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Enhancing Higher Order Thinking Skills in a Sri Lankan English Medium Instruction Science Classroom: An Action Research

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Abstract

This interventionist action research aimed to enhance Higher-Order-Thinking Skills (HOTs) which are essential for the 21st- century to face unprecedented challenges. The participants were Grade eight students who learn Science through English Medium Instruction (EMI) in a Sri Lankan public school. The study also aimed to address the examination-oriented mindset that prioritizes memorization over critical thinking, and scaffolding language gaps. The pre-intervention questionnaires and pre-tests revealed that students grapple with higher-order questions and primarily rely on lower-order thinking. To address this, “What If” questioning and “Notice and Wonder” techniques were adopted in collaborative group work over five 40-minute lessons to stimulate curiosity and encourage deeper cognitive engagement necessitating peer feedback, consciousness-raising, and co-construction of knowledge. The study combined quantitative statistical analysis of test scores with qualitative thematic analysis of student perceptions about their experiences elicited through questionnaire responses and corroborated through teacher reflection. Results demonstrated a significant improvement in students’ use of HOTs, also evidenced by increased post-test scores and student self-reflective feedback. Students reported enhanced engagement, motivation, and confidence in tackling complex problems, showing the effectiveness of the intervention in initiating, and developing a more analytical/curious mindset. The findings suggest that incorporating these pedagogical strategies into the curriculum can effectively shift focus from rote memorization to critical thinking, better preparing students for 21st-century challenges. This study contributes valuable insights into effective pedagogical approaches for developing HOTs in secondary science education, with potential implications for curriculum development and teaching practices in similar educational contexts.

Keywords: Higher Order Thinking; Collaborative Groupwork; English Medium Instruction; action research; science education; Content Language Integrated Learning (CLIL)

Introduction

Sri Lanka’s education system is heavily geared toward examination performance, a phenomenon often referred to as “examination hell” (Liyanage, 2013). This heavy reliance on content and examination results (NEPF, 2023) promotes rote memorization and surface understanding at the expense of critical and higher-order thinking skills (HOTS) that negatively impact students’ ability to analyze, evaluate, and create solutions (World Bank, 2011). Higher Order Thinking (HOT) involves critical, analytical, and creative thinking skills that go beyond memorization, promoting problem-solving, decision-making, and deeper understanding in learners. These skills are crucial for addressing complex real-world challenges. The typical examination questions focus on the lower levels of Bloom’s Taxonomy— remembering

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and understanding—resulting in students who can recall information but struggle with more complex cognitive tasks (Anderson & Krathwohl, 2001). The pressure to perform well in exams has also led to a significant reliance on shadow education or private tuition, which further reinforces rote learning practices (Daily FT, 2017). According to NEC (2022), students often resort to private tuition to prepare for public examinations, sacrificing their leisure time, which should be spent playing, interacting with the environment, and engaging in creative thinking. Furthermore, NEC states that the curriculum and examinations still rely on traditional models that prioritize memory-based, lower-order thinking (LOT) questions in classroom assessments and public high-stakes examinations. Consequently, students often find themselves ill-prepared for real-world problem-solving and critical thinking demands hindering their ability to face unprecedented challenges effectively, which is crucial in 21st-century education. Against this backdrop, it is determined that teaching practitioners should initiate preparing students for the 21st Century without waiting for state policies to be implemented. As such, the objectives of the present study aimed to take the following remedial pedagogical actions and assess their effectiveness.

Research Objectives

1. Enhance higher-order thinking skills among Grade 8 EMI science students through innovative pedagogical interventions.
2. Address language barriers in EMI science classrooms through CLIL strategies.
3. Evaluate the effectiveness of "What If" questioning and "Notice and Wonder" techniques in promoting HOTs.

The Study

The participants of this study learn science in English, a language in which they lack proficiency. These students complete their primary education in their mother tongue and transfer to EMI in grade six. The relationship between language proficiency and critical thinking in Content and Language-Integrated learning or CLIL classrooms presents a complex challenge. When students learn content through a second language, their cognitive load increases significantly as they must simultaneously process both content and language (Coyle et al., 2010). This dual processing can impede their ability to engage in higher-order thinking tasks. According to Cummins's (2008) distinction between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP), students may struggle with critical thinking tasks not because they lack cognitive ability, but because they have not developed the CALP necessary to express complex thoughts. For example, while students might understand scientific concepts, they may struggle to articulate analysis, evaluate, or create hypotheses in their second language. This may also lead them to rely heavily on rote learning. In response to these challenges, this practitioner interventionist action research was conducted to enhance HOTs among grade eight Science students in a public school in Sri Lanka.

The intervention addressed language barriers through several key strategies:

1. Pre-teaching scientific vocabulary through visual aids and bilingual support
2. Use of language frames for "What If" responses
3. Peer support through mixed-ability grouping
4. Wait time for language processing and response formulation.

The project was conducted as a partial requirement of fulfillment of the Professional Certificate in CLIIL, a continuing teacher professional development (CTPD) for EMI Content teachers conducted by Sri Lanka Institute of Information Technology. The interventions involved two 'actions or strategies: "What If" questioning and "Notice and Wonder" in collaborative groups. These strategies were chosen based on their proven effectiveness in promoting critical thinking and curiosity in students (Susanti et al., 2021; NCTM, n.d.).

The Action (Intervention)

What if' and 'Notice and Wonder'

The intervention included several strategies, *viz*., Collaborative Group work 'What if' questions, and the 'Notice and Wonder' approach. 'What If" questions encourage students to explore hypothetical scenarios, thereby stimulating their power of imagination, creativity, and critical thinking. For instance, asking students, "What if there were no gravity?" prompts them to think beyond the textbook and apply their knowledge in new contexts. The "What If" learning strategy is one of the appropriate learning strategies used to improve students' mathematical thinking skills (Payadnya & Atmaja, 2020), The "Notice and Wonder" approach involves students observing a phenomenon and asking questions about what they notice and wonder, which cultivates a sense of curiosity and drives deeper understanding (NCTM, n.d.). These were utilized in Pre-Lesson activities as stipulated in the Lesson Plan structure given in the CLIIL CTPD program (Wijesekera, 2021). Pre-lesson activities are well-structured teacher-prepared activities for students to complete through independent collaborative learning and come to the classroom after exploring the phenomena being learned in the class.

Theoretical Underpinning

The above strategies can be situated under the overarching theory of Constructivism that emphasizes that learners actively construct knowledge by interacting within one's cognition and with the outside world. While cognitive constructivism (Piaget, 1952) emphasizes one's active engagement in knowledge construction based on prior knowledge, according to social constructivism (Vygotsky, 1978) knowledge is received and constructed through social interaction where learners may achieve the Zone of Proximal Development (ZPD) through scaffolding provided by the more knowledgeable ones (Vygotsky, 1978). This posits that students learn more effectively through guided interactions with peers (Prepscholar, 2024) in collaborative and cooperative group tasks. Hence, cooperative group work will not only help scaffold content gaps but also address the English language gaps in the students, improving both their comprehension of the subject matter and their ability to express the content and knowledge (Wijesekera, 2012).

Research: Materials and Methods

This action research, conducted over six weeks, employed a comprehensive mixed-methods approach to investigate the effectiveness of specific interventions to enhance HOTs among Grade eight Science EMI students in a Sri Lankan type 1AB public school, involving a group of 32 students (1AB Schools are Secondary school offering subjects at GCE Advance Levels in all three streams: Arts, Commerce, Science).

At the beginning of the study, students faced a Pre-Intervention test, which served as a baseline measure of their initial HOT levels. This was done by one writer of this paper, their science teacher, having observed the absence of HOTs among the students. The pre-intervention test was designed to go beyond mere factual recall, instead, it challenged students with open-ended questions that required them to engage in higher-level cognitive processes such as analysis, evaluation, and creation. By structuring the test in this manner, we aimed to gain insight into the students' ability to think critically, solve complex problems, and generate original ideas within the context of their science curriculum. Complementing the Pre-Intervention test, a questionnaire was administered to gather qualitative data on students' attitudes towards learning, their confidence in tackling complex problems, and their typical approaches to schoolwork. The responses to the questionnaire provided valuable context for understanding the students' mindsets and learning styles before the implementation of the interventions. The Intervention was structured around three key components:

1. Pre-Lesson Activities: Comprising Independent learning through educational videos and reading; Vocabulary discovery and concept preparation; Connection building between prior and new learning.

2. In-Class Activities: Consisting of "Notice and Wonder" observations and discussions; "What If" questions through collaborative group work; Peer feedback and knowledge co-construction

3. Post-Lesson Consolidation: Online engagement through Padlet; Student-created "What If" questions; Reflection and assessment.

The core of the intervention comprised five well-planned 40-minute lessons, each incorporating two key strategies: "What If" questioning and "Notice and Wonder" activities. We recognize the fact that five activities are inadequate to enhance HOTs in students. Nevertheless, our main intention was to see if the selected intervention can enhance HOTs so that they can be utilized in the next cycles of action research and further explore the ways and means to enhance HOTs in CLIL students.

These strategies were selected for their potential to foster interactive and collaborative engagement among students, encouraging them to think more deeply about scientific concepts and their real-world applications. By engaging in collaborative work, students are more likely to develop critical thinking skills and apply knowledge through peer feedback (both negative and positive), consciousness-raising about gaps, and scaffolding (Wijesekera, 2012). It was deemed that student engagement is a critical factor in promoting HOTs, which involve complex cognitive processes such as analysis, synthesis, and evaluation (Anderson & Krathwohl, 2001). Strategies that increase engagement, such as interactive activities, relevant and challenging content, and supportive learning environments, have been shown to contribute significantly to improving students' cognitive abilities (Fredricks et. al, 2004). Engaged learners are more capable of critical analysis and problem-solving, as they are motivated to understand the subject matter at a deeper level (Chen at el., 2010). Collaborative learning is an effective instructional approach, especially in ESL writing classrooms, which can improve learning outcomes by creating a social context where students support each other to improve their skills. When students work together in groups, they can share their ideas, get feedback on their work, and learn from each other. This type of interaction can help students to identify gaps in their knowledge and develop strategies for improvement. Further, they recognize the importance of mutual understanding and cooperation and appreciate the opportunity to learn about different languages and cultures and develop respect for them (Wijesekara, 2012; 2018).

The "What If" questioning strategy was implemented through an innovative card game format. Each card presented students with a hypothetical scenario related to the lesson topic, such as "What if the Earth's magnetic field disappeared?" This approach was designed to stimulate creative thinking and encourage students to apply their scientific knowledge to novel and often complex situations. One student reflected: "Before, I just memorized facts. Now I think about how everything is connected and what could happen in different situations." Working in groups, students were tasked with discussing these scenarios and proposing potential solutions or explanations. This collaborative aspect not only enhanced their critical thinking skills but also promoted communication and teamwork. Payadnya & Atmaja (2020) proved that "What-If" learning strategy can effectively enhance students' mathematical critical thinking skills in the context of a Statistical Method I course. They suggest that this approach could be further explored and adapted for use in other subjects and educational settings.

The "Notice and Wonder" strategy was integrated into each lesson through activities where students were presented with phenomena related to the topic being studied. They were then asked to note their observations (what they noticed) and questions (what they wondered about). This approach was intended to foster curiosity, enhance critical observation skills, and encourage students to engage more deeply with scientific concepts by formulating their own questions and hypotheses. A student commented: “I started seeing details I never noticed before. When we share our observations in the group, everyone notices different things, and it makes me think more deeply.”

To maximize the effectiveness of the limited class time, Pre-lesson activities were assigned to students as per the lesson plan structure given in the CLIL Teacher Professional Development module (Wijesekera, 2021). Pre-lesson activities, a structured independent learning process, of the present intervention typically involved watching educational videos or reading relevant materials to prepare for the collaborative in-class activities. They intended to bring prior learning and present learning connected, discovery of new vocabulary, and concepts coming in the new lesson. By sharing some of the content early, we also aimed to create more time for interactive learning, discussion, and consolidation during classroom activities. The integration of technology played a significant role in the study’s design. The online platform Padlet was utilized to facilitate learning, allowing students to create and share their own “What If” question cards. This not only provided a dynamic and engaging way for students to interact with the content and new language/terminology but also allowed them to take ownership of their learning process. The use of technology also enabled easier tracking student participation and progress throughout the study.

Post-Intervention

Following the six-week intervention, a Post-Intervention Test was conducted. This test was designed to be similar in structure and difficulty to the Pre-Intervention Test, allowing for a direct comparison of students’ HOTs before and after the intervention. The Post-Intervention Test aimed to measure any improvements in students’ abilities to analyze, evaluate, and create within the context of their science curriculum. To corroborate additional qualitative data on the students’ experiences and perceptions of the interventions were gathered through a follow-up questionnaire which collected descriptive data about how students felt the interventions had impacted their learning, their engagement with science, and their overall academic confidence.

Data analysis

The data analysis and interpretation phase of the study employed both quantitative and qualitative analysis/interpretation methods to provide a comprehensive understanding of the interventions’ effectiveness. The simple statistical approach allowed us to determine if there was a significant improvement in students’ HOTs over the course of the study period. The qualitative data gathered from the pre- and post-intervention questionnaires, which were provided to the students in their mother tongue and later manually translated into English with caution, offered valuable and deeper insights into how the interventions may have influenced students’ cognitive skills and their attitudes towards learning, as perceived by them. We quote from teacher reflective entries by the first author to begin with, offering an overarching tone for data analysis.

*“*Week 3*: Today’s ‘What If’ discussion about Natural Disasters revealed considerable progress in students’ ability to connect concepts. They are not just recalling facts but considering complex cause-and-effect relationships. The language support frames helped less confident speakers participate more actively. However, some groups still need additional scaffolding for expressing complex ideas in English.”*

*“*Week 5*: The collaborative approach is showing clear benefits for both content understanding and language development. Students are naturally supporting each other’s language needs while engaging with complex scientific concepts. The wait time during group discussions has notably improved the quality of responses.*

Results and Discussion

The results provide evidence for the effectiveness of the implemented interventions in enhancing HOTs among the participant grade eight Science BE students. The pre-intervention questionnaire analysis reflected a significant lack of confidence among students in attempting to solve complex problems independently. Many students reported rarely engaging in activities that required critical thinking or problem-solving beyond rote memorization. 'Notice and wonder' activities and 'What if' questions were new to students prompting them to think critically and find solutions collaboratively rather than through conventional learning methods. As they revealed they felt there was a noticeable difference between these interventions and traditional learning. This initial finding illustrated a crucial gap in the students' learning experiences, highlighting the need for interventions that could increase higher-order thinking skills.

The pre-intervention test scores confirmed these questionnaire findings. Students struggled to provide in-depth answers to questions designed to assess HOTs, indicating a limited ability to analyze, evaluate, and create responses beyond simple recall of facts. Following the intervention period, there was a clear improvement in students' performance on HOT-related tasks.

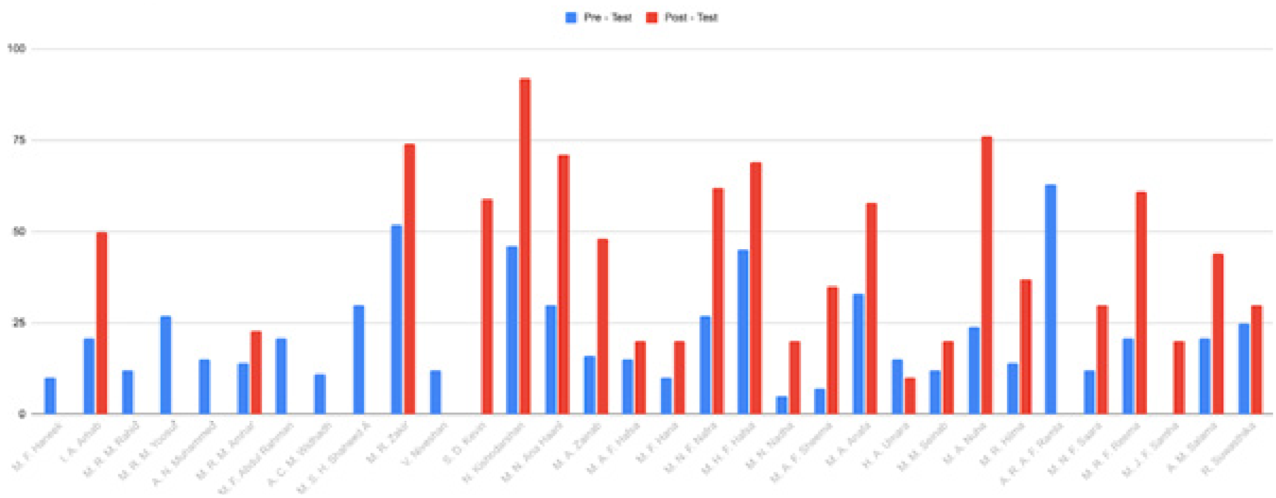

Figure 1. Scores of Pre-intervention test and post-intervention test

A detailed analysis of individual student performance reveals that out of the thirty-two students in the study, twenty demonstrate improved performance from pre-test to post-test. This represents a considerable majority of the students for whom complete data was available, as eleven students were excluded from this analysis due to absence in the pre-test, post-test, or both. Only one student showed a decrease in performance. These results indicate that the interventions had a positive impact on most students' HOTs development.

Table 1. Mean and Standard deviation of Pre-Intervention test and post-intervention test

Groups	*Count*	*Sum*	*Average*	*SD*
Pre - Test	21	465	22.14	12.63
Post - Test	21	950	45.24	22.71

The post-intervention test scores showed a substantial increase, with the mean score rising from 22.14 in the pre-test to 45.24 in the post-test. This improvement suggests that the "What If" questioning and "Notice and Wonder" strategies were successful in developing students' abilities to analyze, evaluate, and create. This was corroborated by students' perceptions about their work, engagement, and the scores they received from pre- and post-intervention tests.

Post-intervention questionnaire

The post-intervention questionnaire was given to students in their mother tongue and later translated into English for analysis. The responses from the post-intervention questionnaire provided qualitative data that offered deeper insights into students' learning experiences and perceptions of the interventions. Several key themes emerged from this analysis, which are summarized below, considering the word limit.

1. Increased Engagement: Students reported that the interactive nature of the lessons was more engaging compared to traditional teaching methods. The use of hypothetical scenarios in the "What If" questions and the observational activities in the "Notice and Wonder" approach seemed to have attracted their interest and motivated active participation according to their perceptions. As one student said: "Science class is different now. Instead of just listening and memorizing, we get to think and discuss our ideas. It makes me want to participate more."

2. Collaborative Learning: Many students value the collaborative aspects of interventions. Working in groups allowed them to share ideas, learn from their peers, and develop their cognitive skills through discussions. A student noted: "Working in groups helps me learn both science and English. When I don't know how to say something, my groupmates help me find the right words."

3. Enhanced Curiosity: The "Notice and Wonder" strategy and "What If" questions were particularly effective in developing a sense of curiosity among students. They reported that this approach encouraged them to ask more questions and think more deeply about the topics presented. One student reflected: "Now I do not just accept facts; I ask 'why' and 'what if.' It helps me understand science better."

4. Language Skills Development: The interventions provided increased opportunities for writing, speaking, and presentation in English. Students who were previously hesitant to communicate in their second language reported feeling more confident in using English during these activities. This may be due to a kind of 'wait time', where students had time to prepare to answer questions or similar questions since they engaged in the lesson content through pre-lesson activities. Theoretically, this can be attributed to Krashen's Monitor Hypothesis, suggesting that the students had time to monitor the accuracy of their responses before producing them. This suggests that the interventions had additional benefits beyond cognitive and critical thinking skill development, contributing to language proficiency and communication confidence. The teacher's reflective journal documented this progress: "Students who were initially hesitant to speak in English are now more willing to participate (or started to show willingness), especially when they have time to prepare their responses in groups."

Qualitative feedback from students offers valuable insights into the mechanisms by which these interventions were effective. The increased engagement reported by students is particularly remarkable, as engagement is often a foundation for deeper learning. By making lessons more interactive and challenging, the interventions seem to have created a more helpful environment for the development of higher-order thinking skills. The collaborative nature of the activities appears to have played a crucial role in the interventions' success. Group discussions and peer learning not only enhanced students' thinking skills but also provided a supportive environment for exploring complex ideas. This aligns with constructivist learning theories, which emphasize the importance of social interaction in cognitive development. The enhancement of curiosity through the "Notice and Wonder" strategy is a particularly promising outcome. Curiosity significantly influences scientific inquiry and lifelong learning. Researchers view curiosity as an intrinsic motivation that drives individuals to seek new information and experiences, thereby fostering continuous learning and scientific exploration (Engel, 2013). The improvement in English language skills among bilingual students highlights the potential for integrated learning approaches. This finding suggests that the study's interventions can have cross-curricular benefits, improving not just subject specific skills but also general academic abilities like language proficiency.

Limitations

While the results are promising, it is important to note some limitations of the study. The sample size of thirty-two students is relatively small, and the absence of eleven students from either the pre-test or post-test limits the data's completeness. Future studies could benefit from larger sample sizes and strategies to minimize data loss due to student absence. The study's duration of six weeks, while sufficient to show significant improvements, may not capture long-term effects. Nevertheless, we invite other CLIL teachers to experiment with the strategies irrespective of the learning context.

Conclusions

This action research aimed to enhance HOTs among grade eight BE students through targeted interventions during science teaching/learning in the EMI classroom. The results revealed a significant positive impact on students' critical thinking abilities, problem-solving, and overall engagement with scientific concepts which are essential in the 21st century to face unprecedented challenges. Pre-intervention findings highlighted a lack of confidence among students in tackling complex problems independently. This was corroborated when questioned about their use of critical thinking in school assignments. Many students reported rarely applying such skills. They faced challenges such as confusion and difficulty in generating effective ideas for higher-order thinking tasks. There was a noticeable disconnection between academic learning and real-life applications of HOTs. These findings suggest that the implemented interventions - particularly the interactive and collaborative elements - were successful in fostering an environment conducive to developing HOTs. Students not only improved their academic performance but also empowered and gained confidence in applying critical thinking skills to real-world scenarios according to data. The study underscores the effectiveness of integrating engaging, inquiry-based approaches into science education to enhance students' higher-order thinking abilities. It highlights the potential of such interventions to transform students' learning experiences, making science more accessible and relevant while preparing them for the complex problem-solving demands of the future. While the results are promising, further research into larger groups of participants and over extended periods could provide additional insights into the long-term impact and sustainability of these interventions. For instance, delayed post-tests should be one aspect to consider. Nonetheless, this study offers valuable evidence for educators and curriculum developers on effective strategies to cultivate HOTs in science education.

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