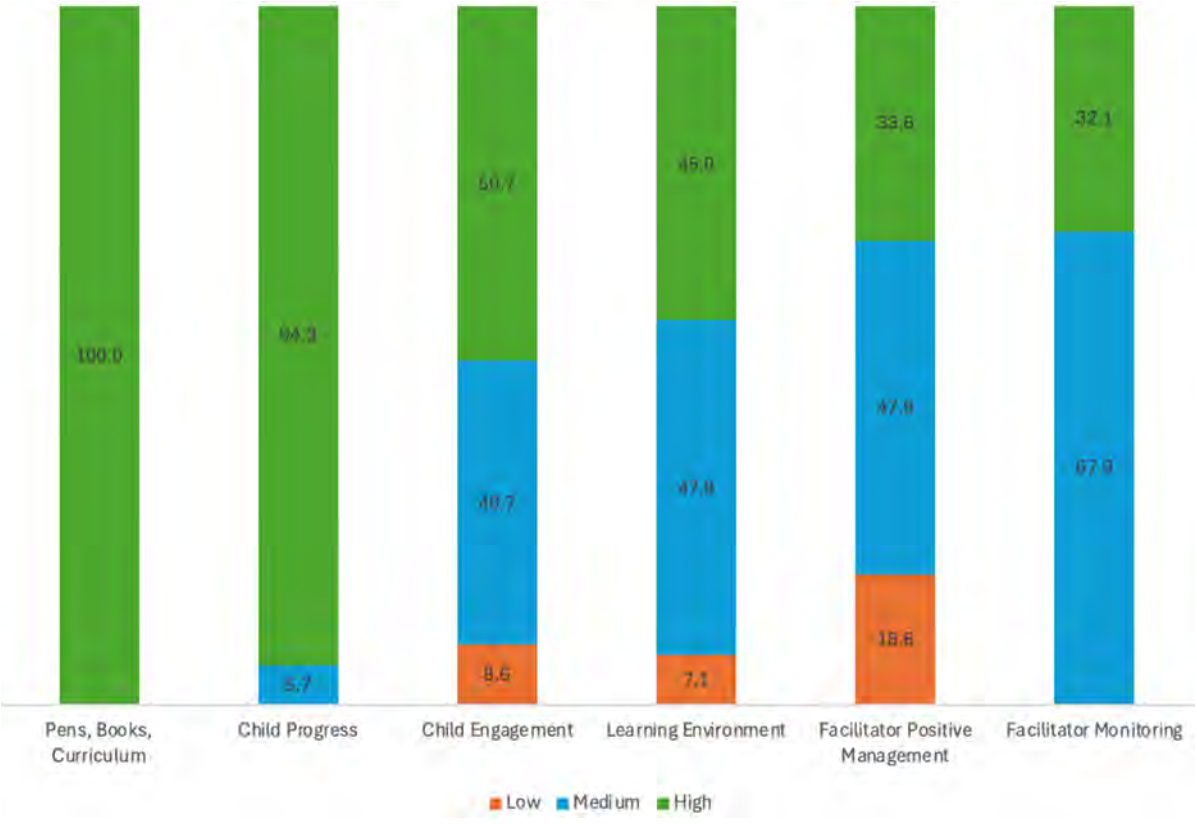

Figure 2. % of observers finding low, medium, and high levels of implementation quality (by sub-category).

Student levels of engagement and learning facilitator preparation

This was partially addressed in research question one, which noted that while 90% of observers reported students being very engaged, 49% observed at least one student appearing distracted or disengaged. In the learning facilitator survey, over three-quarters of facilitators indicated that children often or sometimes need reminders to stay focused on activities with the talking pens and books, and a quarter mentioned that students sometimes feel bored. Additionally, nearly 70% of facilitators in pre-classroom observation interviews indicated that children sometimes or often need help understanding instructions related to talking pens and books. More than 80% of facilitators noted that children sometimes or often struggle to complete activities using talking pens and books. Observers found that students raised their hands to ask about content in only 7% of classes, suggesting a need for improvement in this area. Despite these challenges, students generally did not face difficulties progressing due to technical issues, the condition of the books, or understanding instructions.

While positive discipline and encouragement could continue to be improved alongside learning facilitators helping learners to find their own solutions (observed by 35% of observers), the learning facilitators overwhelmingly noted that they felt well-prepared to implement the talking pens and books.

Table 3 shows the average ratings from the learning facilitator survey on each of these questions regarding preparedness. Learning facilitators were asked to rate the question on a scale of 1 to 9. The first three statements show high averages and suggest that the learning facilitators find the talking pens reliable, feel supported to implement them well, and are able to communicate instructions effectively. The remaining five statements in grey demonstrate greater room for improvement. Note that for negatively stated questions such as the final two, a lower score is better. This table suggests that improvement could be made in learning facilitators receiving help to fix technology in a timely manner and engaging in further training to resolve issues with the books and talking pens.

Table 3. Learning facilitator feelings of preparedness.

"Feelings of preparedness" survey statements	Mean	Standard deviation
The talking pens are, for the most part, reliable.	8.551	1.195
I feel fully supported in implementing the talking pens and books well.	8.414	1.346
The students always understand my instructions.	8.257	1.359
I receive help fixing technology problems in a timely manner.	7.457	2.191
I am able to fully resolve issues with the books.	7.103	2.705
I am able to fully resolve issues with the talking pens.	6.929	2.784
I experience regular challenges with the talking pens.	2.529	1.886
I experience regular challenges with the books.	2.057	1.578

In terms of perceived competence, the learning facilitators showed averages consistently above 8 that indicated they felt confident teaching with the pens, were comfortable providing support and instructions, and could easily help address issues and support students having challenges with the content.

The students expressed overwhelming satisfaction with the learning facilitators, with over 98% indicating that the facilitators effectively repair malfunctioning pens, explain instructions, help them understand content, and address their questions.

While support and training will be discussed further as a part of the next research question, learning facilitators noted in the interviews and focus groups that they felt well-prepared to implement the talking pens and books.

> "Okay. As a learning facilitator, we were trained on how to use this book and this pen. So, we have already gotten the skills and the necessary knowledge to use it. And by experience, we have used this pen for at least five or more months. So, it has become part of us. So, we are always ready and well prepared."

Many discussed feeling prepared because the content is set with pictures and charts already included which allows the learning facilitator to simply guide the lesson rather than prepare a new lesson every day.

> "Well, to me it makes the change easy and fast so that everything is there in the book and in the pen. So the only things I do is just to guide the learners. So, everything is scripted, I don't need to start writing on the board or everything is just there. I'll just

> guide them. And it makes teaching to me easy too, because I don't have to draw charts, pictures. It's everything. It's there for them to see."

Several also noted that they felt more prepared because they had their own copy to practice with and prepare at home prior to the lesson. One learning facilitator even said that they practiced with the neighborhood children prior to teaching the class – suggesting the potential for waterfall-positive effects outside of the learning program.

> "I was given my own copy to go home and practice with it so that I don't come and fumble in front of the learners. I have the talking pen with me. I practice with it first; I learn with it before I come and present the lesson to the learner."

While challenges will be discussed further below, a couple of learning facilitators noted that they still felt they needed to improve in numeracy in order to ensure preparedness.

> "Numeracy. I need to improve in numeracy, seriously. Math is difficult sometimes for me. I need to improve in that area."

Others noted the importance of support from their colleagues in feeling prepared and being able to ask them questions as needed. One recognized they would benefit from more observation time from their supervisor.

> "So, if we can have additional supervisor or additional time, I think it will help us to move to the next level. Because you may make a mistake today and the supervisor may not be in your class to be able to put you in the right place."

The next section details the learning facilitator's perception of the different supports provided.

Support for learning facilitators

The supports offered included AprendIA, Training, Facilitator Learning Circles (FLC), Coaching, and WhatsApp Group chats. Two hands-on training sessions - at the beginning of the study and mid-study - were offered to LFs to guide them on the use of the Mavis talking books and pens. The AprendIA AI-driven educational chatbot provided the LFs with professional development content, particularly on time and classroom management. The FLCs provided LFs with opportunities for holding one-to-one discussions, sharing tips on effective lesson delivery and collaborating in finding solutions to the problems they faced in classes. Weekly coaching visits were conducted by mentor LFs - these were headteachers with over 20 years of teaching experience - to observe lesson delivery and identify and offer insights on areas that needed improvement. Lastly, there was a WhatsApp group dedicated to information sharing and LFs could post questions and receive answers from other LFs and INGO program staff.

Overall, learning facilitators reported that both the initial training and ongoing support were valuable, as indicated by their positive ratings in Table 4 (on a scale of 1 to 9, with 9 representing the most favorable response). However, while these aspects are rated positively, there is notable potential for improvement in enhancing opportunities for facilitators to share lessons learned with their peers. This area, although still receiving favorable ratings, presents the most significant opportunity for further development.

Table 4. Learning facilitator perception of support received.

"Perception of supports received" survey statements	Mean	Standard deviation
The training I received could be easily applied in my learning session.	8.714	0.837
I feel adequately trained in the skills needed to support students in using the talking pens.	8.443	1.211
I feel adequately trained in the skills needed to support students on the content.	8.2	1.621
I receive ongoing support that is helpful.	8.157	1.603
I have enough opportunity to share lessons learned from my experience with other facilitators.	7.803	1.923

In the survey, when asked to select the two most helpful forms of support, all learning facilitators (100%) identified the training as the most beneficial, while 71% highlighted the FLC groups. AprendIA was chosen by 26% of respondents, and only 3% selected the chat as their preferred support.

In interviews and focus groups, several learning facilitators suggested that more frequent training sessions would be beneficial. FLC groups were consistently highlighted as a top support mechanism, allowing facilitators to collaboratively share ideas and resolve issues. Although mentioned less frequently, AprendIA was noted for its

usefulness in offering guidance on grouping students and providing quick, private answers without the need to seek help from others.

Table 5. Most and least helpful supports (% of LFs).

Most helpful supports	% of LFs
Training	100
FLC Groups	71.43
AprendIA	25.71
Chat	2.86

Least helpful supports	% of LFs
Chat	95.71
AprendIA	65.71
FLC Groups	20

Among the supports provided, the chat and AprendIA were deemed the least helpful by most learning facilitators, with 96 and 66% respectively expressing dissatisfaction. Many facilitators reported not knowing how to use the chat or choosing not to use it at all. Similarly, a significant number struggled with using AprendIA, and even when they did, it often failed to provide the direct answers they sought, prompting them to turn to the FLC support option instead. Additionally, issues related to limited data on their devices were frequently mentioned. Improved uptake of these options could be achieved through additional training and ensuring data availability for their usage when needed.

Benefits and challenges of talking pens and books

Learning facilitators consistently placed a high value on the Mavis talking pens and books. In the facilitator survey, over 82% of respondents rated each of the following aspects with a full 9 (indicating “A lot / A great deal”) on a scale of 1 to 9: the usefulness of the talking pens/books for improving student literacy skills and numeracy skills; their effectiveness in increasing students' interest in learning; the level of student engagement with the talking pens/books; the technology’s role in helping students gain knowledge; and the facilitators' likelihood of recommending this learning method to others.

The learning facilitators overwhelmingly reported positive changes in their students' literacy and numeracy skills, engagement, motivation, and social interactions. These aspects received average ratings above 8 on a scale of 1 to 9, with 9 representing the most favorable response.

In the interviews and focus groups, learning facilitators consistently highlighted how talking pens and books enhance teaching and learning. The tools simplify instruction, engage students in both Hausa and English and effectively combine words and pictures. Facilitators noted that the tools are clear and straightforward, align with the curriculum, are easy to use, reduce the teaching burden, improve learning outcomes, accelerate the learning process, and are learner-centered.

One facilitator explained how the talking pens and books have made it easier to work with learners who have not gone to school:

> “Before I never think that I can use, I can pass knowledge to somebody that has not gone to school. In an easier way like that, I've never thought of that. But with the use of this Mavis Pen and talking book, not only the learners have really improved, myself. Because now I know how to go about it. I know how to coach learners that have not even gone to school before. I know how to go about it.”

The tools also make lesson preparation easier, as another facilitator noted:

> “Before the use of this talking pen, I was like how do I explain the lesson to them but this talking pen make everything easier.”

The power of combining pictures and words and the use of dual language was highlighted by a third facilitator:

> “They also learn two things at the same time, how to pronounce the word and they also learn to see the picture that particular object that is being pronounced, so whenever they see this they know this is how this is pronounced in English and at the same time, and at the same time this is how it is pronounced in Hausa, the picture is in their front, if they say mat the picture of mat is there, they learn mat, they learn taburma in the picture.”

Moreover, the talking pens and books are viewed as novel and exciting. The learning facilitators perceive the students as listening and engaging better. They view the learners as more motivated and eager to interact with the pens, which has also led to improved classroom management. One facilitator noted:

> “It’s great because I interact better with the children using the talking pen. Once the talking pen is talking and giving instructions, the children keep quiet to listen. So sometimes it makes me feel I can be in charge and control of the class using the pen.”

The tools also assist facilitators with their own pronunciation and in presenting literacy and numeracy content effectively. A facilitator shared:

> "Actually, the pen has features that even I can say some words into it and it will help me, it will pronounce the words more, I don't know the right word to use but it has like a weighing machine that you say a word it weighs it and corrects the word for you. I teach with it, and I learn with it also."

Facilitators appreciated the improved vocabulary and skills in both English and Hausa among students, the user-friendliness of the tools, and how they complement the existing curriculum. One facilitator summarized the motivational impact on students:

> "Yes, they are always eager to come. They always come and they always want to learn and they ask me questions. I notice that when they came newly, they didn't even know a good morning aunty or they didn't know anything, even to even show you A or B or add anything they didn't know. But now they say, aunty, how do I do this? And I will tell them, and you see them smiling, they will go and sit down and do it."

The talking pens also help students who have been out of school or have never attended school by making learning fun and easier, as another facilitator explained:

> "I think it has facilitated learning, it makes the learning process easier for someone who has been out of school and someone who has never been to a classroom will come and find something that talks to him, use the pen to learn, it makes learning fun and easier."

Overall, the talking pens and books are perceived as highly valuable, positively influencing both facilitators and learners and contributing to an engaging and effective learning environment.

However, learning facilitators also identified several challenges related to the use of talking pens and books. They expressed a need for more time with the pens, particularly because of students who arrive late, and suggested increasing the number of days they use the pens from the current three days per week. Lowering the student-to-pen ratio was also recommended, with some facilitators advocating for one pen per two students and others for one pen per student. Ideally, each student would have their own pen to use at home. Facilitators also noted issues with students working on unassigned content by flipping ahead in the books and highlighted the necessity for the teacher's pen to have a louder speaker for demonstrating examples. Given the different learning paces among students, one-on-one time with the teacher, pen, and student was seen as beneficial. Additionally, there is a need to differentiate instruction and pay more attention to students with varying needs and those who get easily distracted. Grouping students facing challenges with stronger students was suggested as a strategy. Facilitators also called for increased training, including pedagogical training and training on using the devices more effectively, with a preference for more frequent training that directly corresponds to the content being taught.

Regarding the improvements needed for the pens and books, facilitators emphasized the need to localize the Hausa dialect and pronunciation. They also pointed out that the color shown in the book does not always correspond to the color the pen says and suggested that while the content is generally straightforward, the math content could be further simplified and broken down. There were also practical issues with charging the pens, with some not being charged when they should be. Facilitators reported problems with the pen's sensor, causing delays in saying the word when pointed at the text, and the pen turning off too soon to save battery. Lastly, they discussed the need to engage community leaders and caregivers to address the issue of inconsistent attendance, as some students miss school to make money or attend religious (Almajiri or Tsangaya) school.

DISCUSSION AND CONCLUSION

The implementation of the Mavis talking pens and books was generally high-quality, with observers noting effective use by learning facilitators. The materials were well-regarded, and significant progress was observed in students. However, there were notable variations in several areas. While student engagement was mostly positive, some instances of distraction were observed. The learning environments often suffered from issues such as cleanliness and inadequate equipment. Additionally, although positive management techniques were frequently applied, they were not consistent across all facilitators. Facilitators felt well-prepared and supported overall but reported occasional technical difficulties and a need for improved numeracy skills.

Challenges highlighted by facilitators included the need for increased time and frequency of use, a lower student-to-pen ratio, and improved content management. The state of the learning environment, marked by issues with cleanliness and equipment, affected the overall educational experience. Consistency in management techniques was lacking, suggesting a need for more uniform practices. Furthermore, community engagement

emerged as a significant concern, with inconsistent student attendance linked to external factors such as economic pressures and attendance at religious schools. Addressing these challenges requires a focus on enhancing support systems, refining resource management, and improving community involvement.

The Mavis talking pens and books reflect core principles observed in other successful EdTech initiatives in low-resourced settings, such as the Ahlan Simsim and Rumie Initiatives. The Ahlan Simsim program, created by Sesame Workshop and the IRC, exemplifies how integrating multimedia content with accessible platforms like WhatsApp can enhance early childhood education by fostering literacy and numeracy in challenging contexts (*Ahlan Simsim*, 2023). This approach of leveraging technology to provide engaging, interactive content parallels the use of Mavis pens and books to improve learning outcomes. The Mavis pens and books provide an engaging way for students to learn at their own pace and interact individually and in groups with the content. The learning facilitators noticed this increased engagement and enthusiasm of the students with the Mavis pens and books – with even improved attendance. Similarly, the Rumie Initiative's focus on offline educational resources underscores the importance of ensuring that learning materials are accessible regardless of internet connectivity, aligning with Mavis's approach of using tangible, offline tools to support learning (Tauson and Stannard, 2018). The Mavis pens can be used offline and charged using solar energy, both of which are extremely important in the context of Nigeria where internet connectivity and electricity access can be inconsistent. These additional features make the pens and books – and therefore the innovative learning approach associated with them – accessible to these students despite the challenging circumstances. Both programs, alongside Mavis, demonstrate the potential for EdTech to overcome barriers in low-resourced settings, while also highlighting common challenges such as the need for effective implementation strategies, sustainability, and local adaptation.

To enhance the effectiveness and sustainability of the Mavis program, several recommendations are proposed. Firstly, it is essential to provide enhanced and more frequent training for facilitators to improve their technical skills and numeracy abilities (Burns, 2023; Shankar et al., 2023). Additionally, improving the learning environment by ensuring cleanliness and providing adequate equipment is crucial. Strengthening support systems, such as offering timely technical assistance and creating opportunities for facilitators to share best practices, will help address ongoing challenges. Increased community involvement is also important for tackling attendance issues and ensuring the relevance of EdTech solutions (McIntyre et al., 2021). Furthermore, developing more interactive and varied content will help sustain student engagement. By addressing these challenges and leveraging existing strengths, the Mavis program can significantly enhance its impact in non-formal classrooms in Nigeria.

The experience with the Mavis talking pens and books underscores several important lessons for EdTech initiatives. Successful programs should ensure comprehensive and ongoing training for facilitators to address technical and pedagogical needs. Creating a clean, well-equipped learning environment and providing robust support systems are crucial for effective implementation. Engaging with local communities to address issues like inconsistent attendance and tailoring content to fit local contexts and learner needs is also essential. Finally, maintaining flexibility and adaptability in program design can help address unforeseen challenges and enhance the overall impact of EdTech solutions. These lessons can guide future initiatives in designing more effective, sustainable, and impactful educational technologies.

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