Enhancing Science Terminology among Low-Achieving Bilingual Grade 8 Students through a Multicomponent Intervention: An Action Research Study

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Abstract

This article presents the findings of an action research study that investigated the feasibility of using a structured pedagogical approach to enhance Grade 8 low-achieving bilingual students' knowledge of English scientific technical terms (STTs) in a rural secondary school in Sri Lanka. A mixed-methods action research design was employed with ten purposively selected students over six intervention sessions focusing on Grade 8 Biology content. A multimodal, multicomponent intervention was implemented, integrating bilingual glossary support, visual representations, short video segments, guided collaborative learning, Frayer Model-based activities, and gamified learning to address language barriers and promote conceptual understanding. Data were collected through pre-tests, formative assessments, post-tests, student feedback forms, classroom observation notes, and a reflective teaching journal.The quantitative findings demonstrated a substantial improvement in students' knowledge of scientific technical terminology. The mean score increased from 28.20 (SD = 4.04) in the pre-test to 64.20 (SD = 5.77) in the post-test. A paired-samples *t*-test confirmed that this improvement was statistically significant, $t(9) = 15.02$, $p < .001$, with a Cohen's d of 4.74, indicating an extremely large effect size. Formative assessment results also demonstrated a progressive improvement in students' performance across the six intervention sessions. Qualitative findings complemented the quantitative results, revealing increased student engagement, confidence, willingness to participate, and use of scientific technical terminology. However, some students continued to experience difficulties with abstract and complex biological concepts, suggesting that vocabulary development alone may not be sufficient to ensure deeper conceptual understanding. The study concludes that explicit, linguistically responsive, multimodal, and collaborative instruction of scientific technical terminology can help bilingual learners overcome an important linguistic barrier to science learning. The findings further demonstrate the potential of classroom-based action research to generate practical, context-sensitive pedagogical solutions for supporting low-achieving bilingual learners in science education.

Keywords: Bilingual Education, Science technical terms, multimodal, multicomponent intervention, Frayer Model, progressive learning

Introduction

In a science classroom that includes bilingual students, many concepts to be learned are often doubly challenging because students must simultaneously master discipline content and language. This is a particularly complexes demand when the scientific ideas are abstract, technical and linguistically unknown. In these contexts, students might know a concept in their own language but be unable to specify, describe or explain the same concept in English. This can lead to lower confidence, decreased engagement, and diminished performance for many even when they know the concepts well. The present study addresses this issue by implementing a classroom-based action research intervention with Grade 8 bilingual learners in rural Sri Lanka

The study was motivated by observations in a bilingual Grade 8 science classroom, where students demonstrated an ability to discuss basic scientific concepts in Sinhala but experienced considerable difficulty in appropriately using the corresponding English scientific terminology required for classroom learning and examinations. This difficulty extended beyond a simple lack of familiarity with technical terms. Limited knowledge and use of scientific terminology appeared to constrain students' ability to recall concepts, provide oral explanations, formulate written responses, and engage meaningfully with science content. In this context, restricted access to the academic language of science may create a misleading impression of limited scientific ability, as students' difficulties in expressing their understanding in English can mask their underlying conceptual knowledge. The issue, therefore, represents both a linguistic and a pedagogical challenge, requiring attention not only to students' acquisition of scientific concepts but also to their development of the specialized language through which those concepts are communicated and demonstrated in science classrooms and assessments.

Literature Review

Assuming that deliberate language support can help bilingual learners, the research was guided by this. The Linguistic Interdependence Hypothesis introduced by Cummins (2000) states that conceptual knowledge and literacy acquired in a first language can facilitate language acquisition in a second language. Vygotsky's Sociocultural Theory (1978) emphasizes the importance of social interaction, scaffolding and learning in the Zone of Proximal Development (ZPD). Paivio's Dual Coding Theory (Paivio, 1990) can be used to account for how verbally presented material that is accompanied by visual and multimodal representations is enhanced for memory and comprehension. From these perspectives, the following support an intervention that is based on the value of the learner's first language, collaborative learning, and visual reinforcement

The study's primary goal was to develop, apply and analyze a feasible program that could help improve the understanding of science English technical terms. Specific objectives included assessing students' current knowledge, developing an intervention to improve students' knowledge, implementing the intervention, evaluating the intervention, and soliciting students' feedback for improvements. This research was limited to Biology content since this was the content covered during the school term. In terms of scope it was deliberately constrained, but focused in terms of purpose, it was to develop a usable classroom model to inform and guide other bilingual science contexts.

What is important about the study is that it can be applied to the classroom. At the learner level, it was set to raise learner's achievement and confidence. It was a model at the teacher level of how action research can be used for the purpose of diagnosis, to attempt a responsive intervention, to observe learning in intervention, and to refine practice. At the school and policy level, it provides evidence that bilingual science instruction means more than just a policy label; it requires language support and scaffolding, professional judgment, and context-specific resources. Therefore, this study makes a contribution to practice and to the broader discourse on improving the role of bilingual education for students under-resourced schools.

Methodology

The study employed a mixed-methods approach within an action research design. Action research was considered appropriate because the research problem was immediate, context-specific, and directly related to classroom instruction and students' learning needs. Rather than viewing the classroom merely as a setting for observation, the study regarded it as a context for systematic and purposeful instructional improvement. The researcher assumed the role of teacher-researcher and followed the cyclical process of action research, comprising planning, implementation, observation, and reflection. This iterative process enabled the researcher to identify students' learning needs, implement targeted instructional strategies, monitor their effectiveness, and make appropriate adjustments throughout the intervention. Consequently, the design facilitated the examination of both the outcomes of the intervention and the processes through which change occurred, making it particularly relevant for evaluating improvements in teaching practice and students' overall learning performance.

The study sample comprised 10 low-performing Grade 8 bilingual students selected through purposive sampling from the bilingual section of a rural secondary school in Sri Lanka. The target population consisted of Grade 8 students receiving Science instruction in two languages. The participants were specifically selected based on their identified difficulties in understanding and using scientific technical terminology. The relatively small sample size was appropriate to the action research context, as the study prioritized in-depth engagement, individualized instructional support, and close monitoring of students' learning progress throughout the intervention. This focused sampling approach enabled the teacher-researcher to respond more effectively to the specific learning needs of the selected students and to examine their development in a detailed and systematic manner.

The intervention was implemented over six sessions and was closely aligned with the Grade 8 Biology curriculum. Selected scientific technical terms were systematically introduced, explained, practiced, and reviewed using a range of bilingual and multimodal instructional strategies, including bilingual word lists, visual representations, short videos, group discussions, guided explanations, and the Frayer Model. The intervention also incorporated gamification and collaborative learning activities to enhance student engagement, encourage active participation, and reduce anxiety associated with learning unfamiliar scientific terminology. The instructional sequence was designed to progressively deepen students' understanding of the target terminology, moving from explicit teacher guidance and structured practice towards increased student participation and greater independence in using and interpreting scientific terms.

Data collection was deliberately triangulated to provide a comprehensive understanding of the effectiveness of the intervention. Quantitative data were collected through pre-test and post-test assessments designed to measure students' knowledge of scientific technical terminology, as well as six formative assessments administered at the end of each intervention session. Qualitative data were obtained through student feedback forms, classroom observation checklists, and the teacher-researcher's reflective journal. The pre-test and post-test results enabled a direct comparison of students' achievement before and after the intervention, while the formative assessments provided evidence of students' learning progress over the course of the six sessions. The qualitative data complemented the quantitative findings by providing deeper insights into the processes underlying the effectiveness of the intervention, including how students responded to the instructional strategies and why changes in their learning, engagement, and participation occurred. The integration of these data sources strengthened the overall interpretation of the findings through methodological triangulation.

Descriptive statistics were used to summarise the pre-test and post-test results, including the mean scores and standard deviations. To determine whether the observed difference between students' pre-test and post-test performance was statistically significant, a paired-samples *t*-test was conducted. In addition, Cohen's *d* was calculated to determine the effect size and assess the practical magnitude of the intervention. The qualitative data were analysed thematically to identify recurring patterns related to students' conceptual clarity, engagement, confidence, and attitudes towards the learning activities**.** The integration of quantitative and qualitative analyses provided a more comprehensive understanding of both the extent and nature of the changes resulting from the intervention.

Ethical principles were maintained throughout the research process. Appropriate informed consent was obtained, students' privacy and confidentiality were respected, and care was taken to avoid the use of language that could stigmatise participants because of their academic performance. The researcher also recognised that the dual role of teacher and researcher could potentially introduce bias into the collection and interpretation of the findings. To address this concern, the teacher-researcher's observations and reflections were considered alongside students' feedback and quantitative assessment data. This triangulation helped strengthen the credibility of the findings and provided a more balanced interpretation of the intervention's effectiveness.

Results

The quantitative findings demonstrated a substantial improvement in students' knowledge of science technical terms following the intervention. As presented in Table 1, the mean pre-test score was 28.20 (SD = 4.04), whereas the mean post-test score increased to 64.20 (SD = 5.77). Thus, following the six-session intervention, students achieved an average gain of 36 points. The pre-test scores ranged from 22 to 35, while the post-test scores ranged from 57 to 73, indicating a clear and consistent upward shift in students' performance across the group. Overall, these findings suggest that the intervention was effective in enhancing students' knowledge and understanding of science technical terminology.

The paired-samples *t*-test revealed that the improvement in students' performance from the pre-test to the post-test was statistically significant, $t(9) = 15.02$, $p < .001$. The calculated Cohen's *d* value of 4.74 indicated an extremely large effect size, demonstrating a substantial learning gain following the intervention. This finding suggests that the intervention produced a particularly strong improvement in students' mastery of science technical terminology within a relatively short period.

As shown in Table 2, students also demonstrated a consistent improvement across the six intervention sessions, as reflected in their formative assessment scores. The mean score increased progressively from 6.1 in Session 1 to 8.9 in Session 6. Although a slight decline in performance was observed in Session 4, students subsequently regained and improved their performance in the following sessions. This temporary setback provided an opportunity to review students' difficulties and make appropriate instructional adjustments. The subsequent improvement suggests that the formative assessment process supported the teacher-researcher in monitoring students' progress and adapting the intervention to address emerging learning needs.

The qualitative findings were broadly consistent with the patterns observed in the quantitative results. Students' comments indicated that the bilingual glossary, visual materials, videos, and group activities facilitated their understanding of the lessons and supported their acquisition and use of science technical terminology. Students also reported feeling more confident in expressing their ideas in their first language before attempting to communicate them in English, suggesting that the strategic use of the first language served as a bridge to English-medium scientific communication.

Observation notes further indicated increased classroom participation, willingness to respond to questions, and engagement in collaborative learning activities throughout the intervention. The reflective journal provided additional evidence regarding students' responses to the instructional activities. Students appeared particularly receptive to structured practice and visible learning supports, such as glossaries, pictures, and other contextualized resources. However, the reflections also indicated that abstract biological concepts required additional explanation, scaffolding, and opportunities for reinforcement to ensure meaningful understanding. Overall, the qualitative evidence complemented the quantitative findings by illustrating not only the extent of students' learning gains but also the instructional processes that contributed to their improvement.

Overall, the findings indicate that the integrated use of language support, visual resources, and collaborative scaffolding was effective in enhancing students' learning of science technical terminology. The convergence of evidence across the three data sources—pre- and post-test scores, formative assessments, and students' voices—revealed a consistent pattern of improvement. This alignment between quantitative and qualitative evidence strengthens the credibility of the findings and suggests that the observed learning gains were not limited to test performance but were also reflected in students' ongoing classroom engagement and learning experiences.

Table 1. *Descriptive statistics for the pre-test and post-test (N = 10)*

Statistic	**Pre-test**	**Post-test**
Mean	28.20	64.20
Standard deviation	4.04	5.77
Median	28.50	64.50
Range	13	16

Table 2. *Formative assessment means values across the six sessions*

Session	**Mean score (out of 10)**
Session 1	6.1
Session 2	6.8
Session 3	7.5
Session 4	7.3
Session 5	8.2
Session 6	8.9

Discussion

The findings suggest that, for bilingual learners, the key challenge is not necessarily a lack of exposure to scientific terminology but rather a lack of structured, meaningful, and accessible exposure. The substantial gain observed between the pre-test and post-test indicates that students were capable of learning science technical terms prior to the intervention. Rather, they appeared to have had limited access to instructional experiences in which the language of science was made explicit, visible, memorable, and usable. This finding supports the view that content-specific technical vocabulary is more effectively acquired through repeated and meaningful encounters with words rather than through incidental exposure alone.

The effectiveness of the intervention can be interpreted through the three theoretical perspectives that informed the study. First, the strategic use of Sinhala alongside English provided learners with opportunities to draw upon their existing first-language knowledge when developing understanding in the second language. This finding is consistent with Cummins' (2000) view that learners' first-language knowledge can support their academic and cognitive development in a second language. Second, the incorporation of collaborative group tasks, guided questioning, and peer discussion reflected the principles of Vygotskian scaffolding and the Zone of Proximal Development (ZPD), whereby learners are supported to accomplish tasks that they may not yet be able to perform independently (Vygotsky, 1978). Third, the deliberate association of technical terms with images, videos, and concrete examples was consistent with Dual Coding Theory (Paivio, 1990). Presenting verbal and visual representations together may have provided students with multiple pathways for encoding, recalling, and using the newly learned terminology. Taken together, these theoretical perspectives help explain how the integrated intervention transformed science technical vocabulary from relatively inaccessible terminology into language that students could understand, remember, and use meaningfully (Cummins, 2000; Paivio, 1990; Vygotsky, 1978).

The qualitative evidence provides a deeper and more nuanced interpretation of the quantitative findings. Improvements in students' confidence, motivation, and classroom participation are particularly significant because they suggest that the intervention influenced not only students' test performance but also their affective and behavioral engagement with learning (MacIntyre, 2017). Students became more willing to speak, attempt to use science technical terminology, and participate in collaborative group activities, indicating increased confidence in using the language of science (Pabro-Maquidato, 2021). Such changes are particularly meaningful in bilingual classrooms, where fear of making linguistic errors may discourage learners from participating actively and using the target language (Horwitz et al., 1986; Jalleh et al., 2017).

At the same time, the findings indicate that improved knowledge of technical terminology alone does not necessarily guarantee conceptual understanding. Some students continued to experience difficulties in understanding abstract biological processes, suggesting that vocabulary knowledge needs to be accompanied by appropriate conceptual explanations and learning experiences. Thus, while technical terminology is essential for accessing and communicating scientific knowledge, terminology alone is insufficient for developing deep conceptual understanding (Sibanda, 2024; Snow, 2010). Students require carefully designed opportunities for explanation, guided practice, discussion, and meaningful application of concepts to consolidate their understanding of abstract scientific ideas (Grospietsch & Mayer, 2018).

From a pedagogical perspective, the findings suggest that low-cost instructional strategies can produce meaningful learning gains when they are implemented systematically and consistently (Black & Wiliam, 1998). Although each strategy may appear relatively simple when considered independently, their integration created a coherent and effective learning sequence. In particular, the combination of a bilingual glossary (García & Wei, 2014), visual prompts (Paivio, 1971), short, focused discussions (Mercer & Littleton, 2007), and a structured graphic organizer (Marzano et al., 2001) provided students with complementary forms of linguistic, visual, interactive, and organizational support. The effectiveness of the intervention therefore appears to have emerged not from any single technique, but from the purposeful integration of these strategies within the learning process.

The action research approach was particularly valuable because it enabled the teacher-researcher to continually examine students' responses, identify emerging difficulties, and refine the instructional strategies during the intervention rather than waiting until the end of the teaching period (Revans, 1982; Sagor, 2000). This iterative process reflects one of the key strengths of classroom-based inquiry: its capacity to generate context-responsive and practice-oriented improvements in teaching and learning (Cochran-Smith & Lytle, 2009). Thus, the findings demonstrate that effective pedagogical innovation does not necessarily depend on sophisticated or costly resources; rather, it can emerge through the thoughtful integration, continuous monitoring, and responsive adaptation of accessible instructional practices.

Conclusion

The aim of this study was to enhance Grade 8 students' knowledge and use of domain-specific English technical terminology in a low-performing rural Sri Lankan school. The findings provide strong evidence of the effectiveness of the intervention. Students demonstrated substantial improvement in their post-test performance, showed consistent progress across all six intervention sessions, and expressed positive attitudes towards the learning activities. The integration of bilingual language support, visual materials, collaborative learning, and explicit instruction in technical terminology appears to have reduced an important linguistic barrier to learning science and enabled students to engage more confidently with scientific content.

The broader contribution of the study lies in demonstrating how classroom-based action research can be used not only to address an immediate instructional problem but also to generate meaningful, practice-based knowledge. The findings suggest that effective bilingual science instruction should make technical terminology explicit, provide appropriate visual and contextual support, and build on learners' existing linguistic resources. Such an approach can help bilingual learners move from partial conceptual understanding and limited linguistic expression towards more confident and academically appropriate use of scientific language.

Nevertheless, the findings should be interpreted in light of the study's limitations. The study involved a relatively small number of students and focused specifically on Biology-related content within a particular rural school context. Therefore, the findings cannot be readily generalized to other student populations, subject areas, or educational settings. Despite these limitations, the results provide a valuable basis for further classroom-based experimentation and larger-scale research. Future studies could apply the intervention across different strands of science, involve larger samples, and incorporate comparison groups or multiple schools to examine its effectiveness across diverse contexts. At present, however, the study offers a practical and context-sensitive model for teachers seeking to support bilingual learners in developing both their scientific knowledge and the academic language needed to communicate that knowledge effectively.

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