Language Barriers in STEM Education: Comparative insights from Zanzibar and Seychelles on multilingual pedagogies

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Introduction

While the world continues to strive for basic education for all, millions of students are still denied a quality inclusive education because they are taught in a language they barely understand. According to UNESCO (2016), approximately 40% of the global population does not have access to education in a language they speak or understand, something which significantly affects learning outcomes and academic achievement. In Zanzibar, language barriers pose a major challenge in science, technology, engineering and mathematics (STEM) in secondary education, as English, the medium of instruction (MoI) in these subjects, is a second language (L2) for most students. Research indicates that when students are taught in a language in which they are not proficient, their ability to grasp complex scientific and mathematical concepts is significantly hindered (Brock-Utne, 2017; Trudell, 2016). Barrett et al. (2014) highlight the challenges students face when learning in a second language, particularly in STEM subjects. They demonstrate that Tanzanian secondary school textbooks often use English that surpasses students' reading proficiency, making it difficult for them to comprehend subjects such as biology and mathematics. Seychelles has experienced similar challenges in STEM subjects. Here, the transition to English MoI starts even earlier. Comparison between the two education systems provides an opportunity to discuss how structured language transitions can improve content learning in different types of transition systems.

The Language Supportive Pedagogy (LSP) approach provides a practical solution to address language challenges associated with L2 MoI. LSP encourages the strategic use of students' first language (L1) for informal discussions while transitioning to L2 for more formal content delivery, facilitating deeper comprehension and engagement (Clegg and Simpson, 2016; Erling et al., 2021; Tollefson and Tsui, 2018). This approach is grounded in sociocultural and constructivist learning theories, particularly Vygotsky's (1978) Zone of Proximal Development (ZPD), which emphasizes the role of scaffolding in achieving higher cognitive outcomes. The integration of LSP into STEM classrooms helps mitigate the linguistic challenges that often impede students' ability to access content knowledge.

This article presents findings from an evaluation of a STEM teacher development project in Zanzibar, which integrated LSP amongst other pedagogic innovations, and discusses them in relation to MoI policies and practices in Seychelles. The intention is to contribute to a broader debate on language policy, inclusive education, and the role of pedagogical adaptation in improving learning outcomes in linguistically diverse contexts. The article starts by describing the STEM4SUCCESS Zanzibar (S4SZ) Project and its interpretation of LSP. Challenges associated with language transition in Zanzibar and Seychelles are then compared. The theoretical underpinnings of LSP are discussed and the evaluation methodology described, with attention to elements that focused on language practices. Findings are presented and discussed in relation to the Seychelles context to draw out comparative insights. The article finishes with policy recommendations.

Background

This study reflects on the transformative experiences of lower secondary school teachers in Zanzibar who participated in the STEM4SUCCESS Zanzibar (S4SZ) Project, initiated in 2019. The project's primary aim was to improve the quality of STEM education through innovation and by enhancing teachers' pedagogical skills. Through a focus on eight innovative pedagogical approaches, the project trained 75 STEM educators from fifteen secondary schools across the Unguja and Pemba districts in Zanzibar. Approaches included:

- **ASEI-PDSI** – *Activity, Student, Experiment, Improvisation / Plan, Do, See, Improve*: A teaching approach emphasizing student engagement through active, hands-on learning and reflective improvement (Emeji, 2015).
- **5Es-7E** – *Engage, Explore, Explain, Elaborate, Evaluate (+ Extend, Enrich)*: A model promoting inquiry-based science learning by guiding students through structured exploration and understanding (Bybee, 1997).
- **PEOE** – *Predict, Explain, Observe, Explain*: A method encouraging scientific thinking by having students make predictions, observe outcomes, and refine their explanations (White and Gunstone, 1992).
- **Circus Experiments** – *Rotating hands-on science stations*: Fun, interactive experiments set up at different stations where students rotate, promoting engagement and discovery (Wellington and Ireson, 2008).
- **Context-Based Learning** – *Linking content to real-life contexts*: Teaching that connects academic concepts to everyday situations to enhance relevance and understanding (Gilbert, 2006).
- **Problem-Based Learning (PBL)** – *Solving real-world problems collaboratively*: Students work in teams to investigate and resolve complex, authentic problems, building critical thinking and self-directed learning (Hmelo-Silver, 2004).

- **Project-Based Learning (PjBL)** – *Extended inquiry projects*: Students explore and respond to meaningful questions or challenges through long-term, interdisciplinary projects (Laverick, 2018).
- **Language Supportive Pedagogy (LSP)** – *Scaffolding language learning within science lessons*: Teaching strategies that help students understand subject content through targeted language support, especially in multilingual classrooms (Rubagumya et al., 2021).

While all methods had a positive impact, LSP stood out in transforming classrooms by making STEM content accessible and inclusive. Data collected in 2024 through surveys, follow-up telephone calls, and classroom observations, revealed that LSP, combined with digital tools such as projectors, Kio Kits[1] and drones, significantly improved student engagement, confidence, enthusiasm, and conceptual clarity for STEM subjects. LSP is thus the focus of this paper. Note, however, that we are fully aware of the fact that other pedagogies listed above may also have impacted the results, particularly the results related to student engagement.

Language Supportive Pedagogy – LSP

LSP is a praxis-based initiative to strengthen teaching and learning in contexts where change from L2 medium of instruction policies seems unlikely (Bowden and Barrett, 2022; Erling et al., 2021; Milligan et al., 2016). LSP thus recognizes the formal role of L2s in the classroom but elevates the role of the L1 as a support in learning. Focus lies on developing and refining 'a range of strategies to amplify meanings' (Clegg and Milligan, 2021, p.206).

LSP incorporates several language supportive measures. These include strategic use of learners' first language/s to aid comprehension and learning by, for example, introducing and discussing topics in the L1. Special attention is paid to new vocabulary and the use of translation and visual semiotic resources, including adaptations of textbooks and/or production of complementary learning materials in the L1. Structured support (scaffolding) to deal with subject topics using formal written and spoken L2 is also important. In addition, LSP focuses on adapting the L2 teaching to better suit the proficiency levels of the learners and to include the local contexts in teaching.

A typical LSP adapted lesson (see Figure 1 below) will consist of a preparatory stage where learners' prior knowledge is elicited through question and answer, accepting answers in

[1] A Kio Kit is a portable digital classroom solution developed by global communications corporation, BRCK, designed for use in areas with limited access to electricity and internet. It typically includes a secure charging case with 40 tablets, a wireless router with offline educational content, and a solar-powered charging system, making it ideal for remote or under-resourced schools.

L1, or through a group activity, or informal exploratory discussion in L1 (as recommended by Barnes, 2008). The teacher may at this point introduce new vocabulary in L2 or this may be integrated into the second part of the lesson. The second part is usually conducted mainly in the L2 and focuses on introducing new concepts. Teacher talk in L2 should be slow, with sentences kept short and a restricted range of vocabulary that is known to students. Teachers often translate key words and key points at this stage. They may switch between presentational talk in L2 and informal talk in L1, helping learners relate content to their knowledge and experiences outside school. However, when students are given time and support to produce translation this enhances understanding of scientific concepts as well as language learning. They may also use visual aids to help interpretation of L2. Visual representations are particularly important in STEM subjects, which target multimodal literacies involving diagrams and formulae. Understanding can also be checked and expanded through use of open questions as long as answers are accepted in L1. If learners do choose to use L2 then grammatical errors should be tolerated so as not to inhibit student participation. In the third stage, learners attempt tasks that develop or rehearse STEM knowledge whilst also providing scaffolding for using L2. Examples include labelling a scientific diagram using scientific vocabulary in L2, a structured writing task such as fill in the blanks, or recording observations from an experiment using a provided structure. Tasks should be adapted to the age of the learners and their proficiency in L2. The lesson might then end with some form of debriefing, such as the student asking clarifying questions or offering reflections.

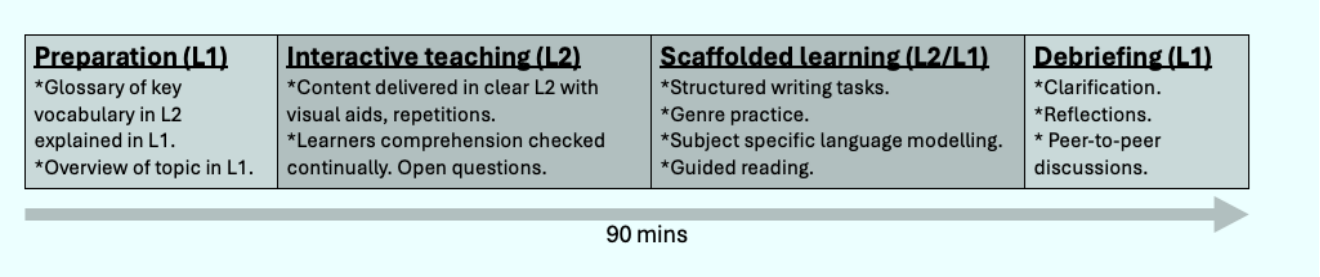

Figure 1: Possible structure of LSP-adapted lesson

Theoretically, LSP draws on social constructivist theories of learning frameworks (Daniels, 2001), Systemic Functional Linguistics (Halliday and Matthieson, 2014), and Cummin's concept of Cognitive Academic Language Proficiency (CALP) (Cummins, 2000), as is explained in the next section.

Connecting Zanzibar and Seychelles in MoI challenges and STEM education

STEM education in multilingual contexts like Zanzibar and Seychelles is often constrained by language barriers. Connecting Seychelles with this study of LSP implementation in Zanzibar provides a comparative study of multilingual STEM delivery solutions in different transition systems. In Zanzibar, English is the MoI at the secondary level, despite being an L2 for the majority of students. Introduction of English as MoI, however, starts with STEM subjects in upper primary school (Grade 5). This mismatch

undermines comprehension and engagement, particularly in STEM subjects that rely on abstract and technical vocabulary.

In Seychelles, transition to English MoI takes place even earlier, in Primary 3. This is arguably before children have developed what Cummins (1981; 2000) calls basic Cognitive Academic Language Proficiency (CALP), something which can lead to even greater challenges in STEM subjects. Deutschmann and Zelime (2021) point out that the use of Kreol Seselwa in early years helps to foster foundational literacy and numeracy (see also Lauwerier and Akkari, 2015). However, the abrupt transition to English in early primary years presents challenges in comprehension and confidence, particularly in STEM subjects. Consistent national exam statistics for Primary 6 students from 2018-2024[2] show that learners in Seychelles struggle in mathematics and the sciences. Despite this, policy changes introduced in 2018 allow mathematics to be taught in English from Primary 1. However, no comprehensive evaluation of the impact of these policy changes has been carried out to date.

Several studies conducted across nations caution that early transitions, if not scaffolded, can marginalize learners and impede subject mastery (Brock-Utne and Mercer, 2014; Kioko, 2015; Clegg and Simpson, 2016; Brock-Utne, 2017; Abdala, 2024). Studies from Seychelles confirm these risks and further emphasize the importance of the use of the L1 to build strong educational foundations (see Deutschmann and Zelime, 2021; Deutschmann and Zelime, 2025; Fleischmann, 2008; Fleischmann Schwarz and Nick, 2018; Zelime, 2022; Zelime and Deutschmann, 2016; Zelime et al., 2018; Zelime and Deutschmann, 2019). These studies also underscore the necessity of equipping teachers with skills needed to manage multilingual classrooms effectively. Studies by Zelime et al. (2018) and Zelime and Deutschmann (2019) are of particular interest. They suggest that learners are better equipped to communicate their knowledge of local phenomena, such as fisheries, in their L1 and that they receive better grades when allowed to do so. The studies also show how connecting to the local context is difficult without using the L1 to describe local aspects such as plant and animal life. English often lacks words to do so.

There is thus an urgent need for strategic support during language transition in Seychelles (see also Zelime and Deutschmann, 2025). This is a principle echoed in the trials of the LSP implementation in Zanzibar, as examined in this paper. The implementation of LSP promotes structured use of students' L1 for informal learning, while gradually transitioning to L2 for formal academic instruction (Clegg and Simpson, 2016; Brock-Utne, 2017). LSP thereby mitigates some of the risks of transition.

[2] Based on reports received from the Ministry of Education (Education Statistics 2018-24).

Theoretical underpinnings

LSP is grounded in sociocultural and constructivist theories that emphasize the integral role of language in cognitive development and learning. Vygotsky's Social Constructivist Theory (1978) posits that learning occurs through social interaction and language mediation. The concept of Zone of Proximal Development (ZPD) suggests that learners can achieve higher levels of cognitive development when provided with appropriate linguistic and instructional scaffolding. LSP is an approach that seeks to integrate language scaffolding into STEM education in schools, and so enhance conceptual understanding and engagement.

LSP aligns with social constructivist learning theory by allowing students to first engage in exploratory talk about the content in their L1 and so draw relations between their pre-existing knowledge and new concepts. After this, there is a transition to the L2 for presentational talk and writing. In STEM education, the use of L1 as a scaffold enables students to grasp abstract and complex concepts more effectively. Teachers mediate learning through bilingual instruction, ensuring that students can participate actively in classroom discussions and problem-solving activities within their ZPD. This approach reduces cognitive overload, allowing students to gradually internalize STEM concepts in the L2.

Further reinforcing this perspective, Halliday (2004) provides a linguistic framework that explains the three fundamental roles of language in education, which are essential for the implementation of LSP:

i) Learning a language – Developing linguistic proficiency in L1 and L2,
ii) Learning through language – Using language as a tool to construct meaning and knowledge in STEM subjects, and
iii) Learning about language – Reflecting on linguistic structures, functions, and academic discourse.

By integrating L1 in informal STEM discussions and using L2 for structured learning, LSP facilitates both linguistic development and subject comprehension. Similarly, LSP aligns with Piaget's Constructivist Theory (1950) by emphasizing that learning is an active process where students build new knowledge upon prior understanding. When STEM content is introduced in familiar linguistic structures (L1), students are more likely to connect new information with existing knowledge frameworks. The use of the L1 also allows for more references to common everyday phenomena to exemplify and illustrate complex concepts. This approach supports progressive cognitive development, ensuring that students transition gradually from L1 to L2 without compromising comprehension.

LSP also aligns only partially with additive Multilingual Education (MLE) models (May, 2017), which advocate the maintenance of the L1 alongside L2 to enhance conceptual

understanding. These models are based on understanding that the multilingual mind does not switch between languages but rather is able to draw fluidly across all its 'linguistic resource' (Lin, 2019, p.8) within dynamic processes of meaning making. Heugh and Stroud (2019) argue that horizontal multilingualism – the use of learners' full linguistic repertoire for social communication – makes education accessible and equitable. At the same time, however, they state that education should allow learners the opportunity to develop vertical multilingualism, that is the ability to read academic texts in more than one language. LSP however was designed within two contexts, Tanzania and Rwanda, where the language-in-education policy requires a language transition from a widely spoken African language to English, following which English becomes the single target language for all learning, teaching, and assessment in STEM subjects. LSP complies with the policy context by placing horizontal multilingualism (communicative talk in both L1 and L2) at the service of learning academic language in L2 (vertical monolingualism). Unlike subtractive bilingualism, which replaces L1 with L2, LSP does recognize the complementary cognitive functions of L1 and L2 in learning but does not, like additive MLE, target their simultaneous development. Finally, it is worth noting that languages are not the only semiotic system used in STEM subjects. Learners are expected to gain proficiency in interpreting and creating multimodal texts that integrate written text with diagrams, charts, graphs and chemical formulae. Hence, LSP emphasizes the use of different semiotics to support interpretation, most especially visual aids.

As illustrated by these theoretical foundations, LSP allows for the integration of students' linguistic backgrounds into subject teaching while still maintaining a L2 based MoI context. By allowing informal use of L1 to support deeper learning and understanding of complex STEM topics while progressively introducing students to L2 for formal subject discussions, LSP functions as both a linguistic and cognitive scaffolding mechanism. Furthermore, LSP allows for more informed use of the local context in STEM education (cf. Zelime et al., 2018; Zelime and Deutschmann, 2019). The benefits of LSP have been demonstrated by previous research (see Milligan et al., 2016; David and Nsengimana, 2021; Barrett et al., 2024), which further validates the significance of these theoretical perspectives.

Methodology

This study employed a qualitative research design grounded in a pragmatic approach, aiming to investigate the effects of Language Supportive Pedagogy (LSP) on STEM teaching and learning in in Zanzibar. Data were collected in three main phases: an online survey, follow-up telephone interviews, and classroom observations.

The online survey was conducted in early 2024 and targeted twenty secondary school STEM teachers from fifteen schools across Unguja and Pemba who had participated in the STEM4SUCCESS Zanzibar (S4SZ) Project. The survey consisted of structured and

open-ended questions designed to explore teachers' perceptions of LSP, their implementation practices, the impact on student engagement and learning, and the challenges faced in using LSP strategies. Participants also shared success stories and provided feedback on training and classroom integration. To enhance the validity of the data, follow-up calls were conducted with 15 participants to clarify responses and probe deeper into emerging themes. These conversations provided context-specific insights that enriched the data set. Teachers were asked to elaborate on specific LSP strategies, reflect on their effectiveness, and discuss how their training supported classroom implementation. In the third phase, classroom observations were conducted in eleven selected schools using a structured LSP classroom observation checklist. This tool included checklists for multiple domains such as language scaffolding, use of L1 and L2, integration of visuals, task design, and assessment strategies. Observations were carried out by trained evaluators who documented the frequency and quality of LSP practices across various lessons.

The triangulation of these data sources – survey, interviews, and observation – ensured the reliability and richness of the findings. Data analysis followed a thematic approach, with recurring themes coded across responses and classroom practices, categorized under three major headings: (i) teacher implementation of LSP methods and technology; (ii) the impact of LSP on students' participation, engagement and performance; and (iii) professional development needs and barriers to LSP implementation. When interpreting the results, two potential sources of error should be noted. Firstly, the interventions under the S4SZ project included other pedagogical methods which may have affected learner effects. Secondly, the current investigation is relatively superficial. We would need closer, continuous monitoring for a longer period of time, looking in detail at various aspects, and also including the learners' voices first-hand to truly evaluate the impact of LSP implementation. As such, this study should be seen as a pilot study scoping the potential to combine LSP with other STEM education teaching strategies.

Ethical considerations included obtaining informed consent from all participants, ensuring voluntary participation, and maintaining confidentiality. Identifiable information was anonymized in all reporting. The study adhered to Zanzibar research ethics guidelines; a research permit was obtained and approved by the relevant research board.

Results

(i) The implementation of LSP methods and technology

Firstly, language issues were identified as a significant challenge in STEM education, with 60% of teachers strongly agreeing and an additional 25% agreeing that English poses a primary obstacle to learning STEM subjects (see Table 1 below).

Table 1: Teachers' responses to the statement: 'English Language is the main barrier to learning STEM subjects in secondary schools'

Option	Frequency	Percentage
Strongly agree	12	60%
Agree	5	25%
Neutral	3	15%
Disagree	0	0%
Strongly disagree	0	0%

Given these perceived language challenges, teachers responded positively to LSP. However, the implementation of LSP techniques was limited to STEM teachers who had received specific LSP training. All these trained teachers reported incorporating LSP techniques into their STEM lessons. Notably, 70% indicated that they strategically used Kiswahili to clarify concepts, while 60% applied vocabulary scaffolding techniques.

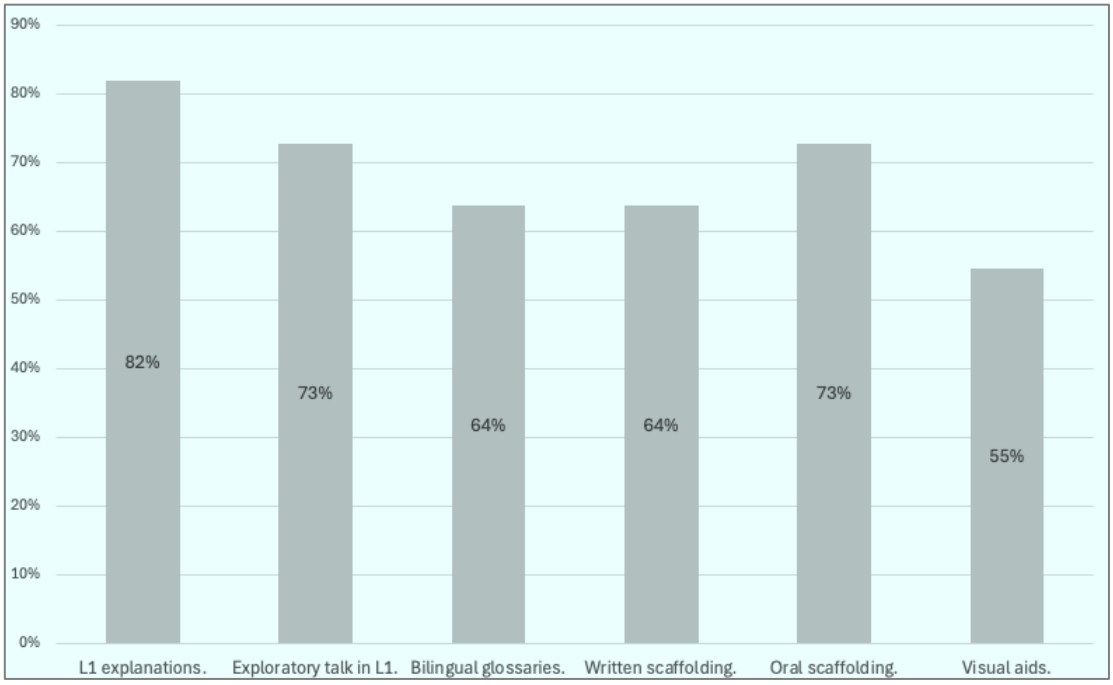

Figure 2: LSP techniques observed in classrooms

Observation data corroborated these findings (see Figure 2 above). In nine of eleven observed classrooms, teachers used Kiswahili to clarify abstract concepts before transitioning to English, and eight out of eleven teachers promoted L1-based exploratory talk before formal English instruction. Bilingual vocabulary boards were observed in seven classrooms to reinforce scientific terminology, and sentence scaffolds were observed in seven classrooms to support learners during written exercises. Furthermore, academic talk scaffolds were observed in eight out of eleven classrooms. Finally, visuals and animations were used in six out of eleven classrooms to explain scientific processes. Some teachers also highlighted the value of integrating LSP into their instruction. As one teacher noted:

It was very useful when I taught the lesson on sinking and floating.

Some teachers also used multimedia to project objects and simulations, enabling students to make connections between theoretical knowledge and practical applications. The incorporation of technology-based learning tools at hand, such as Kio Kits, drones, and projectors, enhanced the effectiveness of LSP by providing students with interactive, hands-on learning experiences. This integration often bridged the gap between abstract STEM concepts and real-world understanding, making the content more accessible and engaging for students.

Teachers who incorporated multimedia recognized its value in boosting student interest and enthusiasm in science lessons, especially given students' limited proficiency in the language of instruction. The use of multimedia offered interactive and visual learning aids, which facilitated better comprehension of complex STEM concepts. Lessons incorporating hands-on digital experiences were observed to be more engaging and effective, allowing students to actively particip that contextua ate in learning processes. This shift in student engagement aligns with research indicating lized and language-supportive teaching approaches enhance learner motivation and involvement in STEM subjects (e.g., Landuyt, 2022). Some teachers also incorporated real objects and tools into their lessons to reinforce learning and help reduce the language barrier.

Teacher feedback in open-ended comments in the survey highlighted the value of the technical tools at their disposal. Several teachers shared specific benefits, including:

Technology use added value.
Lessons come alive with projectors and Kio Kits.
Using digital tools made the learning more fun and effective.

These responses suggest that technology served as a valuable enhancement to LSP-based instruction by reducing the language barriers and making lessons more engaging, interactive, and effective for STEM learners.

Finally, while all eight pedagogical approaches used in the S4SZ project positively impacted STEM teaching, teachers reported that Language Supportive Pedagogy (LSP) had the greatest impact.

(ii) The impact of LSP on students' participation, engagement and performance

Effects on participation and engagement

In the survey, 85% of the teachers reported increased student participation after LSP implementation. Furthermore, many comments indicated that student engagement and

enthusiasm were higher in classrooms where LSP strategies were implemented. Some comments that illustrate this included:

> *Once I used these strategies, students became so attracted to learning that they called me for lessons even when it was not their time for that. Moreover, the general performance of the subject gradually increased.*

> *More students became interested in participating in teaching and learning activities, and they found the lessons more enjoyable.*

Teachers highlighted how LSP strategies helped break down difficult STEM concepts, making them more accessible to students with varying levels of English proficiency. Teachers reported that implementing LSP strategies, such as starting lessons in Kiswahili before transitioning to English, led to better classroom management because students felt more comfortable:

> *Students felt more comfortable and confident participating in lessons when they understood the material first in Kiswahili.*

> *When I explain complex science topics in Kiswahili first, students are more comfortable participating and asking questions.*

Several teachers noted a boost in students' self-confidence, particularly because it allowed learners to express themselves in both Kiswahili and English during STEM lessons, as one participant remarked:

> *Students found the lesson fun and were happy to use Kiswahili and English while enjoying their lessons more.*

One teacher described LSP as a '*muarobaini'* a Swahili name for a widely respected medicinal plant believed to cure numerous diseases: 'Yes, I think this is the *muarobaini* of language barriers in science subjects. Pupils were happy'. By using this metaphor, the teacher emphasized the vital role of LSP in addressing challenges related to language in STEM, suggesting that LSP acts as a solution or 'cure' within the educational context. This culturally rooted expression highlights the deep significance and hope teachers place in LSP as a transformative teaching approach.

Another teacher explicitly stated that LSP builds confidence not only for learners but also for teachers.

> *Increasing confidence in the learning and teaching process.*

Learning outcomes

The findings reflect clear improvements in students' broader learning outcomes following the implementation of LSP. In the survey, 90% of teachers reported increased student performance after LSP implementation. Several participants claimed that LSP strategies helped students express scientific ideas more effectively, for example by using comparative language or visual tools, like tables, to clarify concepts.

Examples from classroom observations supported these claims, showing students collaborating in Kiswahili before presenting in English, brainstorming in Kiswahili before presenting in English, and solving word puzzles to reinforce STEM vocabulary. One teacher supported this point with a clear example, noting that:

> *Some students are now able to use different words to represent ideas. For example, when they want to differentiate things, they can use tables, or differentiate words like 'but' or 'while,' even in science concepts.*

Several teachers also noted improved results in assessments and exams, stating: 'Good exam results… results actually improved'. Furthermore, the approach enhanced the overall quality and lesson structure, as noted by a teacher whose LSP-based lessons were praised by inspectors: 'Inspectors [quality assurers] enjoyed my lessons'. These examples illustrate LSP's effectiveness in improving students' engagement, comprehension, and overall learning outcomes.

(iii) Barriers and professional development needs for LSP implementation

Despite positive outcomes, teachers identified several key areas that acted as barriers to LSP implementation. The most common cited challenge was time constraints and 60% of teachers reported that limited time made it difficult to effectively integrate LSP without falling behind on curriculum coverage. The LSP adapted lessons needed to be longer to fully make use of supportive techniques such as initial L1 explanations and glossary overviews, something which created stress. This issue is compounded by the fact that both the national curriculum and teacher preparation in Tanzania largely overlook multilingual practices, failing to reflect the multilingual reality of the classroom. As a result, teachers struggle to balance LSP integration with the demands of a rigid, monolingual curriculum.

A majority of teachers (60%) identified a lack of resources as a problem, for example, some teachers noted the absence of textbooks tailored to LSP methods. Another common issue was the wide range of students' language abilities which made it difficult for teachers to differentiate instructions effectively. Several teachers (25%) pointed out insufficient administrative support to implement LSP. Interestingly, however, only 15% of the teachers mentioned lack of confidence using LSP technique as a barrier for LSP implementation (see Table 2 below).

Table 2: Reported challenges to integrating LSP techniques among trained teachers

Challenges	Count	Percentage
Time constraints	12	60%
Lack of resources	12	60%
Difficulty differentiating instructions	6	30%
Lack of administrative support	5	25%
Lack of confidence using LSP technique	3	15%

Observation notes confirmed that teachers appeared relatively confident in implementing LSP strategies. One reason for this may be that many science teachers do already code switch between Kiswahili and English, as observed in previous research in Tanzania (Mwinsheikhe, 2009; Barrett et al., 2014). LSP was designed to build incrementally upon these existing practices (as explained in Barrett et al., 2021). However, only five out of the eleven observed teachers were able to explain the rationale behind specific instructional practices associated with LSP. This implies that many teachers had a mere surface-level knowledge of the practical tools of LSP practices but lacked a deeper understanding of the reasoning behind the use of these. This is not surprising in a context where multilingual classroom practices, whilst widespread, are often considered illegitimate (Clegg and Afitska, 2011). One effect of monolingual language-in-education policies is to suppress professional discourse on multilingual alternatives. These findings point to the need for more in-depth training and targeted coaching, as advocated by Robertson and Graven (2019 and 2020), that opens up space for teachers to openly discuss and share multilingual practices.

The need for professional development was strongly echoed by the teachers themselves, who recommended more peer learning opportunities, mentoring, and stronger institutional support for LSP to become embedded in policy and practice. In the survey comments, teachers emphasized the importance of continuous professional development, coaching and mentoring in sustaining the progress made through the S4SZ Project. They recommended ongoing support to refine their use of LSP and other pedagogical approaches, as well as additional training in technology integration. One teacher noted, 'LSP worked wonders in my class, but we need more workshops to stay up to date and improve even further. More training and mentoring are needed'. 'LSP concepts must continue to be taught', added another teacher.

Overall, teachers also recommended expanded workshops on bilingual teaching methods, greater access to digital STEM resources, and structured mentoring programmes to help refine LSP techniques, and finally, modifications of current education policies to fully allow for, and encourage, teachers to apply LSP in schools.

(iv) Summary of results from the S4SZ trials

Our results showed that a vast majority of the teachers considered language challenges to be the major barrier to STEM learning. The integration of LSP within STEM curricula has been identified as a critical factor in fostering inclusive learning environments, particularly for students with limited proficiency in English. Survey responses indicated a strong consensus among educators regarding the impact of language barriers on STEM learning and the benefits of LSP for student learning and engagement. Although teachers were able to implement LSP and identify the challenges involved, the majority demonstrated a surface level understanding. Many pointed to the need for ongoing professional development and targeted pedagogical training to further improve LSP implementation. Participants strongly advocated the continuation and expansion of LSP strategies in STEM education, as one teacher stated:

> *LSP worked wonders in my class, but we need more workshops to stay up to date and improve even further. More training and mentoring is needed.*

Comparative insights – findings from S4SZ in relation to the Seychelles context

S4SZ demonstrates that pilot trials of Language Supportive Pedagogy (LSP) had a significant impact on teaching and learning outcomes in multilingual STEM classrooms in Zanzibar. Similar benefits could be expected if LSP was implemented in Seychelles but while there are common challenges in the two contexts, there are contextual differences that need to be considered.

Findings from the current study underscore the necessity of embedding LSP methodologies directly within STEM curricula rather than treating them as supplemental instructional strategies. Put more simply, STEM subject teachers working in L2 MoI contexts, like Seychelles, need to be aware of linguistic and pedagogic aspects, specific to teaching their subjects, to learners with limited L2 proficiency. At the secondary level in Seychelles, this need is arguably even more acute than in Zanzibar as almost half of all secondary school teachers are expatriates and there are no language requirements concerning Kreol Seselwa (Seychelles Ministry of Education, 2024). The proportion of expatriate teachers is particularly high in STEM subjects. Many of these teachers do not have the option to use the learners' L1 themselves to clarify concepts. Implementing LSP in this context requires special attention to how L2 communication can be better adapted to the proficiency levels of the learners, and more emphasis needs to be put on visual and other multimodal aids to support understanding. They can also still exploit learners' bilingualism by allowing time for informal student discussion, known as exploratory talk (Barnes, 2008), in L1 or horizontal multilingual exploratory talk. There is also a case for introducing L1 teacher assistants who could help bridge language barriers.

At the primary level, the vast majority (94%) of the teachers are Seychellois (Seychelles Ministry of Education, 2024). Integrating LSP in STEM teaching at primary level, after transition to English MoI in Primary 3, would thus be less of a challenge with regards to linguistic competencies of the teachers. Another aspect that could potentially facilitate LSP implementation at this level is the fact that primary teachers in Seychelles are generalists, teaching all subjects in a class. This means that teachers have a good overview of the language competencies of the learners in a class. This generalist approach also facilitates effective incorporation of LSP methodology in teacher training and vocational training that would benefit all subjects.

A major barrier to LSP implementation in Seychelles, however, is the extremely negative attitudes that teachers hold towards Kreol Seselwa being used in education. In a study by Zelime and Deutschmann (2018, p.139), 96.5% of the teachers asked wanted to remove Kreol Seselwa as a language of instruction altogether from primary school, and this finding has been corroborated by others (see Fleischmann, 2008; Fleischmann Schwarz and Nick, 2018). For a change in attitude regarding the role of Kreol Seselwa in education, a prerequisite for LSP, it would be necessary to engage teachers and policymakers in debate and share with them the evidence that use of L1 makes STEM education more inclusive. Here the Ministry of Education has a great responsibility.

Such efforts need to go hand-in-hand with systematic efforts to adapt the curriculum frameworks in Seychelles, as well as Zanzibar, to accommodate LSP. A well-integrated curriculum should incorporate descriptions of language scaffolding techniques, multilingual instructional materials, and structured assessments, that account for the linguistic diversity of the learners. The curriculum also needs to consider the time needed to implement such LSP methods and timetabling needs to be adapted accordingly. This is not the case at the moment.

In the Seychelles context, our studies have shown that while the curriculum framework allows, in theory, for language support in the first language, this is not realized in the field (Zelime and Deutschmann, 2016). As things stand, there is no reference to the practical aspects of implementing language support, and neither are there any directives as to how to address learner language needs. Timetabling does not take language support into account and learning materials are not adapted for L2 learners. In fact, in past reports, there have been indications from the Ministry of Education that the use of Kreol Seselwa as support language is, instead, discouraged (Zelime and Deutschmann, 2016, p.57).

The comparative insights from the Seychelles case (Deutschmann and Zelime, 2021) reinforce the need for structured language-in-education policies that are context sensitive and equity driven. While Seychelles has embraced a trilingual education model, the reduction of Kreol Seselwa's role in upper primary and secondary education has led to increased inequities, particularly for students with limited exposure to English at home.

This mirrors the Zanzibar context, where continued L2 dominance without adequate scaffolding risks excluding learners.

However, as this study of the S4SZ shows, much can be gained by actually introducing LSP in the field, even as a shorter intervention. This may well be the way forward for Seychelles. Using LSP in the classroom and evaluating the outcomes thereof, would arguably raise awareness of the strengths and benefits of using the L1 in supporting learning in the L2 MoI classroom, and hopefully change negative attitudes towards using the L1 in class. These types of trials would also serve to inform future policy change.

General discussion

Findings from this study corroborate research from other East African countries corroborate research from other East African countries (Milligan et al., 2016; David and Nsengimana, 2021; Barrett et al., 2024) demonstrating that LSP can significantly improve teaching and learning in STEM classrooms. The use of Kiswahili as a scaffold in explaining complex STEM content empowered learners to participate actively, confidently and engage deeply with the subject matter. This is in line with Vygotsky's Zone of Proximal Development (ZPD), which emphasizes the importance of guided learning through linguistic and cognitive scaffolding. Teachers who incorporated LSP strategies observed improved comprehension, performance, and participation among students. The pedagogical value of LSP is particularly evident in its ability to bridge language gaps without compromising subject-matter integrity, fostering more inclusive and equitable STEM classrooms. These findings align with broader global studies that highlight the importance of aligning language-of-instruction practices with learners' linguistic realities (Erling et al., 2021; Essien and Msimanga, 2021; Trudell, 2016). The study thus contributes to broader discussions on language policy, inclusive education, and the role of pedagogical adaptation in improving learning outcomes in linguistically diverse contexts. It also reinforces the need for sustained professional development and policy alignment to institutionalize effective multilingual pedagogies in STEM education.

As regards educational inclusivity and equity, our findings corroborate Deutschmann and Zelime (2021), who point to the fact that learners performed better in science subjects when Kreol Seselwa was introduced strategically as the language of instruction in Primary 1-4 in the 1980s, and how current abrupt transitions from L1 to L2 in Primary 3 can disrupt learning and widen inequities. Their study highlights how unplanned or unsupported transitions to L2 can impair both access and achievement, a risk LSP seeks to mitigate. The classroom observations from this study reinforce these insights. Practices such as the use of Kiswahili to clarify complex scientific concepts and scaffolding strategies using bilingual vocabulary boards, exemplify what Cummins (1981 and 2000) refers to as the development of Cognitive Academic Language Proficiency (CALP), whereby mastery of L1 facilitates the acquisition of higher-order thinking skills in the L2.

Erling et al. (2023) underscore that subtractive transition systems – where L1 is abruptly replaced by L2 – contribute significantly to learning poverty in sub-Saharan Africa. They emphasize the importance of instructional language policies that acknowledge learners' linguistic backgrounds and build continuity between home and school languages. The LSP model, which strategically integrates L1 into STEM classrooms, meets some of these policy needs by encouraging exploratory talk (Barnes, 2010) and knowledge construction in both L1 and L2 (see also Macaro et al., 2018; Adamson, 2022; Adamson et al., 2024).

In addition to linguistic support, the integration of digital tools within LSP-based instruction significantly enhanced student engagement and learning outcomes. Technologies such as Kio Kits, drones, and projectors made STEM lessons more interactive, helping students visualize and apply abstract scientific and mathematical concepts in practical contexts. However, to sustain the benefits of LSP supported by technology, investment is needed in technological infrastructure and teaching resources. Furthermore, professional training on how to use these tools is needed.

To ensure the long-term impact and scalability of LSP in STEM education, coordinated efforts are thus needed at the policy and institutional levels. Continuous professional development should be prioritized to equip teachers with both pedagogical and technological competencies aligned with LSP principles. Curriculum reforms must embed language-supportive strategies explicitly, ensuring coherence between instructional goals and classroom realities. Moreover, sustained stakeholder engagement including school leaders, curriculum developers, and education policymakers, is critical to institutionalizing LSP practices. Lessons from comparative contexts such as Seychelles further highlight the importance of language policy alignment in promoting inclusive, learner-centred education in linguistically diverse environments.

Thus, both contexts illustrate the need for LSP within an additive bilingual model, one that builds upon, rather than replaces the learner's first language. The current study adds to this body of evidence by showing that when LSP strategies are used systematically, they do not only bridge linguistic gaps but also promote active learning and support educational equity.

Recommendations

To strengthen the implementation and scalability of Language Supportive Pedagogy (LSP) in multilingual STEM education, a comprehensive and sustained approach is required. Curriculum frameworks should be aligned with LSP principles to ensure that language is used as a tool for learning rather than a barrier. Embedding LSP within national curricula frameworks will help standardize effective teaching practices and promote inclusive, language-aware instruction across educational institutions.

Teacher education should prioritize both pre-service and in-service training on multilingual pedagogy. Continuous professional development is essential to build teachers' confidence and capacity to integrate LSP strategies effectively in their classrooms. Establishing professional learning communities and encouraging peer exchange will further strengthen teaching practices and support collaborative growth among STEM educators.

Language-in-education policies should reflect the linguistic realities of classrooms, particularly in multilingual contexts. Policymakers need to adopt flexible, context-sensitive approaches that legitimize the use of students' first languages in STEM and other subject instruction. Recognizing and validating learners' linguistic backgrounds can enhance comprehension, engagement, and equity in learning. There also need to be special resources available to support learners with limited English proficiency.

Access to multilingual teaching and learning materials is crucial. There should be investment in the development and distribution of bilingual or multilingual learning resources, including textbooks, vocabulary guides, and teacher support tools. These resources will help translate LSP principles into day-to-day classroom practice and improve students' ability to grasp complex STEM concepts.

Digital tools should be integrated into LSP-based instruction to enhance student learning. Technology can support interactive and visual learning experiences, making abstract scientific ideas more accessible. Teachers should be equipped with appropriate digital platforms and low-tech innovations, along with training on how to use them effectively to support multilingual learners.

Schools must receive adequate institutional support to successfully implement LSP. This includes more flexible timetabling and providing teaching aids, language-rich environments, and resources that facilitate inclusive pedagogy. Ensuring that schools are well-resourced will contribute to the sustainability of LSP practices and the broader success of STEM education reforms.

Regional collaboration should be encouraged to foster knowledge exchange and the sharing of best practices. Countries like Zanzibar and Seychelles can benefit from mutual learning through cross-border initiatives, research partnerships, and joint policy development focused on language-supportive STEM education.

Stakeholder engagement remains a key pillar in sustaining the momentum of LSP implementation. Policymakers, school leaders, and education stakeholders must remain committed to supporting teachers and championing policies that promote inclusive, language-aware STEM teaching. Institutional commitment and continued investment are critical for long-term impact.

Lastly, further research is needed to assess the long-term effects of LSP on student learning, teaching practices, and educational equity. Longitudinal interventions and impact assessment studies will generate the evidence needed to refine implementation strategies, inform policy decisions, and scale successful models of LSP in diverse educational systems.

These recommendations underscore the importance of moving beyond policy rhetoric to actionable strategies that honour linguistic diversity as a resource for learning. Implementing LSP at scale requires not only pedagogical innovation but also political will, intersectoral collaboration, and sustained investment in teacher capacity and learning environment

Conclusion

This study reflects on the transformative impact of the STEM4SUCCESS Zanzibar (S4SZ) Project and the pivotal role of LSP in improving STEM education. While other pedagogical methods also contributed to the project's success, LSP stood out as a key factor in making STEM content more accessible and inclusive for students. This study provides valuable insights into the transformative power of LSP in STEM education. The S4SZ Project has shown that LSP, when combined with modern digital tools and continuous professional development, can improve both student outcomes and teacher practices. The success of this approach suggests that LSP should be further integrated into the curriculum, supported by ongoing mentorship and the development of a community of practice among educators. The integration of technology further amplified these results, creating dynamic and engaging learning environments.

The study also highlights the need for continued professional development to ensure that teachers are well-equipped to implement LSP and other innovative pedagogies. The creation of communities of practice among STEM educators is also recommended to foster peer-to-peer learning and support. In essence, the discussion reveals that LSP is not merely a remedial approach but a transformative pedagogical strategy that addresses deep-rooted linguistic inequities in STEM education. For LSP to be scalable and sustainable, it must be embedded within national education policies, supported by continuous teacher training, and reinforced by culturally relevant curriculum materials. Lessons from Seychelles and sub-Saharan Africa more broadly affirm the critical role of well-structured, multilingual pedagogies in advancing quality education for all.

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