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SECONDARY SCHOOL STUDENTS' ANXIETY IN READ-ANSWER-DISCUSS-EXPLAIN-CREATE MODEL WITH ENGLISH AS A MEDIUM OF INSTRUCTION IN SCIENCE CLASS

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ABSTRACT

This study examines the effectiveness of the Read–Answer–Discuss–Explain–Create (RADEC) model, integrated with English as a Medium of Instruction (EMI), in reducing science learning anxiety among secondary school students. The research addresses a common challenge faced by non-native English speakers in science classrooms—language-induced anxiety that hinders conceptual understanding and communication. Employing a convergent mixed-methods design, the study involved 30 secondary students purposively selected from Bandung, Indonesia. Quantitative data were collected through a time-series experiment, while qualitative insights were obtained via in-depth interviews. After five months of implementing the RADEC model with EMI, students exhibited marked reductions in communication apprehension, fear of negative evaluation, and test anxiety. At the same time, they demonstrated enhanced conceptual mastery and confidence in English-mediated scientific communication. The findings suggest that the RADEC model with EMI provides a structured yet flexible pedagogical framework, enabling pupils to access, discuss, and present scientific content in English without fear of linguistic penalties. The novelty of this study lies in its integration of a culturally responsive pedagogical model (RADEC) with EMI to address both cognitive and affective barriers in science education. This approach offers scalable potential for EMI-based instruction in multilingual, cross-national educational contexts.

Keywords: anxiety; English as a Medium of Instruction (EMI); Read-Answer-Discuss-Explain-Create (RADEC); science class; conceptual mastery

INTRODUCTION

The use of English as a Medium of Instruction (EMI) in science classrooms for non-native English speakers has become increasingly prevalent across various regions, particularly in Asia. In Indonesia, the adoption of EMI in diverse courses, including science at the secondary school level, is on the rise (Macaro et al., 2018). Similar trends are observed in Hong Kong and Mainland China, especially in secondary and tertiary education. EMI facilitates access to English-based scientific resources, accelerating learning and conceptual understanding in science. The growing use of EMI aligns with Sustainable Development Goal (SDG) 4, which seeks to ensure inclusive and equitable quality education

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and promote lifelong learning opportunities for all. EMI supports this goal by increasing access to global scientific knowledge, enhancing students' competencies, and preparing learners for active participation in the international academic and professional arenas.

However, non-native English speakers in several Asian countries face numerous challenges when learning through EMI across subjects. These include cognitive difficulties related to language processing, increased cognitive load during assessments, socio-cultural pressures, and prior experiences that negatively impact self-confidence (Chang, 2015; Alghazo & Al-Wadi, 2019; Chang, 2023; Hutabarat, 2024). Despite these obstacles, studying in a foreign language may enhance memory retention and cognitive skills, as learners are encouraged to engage with concepts directly rather than relying on translation (Sukardi et al., 2022).

Secondary students with limited English proficiency often experience test anxiety and fear of negative evaluation, which undermines focus and learning (Khasbani, 2019). Such anxiety in EMI settings causes stress, reduces confidence, and pressures students to prove competence (Hutabarat, 2024). Cognitive overload during assessments further impairs performance. Integrating CLIL (Content and Language Integrated Learning) within EMI fosters reading habits and language-content acquisition, though teaching complex subjects like science in English remains challenging in many Asian contexts (Margana, 2015).

Observations in Indonesian secondary schools show that many science teachers struggle with student anxiety and engagement in EMI settings. In a pilot study, 63% of students felt uncomfortable answering science questions in English, indicating a need for more supportive teaching models. Pre-class reading has been shown to reduce anxiety, promote autonomy, and encourage collaboration (Kang, 2023). A study in two urban schools revealed that structured pre-reading increased student participation and confidence, highlighting the importance of EMI-based models that reduce anxiety and enhance communication.

When suitably implemented, EMI can robustly facilitate secondary students' knowledge acquisition, underscoring the necessity for learning models that encourage English communication within classrooms (Lamb & Coleman, 2008; Coleman & Capstick, 2012). In anxiety-free EMI environments, students demonstrate strong mastery of scientific concepts alongside enhanced communication skills. The RADEC model (*Read – Answer – Discuss – Explain - Create*) enhances concept mastery while strengthening verbal and written communication. By engaging students in regular English reading and speaking, it builds comprehension, confidence, and reduces anxiety. Each stage of RADEC supports effective EMI implementation by prioritising student comfort and progress. Although RADEC has been studied in general science contexts, its specific impact on EMI-related anxiety and communication barriers remains unexplored, presenting a valuable area for further research.

In non-English-speaking regions, such as Asia, EMI supports both the acquisition of scientific concepts and English proficiency (Hutabarat, 2024). This dual advantage is vital, given the rapid progress in science and the dominance of English in fields such as biotechnology, environmental science, and information technology (Khasbani, 2019). EMI removes language barriers, providing students with access to advanced scientific knowledge necessary for success in global academia and careers (Tai & Thang, 2021). It equips learners with essential language skills for international study, research, and English-based professions (Tsang & Dang, 2023; Sahan et al., 2025)

Addressing global challenges such as climate change and pandemics requires international cooperation, facilitated by English proficiency that enables cross-border communication (Dang et al., 2023; Bradford et al., 2024; Jeongyeon & Kim, 2024). EMI equips students to contribute to global research initiatives and mitigate educational inequalities by providing non-native English speakers with equitable access to comprehensive resources and international prospects (Duong & Chuo, 2016). Implementing EMI in foreign language contexts requires effective strategies to target the appropriate audience without inducing anxiety, fear, or trauma among students (Yildiz, 2021; Tsang & Dang, 2023; Williams, 2023). To overcome difficulties in understanding core scientific concepts, bilingual approaches can incorporate scientific terminology within EMI frameworks in science education.

Despite extensive research on EMI, few studies have critically examined the specific mechanisms by which RADEC reduces EMI-related anxiety in science education. Most EMI studies to date have not addressed structured pedagogical interventions that directly integrate language and content learning (Byun et al., 2011; Walkinshaw et al., 2017; Liu, 2022). Thus, this study aims to fill this gap by investigating the use of the RADEC model to mitigate EMI-related anxiety and enhance science communication skills in Indonesian secondary schools. This research offers the potential to support existing findings by demonstrating how specific instructional strategies, such as RADEC, can enhance the implementation of EMI in science classrooms.

EMI improves academic performance and emotional well-being through integrated language-content instruction (Sukardi et al., 2021). Teachers should prioritise concept mastery and gradually introduce scientific vocabulary to strengthen understanding. EMI-related anxiety includes communication apprehension, test anxiety, and fear of negative evaluation (Kang, 2023). Students often feel nervous expressing ideas in English (Luong et al., 2025; Nguyen et al., 2025; Sangkawong & Bucol, 2025; Shadiey et al., 2025), worry about mistakes during assessments (Margana, 2015), and fear being judged by peers or teachers (Williams, 2021; Lu & So, 2024). These factors may cause hesitation, stress, and code-switching, highlighting the need for EMI strategies that reduce anxiety and build confidence (Byun et al., 2011; Kang, 2023; Kim et al., 2024).

The decision to sustain EMI in the Asia-Pacific region influences not only academic outcomes but also academic anxiety and cultural adaptation (Tsou & Kao, 2017; Walkinshaw et al., 2017; Tsang & Dang, 2023). Non-native English students may experience heightened anxiety when comprehending course materials, while instructors face challenges in delivering content effectively across cultural boundaries. Comprehensive evaluations of EMI's sustainability must consider the institutional support capacity and how EMI fosters inclusive and productive cultural adaptation within academic communities.

EMI substantially enhances communication skills and science mastery by exposing students to global scientific terminology and concepts. This exposure enhances vocabulary, comprehension, and active participation in discussions, empowering students to articulate complex ideas with confidence and clarity. Access to extensive English resources broadens knowledge and deepens understanding (Byun et al., 2011; Sukardi et al., 2021). Moreover, learning science via EMI develops critical thinking skills as students analyse and interpret information in English.

Nevertheless, EMI's effectiveness in science education warrants critical evaluation. Contextual factors determine whether EMI facilitates or impedes scientific concept acquisition (Duong & Chuo, 2016; Walkinshaw et al., 2017; Liu, 2022). Alignment between instructional models and EMI implementation is essential. Evaluations should assess EMI's impact on language proficiency, students' comfort expressing scientific ideas, and support for intended learning outcomes. This ensures EMI optimally advances both language and science competencies, contributing to holistic academic development.

Investigating students' communication skills through EMI enhances interpersonal abilities, including active listening, which involves paying attention, clarification, and requesting repetition (An & Macaro, 2025; Nguyen et al., 2025; Sahan et al., 2025). EMI also enhances verbal communication by fostering clear expression of ideas and written communication through accurate articulation. Assertive communication, involving direct yet non-threatening expression of opinions, and nonverbal communication through gestures, is also cultivated (Koeing, 2011). These skills can be evaluated through targeted questioning and observation in discussions and debates.

The RADEC model (*Read – Answer – Discuss – Explain - Create*) is specifically designed to nurture communication skills, build self-confidence, and reduce anxiety. The *Read* step involves independent engagement with materials, which familiarises students with content and lowers anxiety (Lestari et al., 2021). The *Answer* step reinforces comprehension and self-assurance through response to questions (Adriana et al., 2022; Maulana et al., 2022). *Discuss* facilitates peer interaction, enhancing verbal skills and public speaking in a supportive setting. *Explain* involves presenting findings, which develops organisational and presentation skills alongside confidence. Finally, *Create* requires application of knowledge through project-based learning, fostering higher-order thinking, collaboration, and effective English communication in scientific contexts (Lestari et al., 2021; Sukardi et al., 2022; Sari et al., 2025; Le et al., 2025). Through RADEC, students develop a stronger scientific understanding and enhance their English communication skills. This comprehensive approach addresses EMI-related anxiety and fear, creating a positive environment conducive to both language acquisition and science mastery.

In conclusion, although EMI presents challenges such as increased anxiety and cognitive demands for non-native speakers, appropriate pedagogical models like RADEC can mitigate these issues by fostering autonomous learning, reducing evaluative fears, and enhancing communication skills. EMI is vital in today's globalised academic and professional landscape, granting students access to scientific knowledge and preparing them for international collaboration. Educators should therefore implement EMI with supportive strategies, such as the use of bilingual terminology, anxiety reduction techniques, and models that promote active communication. By doing so, EMI can fulfil its potential to empower non-native English students in science education while promoting equity and global academic engagement. The research question is: To what extent and in what ways does EMI reduce secondary school students' anxiety in a science classroom setting?

METHODS

The research employs a convergent mixed-methods design, deliberately integrating both quantitative and qualitative data collection to capture a multidimensional understanding of the phenomenon (Bardoshi et al., 2022). Each phase of the research is explicitly aligned with established methodological frameworks, ensuring clarity and rigour from design through data interpretation. This structured approach enables robust triangulation of data sources, thereby enhancing both internal and external validity. Figure 1 summarizes the previously explained convergent mixed-method research procedure, highlighting key steps from data collection to synthesis.

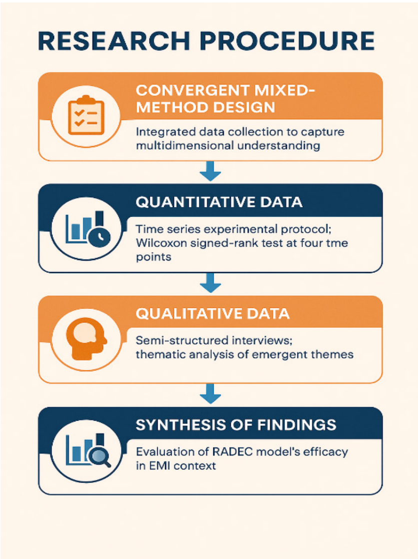

Figure 1. Research Procedure

Quantitative data were collected through a carefully designed time-series experimental protocol, enabling the identification of temporal trends and causality in student responses across multiple instructional points. This method allowed for precise measurement of incremental changes and intervention effects, which is critical given the complexity of language acquisition within EMI settings. Concurrent qualitative data were gathered via semi-structured interviews, providing rich contextual insights into participants' subjective experiences, affective responses, and motivational dynamics. The simultaneous integration of these datasets strengthens construct validity by reconciling objective outcomes with lived realities.

This mixed-method strategy foregrounds the complex interplay between linguistic competence and affective factors, a dimension often overlooked in single-method designs. By systematically combining numerical and narrative evidence, the study advances a nuanced analysis of EMI's pedagogical impact under the RADEC instructional framework (Buldu & Erden, 2023; Choi et al., 2023). Quantitative data were collected at four strategically timed intervals throughout the instructional period, extending beyond traditional pre-post designs to capture longitudinal progression. These intervals corresponded with curriculum modules on classification of living organisms, ecology, pollution, and space science, delivered through EMI employing the RADEC model. The time series experimental design required students to actively engage in EMI without the premature imposition of grammatical perfection, prioritising communicative confidence as a developmental scaffold. This deliberate pedagogical stance recognises that fluency and confidence form the foundation for subsequent grammatical accuracy in second language acquisition. Qualitative data collection via interviews was conducted purposively with three secondary students, selected to achieve maximum variation and depth of insight regarding their emotional and cognitive responses to the EMI environment. This qualitative component allowed the exploration of intricate motivational factors and anxiety manifestations that quantitative instruments alone could not capture.

The RADEC instructional model itself was pivotal, facilitating extensive reading comprehension and collaborative communication practice. This model strategically addresses psychological barriers such as anxiety and negative evaluation, which are critical inhibitors in EMI contexts. Students are scaffolded through stages, from *Read* and *Answer* outside classroom hours, to *Discuss* and *Explain* in supportive group settings, culminating in *Create*, where they synthesize and articulate original ideas with confidence. This scaffolded approach directly targets both cognitive mastery and affective engagement, key to sustained language learning success.

The sample consisted of thirty seventh-grade secondary students from Bandung, Indonesia, selected via purposive sampling to ensure alignment with specific inclusion criteria related to English proficiency and EMI relevance. The cohort comprised 13 males and 17 females. These students demonstrated intermediate English proficiency levels, which are sufficient for participation but without prior experience in EMI classrooms, situating them as ideal candidates for investigating the effects of initial EMI exposure. The choice of Grade 7 reflects an intentional focus on the transitional phase into middle school, which is critical for evaluating early programme impact.

The primary instrument was a questionnaire adapted from Horwitz et al. (1986), rigorously modified and validated for this study's context through expert review and bilingual translation-back translation protocols. The Likert scale ranged from "strongly agree" to "strongly disagree," facilitating nuanced quantitative measurement of constructs such as communication apprehension, test anxiety, and fear of negative evaluation. Interviews, conducted with a purposively selected subset of three students, provided qualitative corroboration and clarification of questionnaire findings. This sampling was justified by data saturation principles, aligning with best practices in qualitative research (Choi et al., 2023). Participants' verbal articulation of their experiences enriched the interpretive framework, enabling a triangulated understanding of the dynamics of anxiety and confidence within the RADEC-EMI intervention.

Table 1. Example of Questions from Questionnaire

No	Indicators	Questions	Original Questions
1.	Communication Apprehension	I always feel comfortable speaking English in science class.	I always feel comfortable speaking English in class.
2.	Test Anxiety	I am not worried about making mistakes while speaking English in science class.	I am not worried about making mistakes in speaking English.
3.	Fear of Negative Evaluation	I tremble when I know I will be called to science class.	I tremble when I know I will be called in class.
4.	Verbal Communication	I effectively convey my views, opinions, and ideas in science discussion forums.	I effectively convey my views, opinions, and ideas in discussion forums.
5.	Concept Mastery	I do understand the science concepts explained by the teacher in English.	I do understand the concepts explained by the teacher in English.

The Wilcoxon signed-rank test was selected due to the non-normal distribution of the questionnaire data, as evidenced by preliminary normality tests ($p > 0.05$). Data were collected at four time points to rigorously track the evolution of students' anxiety, communication skills, and conceptual mastery. This non-parametric test is optimally suited for matched sample comparisons in longitudinal designs, providing robust inferential power despite small sample sizes.

Qualitative interview data were systematically analysed through coding procedures to identify emergent themes related to communication apprehension, test anxiety, and fear of negative evaluation. Participants were prompted to reflect on which anxiety factor was most salient and how the RADEC model mediated these affective challenges. This thematic analysis was conducted with methodological rigor, including iterative coding and inter-coder reliability checks, thereby ensuring the trustworthiness and credibility of findings. By synthesising quantitative trends and qualitative insights, the study presents a comprehensive, methodologically sound evaluation of the RADEC model's efficacy in enhancing student confidence and language skills within an EMI context.

RESULTS AND DISCUSSION

The results and discussion should be presented in the same part, clearly and briefly. The discussion part should contain the benefits of the research results, not the repetition of the results. The results and discussion sections can be combined to avoid extensive quotation.Tables or graphs must present different results. The results of data analysis must be reliable in answering research problems. References to the discussion should not repeat the references in the introduction. Comparisons to the findings of previous studies must be included.

Table 2. Wilcoxon Test Results on Secondary Students' Anxiety

Indicators	Development 1		Development 2		Development 3	
	Z Score	p value	Z Score	p value	Z Score	p value
Fear of Communication (+)	-3.947	<.001	-3.873	<.001	-4.562	<.001
Fear of Communication (-)	-3.421	<.001	-2.668	<.001	-4.463	<.001
Fear of Negative Evaluation (+)	-5.000	<.001	-5.000	<.001	-4.667	<.001
Fear of Negative Evaluation (-)	-4.134	<.001	-4.523	<.001	-5.000	<.001
Anxiety of Test (+)	-3.162	<.001	-4.667	<.001	-5.000	<.001
Anxiety of Test (-)	-5.000	<.001	-3.513	<.001	-4.667	<.001

Notes:
Development 1 = Change from 1st Data Retrieval to 2nd Data Retrieval; Development 2 = Change from 2nd Data Retrieval to 3rd Data Retrieval; Development 3 = Change from 3rd Data Retrieval to 4th Data Retrieval

The process by which EMI reduces anxiety in the science classroom can be attributed to the structured and supportive design of the RADEC model, which systematically scaffolds students' linguistic and cognitive engagement. By initially focusing on the "Read" phase, students are gradually introduced to challenging scientific terminology in a low-pressure setting, allowing them to familiarize themselves with key concepts and vocabulary before active production is required. Subsequently, the "Answer" and "Discuss" phases provide repeated opportunities for oral practice in English, encouraging risk-taking and communication without fear of immediate correction or judgment. This gradual exposure reduces the cognitive overload associated with real-time translation and linguistic formulation, which was previously a primary source of anxiety. Furthermore, the model's emphasis on conceptual clarity over linguistic perfection shifts the classroom culture away from punitive correction towards collaborative learning, which builds students' confidence and reduces fear of negative evaluation. Together, these mechanisms enable students to develop not only their English communication skills but also their scientific reasoning, resulting in a more positive emotional and academic experience in the EMI science classroom.

The mechanism through which EMI reduces anxiety can be elucidated by the linguistic demands inherent in science education. Many scientific terms—such as "photosynthesis," "evaporation," and "oxidation"—originate from English, creating a barrier for students concerned about pronunciation and grammatical accuracy. Such anxieties often impede students' abilities to articulate scientific reasoning, construct arguments, or explain experimental outcomes. The RADEC model addresses these challenges by fostering a supportive classroom atmosphere that mitigates communication anxiety, thereby enabling students to express scientific ideas more confidently in both English and Indonesian. Furthermore, by cultivating an environment that normalizes linguistic errors and prioritizes conceptual understanding, RADEC diminishes the fear of negative evaluation and encourages active participation in discussions and presentations without apprehension.

The significant decrease in test anxiety further evidences the extent of anxiety reduction. Scientific assessments typically require interpreting data, applying formulas, and engaging in logical reasoning—tasks made more daunting when executed in a non-native language. The phased structure of RADEC ("Read," "Answer," "Discuss") incrementally exposes students to scientific terminology and content, thereby enhancing both comprehension and language proficiency prior to the "Evaluate" phase, which in turn reduces test-related stress.

Table 3 corroborates these findings by revealing statistically significant improvements in students' concept mastery and communication skills throughout the three developmental intervals ($p < 0.05$). This suggests that students' diminished anxiety is associated with a deeper understanding of content and enhanced communication capabilities. In the context of scientific literacy, this implies improved competencies in hypothesis formulation, experimental description, and data interpretation. Critically, the pattern of improvement is not transient but cumulative, suggesting that RADEC with EMI fosters sustained anxiety reduction alongside progressive gains in scientific and linguistic proficiency.

Table 3. Wilcoxon Test Results on Secondary Students' Concept Mastery and Communication Skills

Indicator(s)	Development 1		Development 2		Development 3	
	Z Score	p value	Z Score	p value	Z Score	p value
Communication Skills	-2.668	<.001	-4.667	0.001	-5.000	<.001
Mastery of Science Concept	-4.667	<.001	-4.667	0.001	-4.667	<.001

Notes:
Development 1 = Change from 1st Data Retrieval to 2nd Data Retrieval; Development 2 = Change from 2nd Data Retrieval to 3rd Data Retrieval; Development 3 = Change from 3rd Data Retrieval to 4th Data Retrieval

Qualitative data from interviews, summarised in Table 4, provide valuable insights into the process by which EMI reduces anxiety. Prior to intervention, 34% of students cited the fear of forgetting their statements due to the cognitive load of translating from Indonesian to English as their predominant anxiety. Additional concerns included fear of misunderstanding test questions (22%) and apprehension about being ridiculed for errors (18%), with less frequent anxieties related to pronunciation, grammar, and accent stigma.

Following the implementation of RADEC, students reported increased confidence and engagement. The "Read" phase offered early exposure to scientific vocabulary, while the "Answer" and "Discuss" phases allowed practice in a supportive environment. Consequently, 54% of students felt more comfortable communicating, 27% attributed improved reading habits to better preparedness, and 19% credited repetitive communicative practice with reduced anxiety.

Table 4. Analysis of Students' Interview Results

No.	Item	Indicators	Codes	Occurrence in Responses
1	The primary and crucial factors hindering the use of EMI in the classroom before the implementation of the RADEC model	Communication Apprehension	Fear of mispronunciation (CA1)	5%
			Fear of grammar mistakes (CA2)	2%
			Fear of forgetting what to say because of having to think multiple times about word and sentence translations (CA3)	34%
			Fear of having a local accent that makes the spoken English sound funny (CA4)	4%
		Fear of Negative Evaluation	Afraid of being mocked by friends for making mistakes (FNE1)	18%
			Afraid of getting nervous when answering questions (FNE2)	3%
			Afraid of being labeled as arrogant for showing off their abilities (FNE3)	7%
		Anxiety Test	Afraid of not understanding the questions (AT1)	22%
			Afraid of not giving a comprehensive answer on the test (AT2)	5%
		Total		100%
2	The reasons why the RADEC model with EMI can reduce anxiety among secondary students in learning science.	Reading Habituation	The RADEC model forces me to read English texts, so I am better prepared with content if I am required to discuss and communicate (RH)	27%
		Comfort in Communication	The RADEC model allows me to ask or answer questions in two languages if I do not understand (CC1)	54%
			The RADEC model practices communication repeatedly, so I become accustomed to it and feel comfortable (CC2)	19%
		Total		100%

This mixed-methods evidence clearly demonstrates both the extent and the mechanisms through which EMI, via the RADEC model, effectively reduces anxiety among secondary school students in bilingual science classrooms. By creating an inclusive, linguistically supportive, and cognitively enriching environment, RADEC empowers students to become confident bilingual communicators of scientific knowledge, thereby addressing a significant barrier to effective science education. Furthermore, the interview results suggest that students' anxiety is not solely a linguistic challenge but also a complex socio-emotional issue shaped by peer perception, self-esteem, and classroom culture. The fact that 18% of students expressed fear of being mocked for making mistakes, and 7% reported concern about being perceived as boastful when demonstrating competence, reveals a culturally embedded reluctance to engage in public academic discourse, especially in a foreign language. Such responses reflect a broader phenomenon in collectivist educational settings, where maintaining group harmony and avoiding embarrassment often take precedence over individual expression.

This dimension of fear and hesitancy is rarely acknowledged in mainstream EMI literature, which tends to prioritise cognitive or linguistic barriers over socio-affective ones (Hammou & Kesbi, 2023; Lu & So, 2024; Yuan & Li, 2024; Sahan et al., 2025). However, the RADEC model—with its structured yet flexible sequence of activities—seems to address this gap by fostering a psychologically safe environment. The "Answer" and "Discuss" stages, in particular, provide a low-risk platform for verbal participation, while the initial "Read" phase equips students with content familiarity that strengthens their confidence. Consequently, RADEC emerges as more than a language facilitation tool; it functions as a culturally responsive pedagogical framework that reduces both linguistic insecurity and socially constructed barriers to communication (Maryanti et al., 2025; Nabuasa et al., 2025; Putri et al., 2025; Sukardi et al., 2025; Yulianto et al., 2025; Yuniasih et al., 2025). This highlights the critical need for EMI approaches that are not only grounded in sound language acquisition theory but also informed by an understanding of local cultural dynamics and student psychology. In this light, pedagogical success in EMI settings depends as much on emotional and social attunement as it does on linguistic scaffolding.

The RADEC model demonstrates strong potential in supporting the realisation of 21st-century learning goals in science education, particularly within EMI contexts. As science classrooms increasingly adopt EMI, students are required not only to master complex concepts but also to communicate them in a non-native language, a dual challenge that can hinder engagement and learning outcomes if not properly addressed. RADEC responds to this challenge by offering a structured yet flexible learning sequence: Read – Answer – Discuss – Explain – Create, which scaffolds both conceptual understanding and language development. The "Read" phase exposes students to scientific vocabulary in context, building academic language literacy. The "Answer" and "Discuss" phases provide repeated, low-stakes opportunities for students to articulate their thinking in English, gradually reducing communicative anxiety. These features align with second language acquisition theories that highlight the importance of meaningful input and output in reducing the affective filter.

Critically, RADEC fosters a safe, inclusive, and dialogic environment that is essential for effective EMI. By integrating content and language learning in a culturally responsive manner, the model empowers students to become confident bilingual communicators of science, one of the core competencies for participating in a globalised scientific community. Innovatively, the "Create" phase extends beyond recall and reproduction, challenging students to synthesise knowledge and express it through multimodal outputs in English. This not only supports creativity and problem-solving but also reflects authentic scientific practices in the 21st century. Thus, RADEC is more than a pedagogical framework; it is a strategic model that bridges science literacy and language proficiency, enabling EMI classrooms to become both cognitively rigorous and linguistically empowering.

CONCLUSION

This study demonstrates that the RADEC model, when integrated with EMI, effectively reduces secondary students' anxiety in science learning, particularly communication-related anxiety, fear of negative evaluation, and test anxiety, while also enhancing concept mastery and communication skills. By allowing the strategic use of native language alongside English and providing structured, supportive learning stages, RADEC creates an inclusive environment that boosts confidence and participation. Successful implementation in EFL contexts requires teacher training in bilingual scaffolding, structured feedback, and anxiety-reducing strategies, supported by adequate resources and ongoing monitoring. While the study is limited by its regional scope and short observation period, it offers valuable insights for broader application. Future research should investigate the long-term impacts across diverse settings and examine contextual factors, such as teacher beliefs and institutional policies, to gain a deeper understanding of the phenomenon. The findings contribute to CLIL literature by positioning RADEC as a culturally responsive, empirically grounded approach for improving science learning in multilingual classrooms.

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