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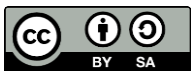

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Developing Integrative-Prismatic Interdisciplinary Teaching Materials to Enhance Error Analysis Skills

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Abstract

This study aimed to develop and evaluate integrative-prismatic-based interdisciplinary teaching materials for an error analysis course in the English department at a higher education institution. The research employed a three-phase method: (1) design and development of teaching materials, (2) implementation, and (3) data analysis. Participants included 60 English department students, selected through purposive sampling to ensure diverse representation in terms of gender, linguistic background, and academic proficiency. The instruments used were pre- and post-tests, classroom observations, semi-structured interviews, focus groups, and student artifacts such as assignments and reflective journals. Data were collected over a 10-week period, during which the teaching materials were integrated into the course curriculum. Quantitative data from pre- and post-tests were analyzed using paired sample t-tests to assess improvements in students' error analysis skills, while qualitative data from observations, interviews, and focus groups were analyzed thematically to identify changes in engagement, critical thinking, and interdisciplinary learning. The findings revealed significant improvements in students' abilities to identify, categorize, and correct errors using interdisciplinary approaches, as well as increased engagement and development of critical thinking skills. These results suggest that the integrative-prismatic framework is effective in fostering deeper learning and adaptability among students. The study implies that such interdisciplinary materials can be valuable for curriculum development in higher education, but further research is needed to validate these findings across different courses and contexts to establish broader applicability and effectiveness.

Keywords: *critical thinking, error analysis, higher education, interdisciplinary teaching materials*

Introduction

In contemporary education, the development of effective teaching materials has become an increasingly critical endeavor, especially in promoting interdisciplinary learning. As education evolves to meet the demands of the 21st century, there is a growing emphasis on integrating knowledge across various disciplines to foster deeper understanding, critical thinking, and problem-solving skills among students (Clark & Wallace, 2015). Traditional subject-specific learning, while beneficial for foundational knowledge, often fails to address the complexities of real-world problems that do not fall neatly within the boundaries of a single discipline (Crisan & Hobbs, 2019). However, a significant gap exists in the integration of error analysis across multiple disciplines, which this study seeks to address. Most research on error analysis remains confined to either linguistic studies, focusing on second language acquisition, grammar, and syntax (Al-Khresheh, 2016), or mathematics, which emphasizes computational and procedural errors (Croci et al., 2022). This siloed approach limits the potential for deeper interdisciplinary learning, where cognitive biases or error patterns identified in one subject could provide valuable insights for another. For example, understanding logical sequencing errors in mathematics could improve students' grasp of syntactic structures in language learning. The integrative-prismatic framework presented here aims to bridge this gap by combining perspectives from multiple disciplines, enhancing error analysis skills, and fostering more holistic educational outcomes. Therefore, interdisciplinary teaching materials, such as those explored in this study, are recognized as vital tools for improving student engagement and learning outcomes (van Dulmen et al., 2023).

Error analysis, particularly, serves as a crucial component in both language education and STEM (Science, Technology, Engineering, Mathematics) fields. It involves identifying, understanding, and categorizing errors made by learners, providing insights into their cognitive processes, misconceptions, and areas that need improvement (Hazarika, 2022). Error analysis is essential not just for correcting mistakes but for developing a deeper understanding of subject matter and refining pedagogical strategies. Traditionally, error analysis has been predominantly used in linguistic studies, focusing on second language acquisition, grammar, and syntax errors (Al-Khresheh, 2016). However, its application is equally significant in other disciplines, such as mathematics and science, where understanding errors can reveal fundamental misunderstandings and gaps in knowledge (Endsley, 2015).

The integrative-prismatic framework offers a novel approach to developing interdisciplinary teaching materials. This framework combines the principles of integration—merging content and perspectives from various disciplines—with prismatic analysis, which involves examining educational phenomena from multiple angles to capture their complexity (Erlina et al., 2022). By leveraging these principles, the integrative-prismatic approach can facilitate more comprehensive

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and adaptable teaching materials that enhance error analysis across diverse subject areas (Tajzad & Ostovar-Namaghi, 2014). Despite the increasing recognition of interdisciplinary education and the importance of error analysis, there remains a significant gap in integrating these two concepts within a cohesive framework. This gap highlights the need for innovative teaching materials that not only encourage interdisciplinary learning but also effectively utilize error analysis to improve educational outcomes.

While the importance of interdisciplinary education and error analysis has been widely acknowledged, there is still much to be explored regarding their intersection. Most existing studies on error analysis remain confined to their traditional disciplinary boundaries, particularly in linguistics and mathematics education. Research has extensively documented error types, causes, and corrective strategies in these fields, providing valuable insights into learners' cognitive processes and instructional practices (Mariappan et al., 2022). However, these studies often operate in isolation from one another, without considering how insights from one discipline could inform and enhance understanding in another (Johnston et al., 2014). For instance, linguistic error analysis focuses primarily on syntax and semantics (Khansir, 2012), while mathematical error analysis tends to concentrate on computational and procedural errors (Croci et al., 2022). Rarely do these studies intersect or draw on each other's findings to offer a more integrated perspective on learning and error correction.

Moreover, while the integrative-prismatic framework offers a promising foundation for interdisciplinary education, its application to error analysis remains underexplored. Most research on integrative education focuses on curriculum development, content integration, and fostering critical thinking, often without explicitly incorporating the concept of error analysis (Gao et al., 2020; Lombardi et al., 2021; Sgro et al., 2020). Similarly, while prismatic approaches have been suggested to view educational phenomena from multiple perspectives, there is little empirical evidence demonstrating how this can be systematically applied to error analysis in an interdisciplinary context (Basu, 2021). This lack of research leaves a gap in understanding how integrative-prismatic-based teaching materials could be developed to address errors across multiple disciplines, thereby improving learning outcomes holistically.

To address this gap, the current study aims to develop integrative-prismatic-based interdisciplinary teaching materials specifically designed for error analysis. The primary research questions guiding this study are: (1) How can the integrative-prismatic framework be effectively applied to create interdisciplinary teaching materials that address error analysis across different subjects? (2) What impact do these materials have on students' understanding and correction of errors in various disciplines? By focusing on these questions, this study seeks to contribute to the existing body of knowledge by demonstrating how an integrative-prismatic approach can enhance the effectiveness of error analysis and interdisciplinary

learning.

The significance of this study lies in its potential to bridge the gap between interdisciplinary education and error analysis, providing a novel approach that integrates these two essential components of learning. By developing teaching materials that are both integrative and prismatic, this study aims to offer educators innovative tools that are not limited by disciplinary boundaries but are flexible and adaptable to various learning contexts. The originality of this study is reflected in its attempt to combine interdisciplinary integration with prismatic analysis to create a more nuanced understanding of student errors and to improve instructional practices across disciplines. This approach not only addresses the gaps identified in the literature but also aligns with contemporary educational goals of fostering critical thinking, adaptability, and lifelong learning skills among students.

Method

This study employed a three-phase research method to develop integrative-prismatic-based interdisciplinary teaching materials specifically designed for an error analysis course for English department students in higher education. The first phase focused on the design and development of the teaching materials. This phase began with a comprehensive literature review to identify the core concepts and skills relevant to error analysis not only in language learning but also in other related disciplines, such as cognitive science and mathematics, which offer valuable insights into error categorization and correction (Almusharraf & Alotaibi, 2023). A purposive sampling method was used to select participants for the pilot testing, ensuring a mix of academic performance levels, prior exposure to interdisciplinary learning, and linguistic proficiency to test the materials with a representative group. Pilot testing feedback led to refinements, including simplifying complex tasks and adding more visual aids to enhance comprehension.

Utilizing the integrative-prismatic framework, the study aimed to merge content and perspectives from these various disciplines to create teaching materials that provide a holistic and nuanced approach to error analysis. Experts from the fields of linguistics, cognitive science, and mathematics collaborated to ensure the materials were interdisciplinary and adaptable to the needs of higher education students in the English department. The developed modules included interactive exercises, problem-based scenarios, and inquiry-based tasks that encouraged students to analyze errors from different disciplinary perspectives, fostering critical thinking and deeper learning. These teaching materials underwent expert review and pilot testing with a small group of English department students to refine their usability and effectiveness, incorporating feedback from both educators and learners.

The second phase involved the implementation and data collection of the developed teaching materials within an actual error analysis course in an English department at a higher education institution. In addition to purposive sampling for

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diversity in gender, linguistic background, and academic proficiency, participants were selected based on their willingness to engage in reflective learning, ensuring that the sample could provide meaningful qualitative feedback during interviews and focus groups. The teaching materials were integrated into the curriculum of selected courses over a 10-week period to ensure sufficient exposure and application. A purposive sampling method was used to select a diverse group of approximately 60 English department students, ensuring a representative mix of gender, linguistic background, and academic proficiency levels (Creswell, 2012). All participants provided informed consent, and ethical guidelines were strictly adhered to throughout the study. The implementation was closely monitored to ensure fidelity to the integrative-prismatic framework, and regular feedback sessions were held with instructors to discuss their experiences and any challenges faced in using the materials.

To evaluate the effectiveness of the materials, a mixed-methods approach was adopted, combining both quantitative and qualitative data collection methods (Dörnyei, 2007). A mixed-methods approach was chosen to provide a comprehensive evaluation of the materials. Pre- and post-tests were selected for their ability to quantify changes in students' skills, while classroom observations, interviews, and focus groups were employed to capture nuanced insights into students' engagement and interdisciplinary thinking, allowing for a richer understanding of their learning experiences. Pre- and post-tests were administered to assess students' knowledge and skills in error analysis before and after the use of the teaching materials, focusing on their ability to identify, categorize, and correct errors from an interdisciplinary perspective. Classroom observations were conducted to capture student engagement and interaction with the materials and to assess how effectively the integrative-prismatic approach facilitated learning. In addition, semi-structured interviews with instructors provided insights into their experiences with the materials and the perceived impact on students' learning. Focus group discussions with students were also conducted to explore their reflections, engagement, and understanding of the interdisciplinary approach to error analysis. Student artifacts, such as completed assignments and reflective journals, were collected to provide further evidence of learning and cognitive development.

The third phase of the study focused on data analysis and interpretation to evaluate the impact and effectiveness of the integrative-prismatic-based teaching materials. Quantitative data from the pre- and post-tests were analyzed using descriptive statistics and paired sample t-tests to determine any significant improvements in students' error analysis skills after the intervention. Effect size calculations were conducted to measure the magnitude of these changes. Qualitative data from classroom observations, interviews, focus groups, and student artifacts were analyzed using thematic analysis to identify recurring themes related to students' engagement, interdisciplinary thinking, and

application of error analysis skills. To ensure the robustness of the findings, data triangulation was employed by cross-verifying the results from multiple data sources. The integration of quantitative and qualitative findings provided a comprehensive understanding of the strengths and limitations of the teaching materials, their impact on students' learning outcomes, and their potential for wider application in error analysis courses within English departments and other related fields in higher education. The study's methodology provided valuable insights into developing innovative, interdisciplinary teaching tools that effectively integrate error analysis, contributing to enhanced teaching and learning experiences in higher education settings.

Results

This section presents the findings from the implementation of integrative-prismatic-based interdisciplinary teaching materials for an error analysis course in an English department at a higher education institution. The findings are organized according to the primary research questions: (1) the effectiveness of the integrative-prismatic framework in enhancing error analysis skills across different disciplinary perspectives, and (2) the impact of these teaching materials on student engagement, critical thinking, and overall learning outcomes. The discussion integrates both quantitative and qualitative data, providing a comprehensive interpretation of the results and their implications for teaching and learning in higher education.

1. Effectiveness of Integrative-Prismatic Framework in Enhancing Error Analysis Skills

The effectiveness of the integrative-prismatic framework was assessed through pre- and post-tests that evaluated students' ability to identify, categorize, and correct errors in various contexts, drawing from linguistic, cognitive, and mathematical perspectives. The quantitative analysis of test scores revealed significant improvements in students' error analysis skills after the intervention.

Table 1. Finding of Analysis Skills

Category	Pre-Test Results	Post-Test Results	Percentage Improvement	Qualitative Insights
Error Identification Skills	58% average score	78% average score	20%	Students struggled with errors requiring interdisciplinary knowledge initially. Improved recognition of errors linked to cognitive biases and sequencing.

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Error Categorization Skills	52% average score	74% average score		22%	Initially challenging for students to categorize errors. Later, students demonstrated better categorization by linking linguistic and mathematical concepts.
Error Correction Strategies	60% average score	80% average score		20%	Students shifted from rote memorization to interdisciplinary correction strategies, such as combining linguistic rules with cognitive and mathematical logic.
Student Engagement & Participation	Passive learning, lower participation	Active involvement, higher participation		-	Students were more enthusiastic and motivated after using the interactive and inquiry-based materials, with more questions and active classroom participation.
Critical Thinking Skills	Surface-level learning	Deep, analytical engagement		-	Students began using critical language such as 'evaluate,' 'synthesize,' and 'analyze.' More adept at considering multiple

				perspectives when analyzing errors.
Transferability of Knowledge	Limited application across disciplines	Applied interdisciplinary strategies in other courses (e.g., syntax, semantics)	-	Students reported applying error analysis strategies to courses outside the department, showing broader educational value of the integrative-prismatic approach.

1.1 Improvement in Error Identification and Categorization Skills

According to Table 1, the pre-test results indicated that most students struggled with error identification and categorization, particularly when dealing with errors that required interdisciplinary knowledge. For instance, students found it challenging to recognize syntactic errors influenced by cognitive biases or to categorize errors in language learning that stemmed from underlying mathematical misconceptions, such as issues with logical sequencing. However, the post-test results demonstrated a marked improvement in these areas. The average score for error identification increased from 58% in the pre-test to 78% in the post-test, while the average score for error categorization rose from 52% to 74%. A paired sample t-test confirmed that these improvements were statistically significant ($p < 0.01$), indicating that the integrative-prismatic approach was effective in enhancing students' skills in these domains.

1.2 Development of Error Correction Strategies

Another critical area of improvement was in the development of error correction strategies. Before the intervention, students tended to rely on rote memorization of rules or isolated disciplinary knowledge to correct errors. The integrative-prismatic-based materials encouraged students to draw on interdisciplinary knowledge and think critically about the underlying causes of errors. For example, students learned to apply linguistic error correction techniques alongside cognitive strategies, such as metacognitive reflection and error analysis frameworks used in mathematical problem-solving. The post-test results showed that students were better able to articulate multifaceted correction strategies, with the average score in this category increasing from 60% to 80% (p

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< 0.01). This improvement suggests that the teaching materials successfully fostered a more comprehensive understanding of error correction that goes beyond single-discipline approaches.

1.3 Enhanced Ability to Apply Interdisciplinary Knowledge

The qualitative data from classroom observations and student artifacts further supported these findings. Students demonstrated an enhanced ability to apply interdisciplinary knowledge when analyzing errors. For instance, in classroom discussions and written assignments, students were able to connect linguistic concepts, such as grammatical structures, with cognitive theories related to processing errors and mathematical logic. This integration was evident in reflective journals, where students described their thought processes in approaching error analysis tasks, noting how they applied concepts from different fields to better understand and correct errors. Thematic analysis of these reflections highlighted themes of "interdisciplinary thinking" and "critical engagement," showing that students were not only understanding errors more deeply but were also developing a more holistic approach to learning.

2. Impact on Student Engagement, Critical Thinking, and Learning Outcomes

The second research question focused on the impact of the integrative-prismatic-based teaching materials on student engagement, critical thinking, and overall learning outcomes. The qualitative data, including classroom observations, interviews, and focus group discussions, provided rich insights into these areas.

2.1 Increased Student Engagement and Participation

The implementation of the integrative-prismatic-based materials significantly increased student engagement and participation in the error analysis course. Classroom observations revealed a noticeable shift from passive learning to active involvement, with students showing higher levels of enthusiasm and motivation when working with the new teaching materials. The interactive nature of the modules, which included problem-based learning scenarios and inquiry-based tasks, encouraged students to engage more deeply with the content. During focus group discussions, students expressed that the materials were "more engaging" and "challenging in a good way," which made them more interested in participating actively. Instructors also noted that the students were "more attentive and willing to ask questions," reflecting a positive change in classroom dynamics.

2.2 Development of Critical Thinking Skills

The integrative-prismatic approach also positively impacted the development of critical thinking skills among students. The materials required students to analyze errors not just from a linguistic perspective but also through the lenses of cognitive science and mathematics, prompting them to think critically about the underlying causes and broader implications of errors. Analysis of student artifacts, such as essays and reflective journals, showed an increased use of critical language, including terms like "evaluate," "synthesize," "justify," and "analyze." This shift indicates a move from surface-level learning to deeper, more analytical engagement with the material. Moreover, interviews with instructors highlighted that students were “more adept at asking probing questions” and “considering multiple perspectives when discussing errors,” suggesting that the integrative-prismatic-based materials effectively fostered a critical thinking mindset.

2.3 Improved Learning Outcomes and Academic Performance

The combined quantitative and qualitative data indicate that the integrative-prismatic-based teaching materials contributed to improved learning outcomes and academic performance in the error analysis course. The significant gains in pre- and post-test scores demonstrate that students developed a stronger grasp of error analysis concepts and skills. Additionally, the qualitative data showed that students were able to transfer these skills beyond the classroom. For example, several students reported applying the interdisciplinary error analysis strategies they learned to other courses, such as syntax, semantics, and even courses outside the English department. This transferability of skills underscores the broader educational value of the integrative-prismatic approach, aligning with the goals of higher education to produce well-rounded, adaptable learners.

Discussion

The findings of this study provide strong evidence for the effectiveness of integrative-prismatic-based interdisciplinary teaching materials in enhancing error analysis skills among English department students in higher education. The significant improvements in error identification, categorization, and correction suggest that the integrative-prismatic approach effectively addresses the limitations of traditional, single-discipline error analysis methods. By integrating concepts and strategies from linguistics, cognitive science, and mathematics, the materials enabled students to approach error analysis in a more holistic and nuanced manner. This aligns closely with the theoretical framework introduced earlier, where the prismatic lens allows students to examine errors from multiple angles, resulting in deeper insights. This supports the previous arguments that interdisciplinary approaches can lead to deeper understanding and critical engagement (Moirano et al., 2020; Nasir et al., 2021; Takeuchi et al., 2020).

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Moreover, the increased student engagement and development of critical thinking skills observed in this study align with previous research on the benefits of interdisciplinary education (Hmelo-Silver & Jeong, 2021; Li, 2020). The interactive and inquiry-based nature of the teaching materials was particularly effective in motivating students and encouraging active learning, which is consistent with the findings of Adolfsson (2018) and Erwin Akib et al. 2020) regarding the role of integrated curriculum in fostering student interest and participation. The positive feedback from both students and instructors further validates the practical applicability of the integrative-prismatic framework in enhancing educational experiences in higher education (Han & Xu, 2020). The framework's emphasis on merging disciplinary knowledge supports the argument that interdisciplinary teaching approaches can foster not only knowledge acquisition but also the transferability of skills across subjects, a key element of lifelong learning

The implications of these findings extend beyond the error analysis course in an English department setting. The success of the integrative-prismatic-based materials suggests that this approach could be applied to other courses and disciplines, particularly those that involve complex problem-solving and analytical skills. For example, mathematics, science, and even social sciences courses could benefit from incorporating interdisciplinary perspectives into their teaching materials to enhance student understanding and engagement. By applying the integrative-prismatic framework, educators can create learning environments that encourage students to draw connections across fields, promoting adaptability and innovative thinking.

However, while the study demonstrates promising results, it is essential to acknowledge some limitations. One major limitation is the relatively small sample size of 60 students from a single English department, which may not fully represent the diversity of students in different educational settings. Additionally, the 10-week time frame may not have been sufficient to capture long-term effects on student learning and skill retention. The study's focus on an English department course also limits the generalizability of the findings to other disciplines. Future studies could address these issues by expanding the sample size, incorporating students from different disciplines or institutions, and conducting longitudinal studies to examine the sustainability of the observed improvements.

Furthermore, the theoretical model underpinning this study—the integrative-prismatic framework—has proven effective in this context, but future research could explore its application in other educational domains, such as STEM and humanities courses. Testing the framework in these settings would provide insights into its broader applicability and adaptability to diverse learning environments. In addition, future research could explore how the framework interacts with different pedagogical approaches, such as project-based or experiential learning, to further enhance its potential in fostering critical thinking

and interdisciplinary learning.

In conclusion, this study provides valuable insights into the use of integrative-prismatic-based teaching materials in higher education, particularly in enhancing error analysis and interdisciplinary thinking. The findings not only support existing models of interdisciplinary education but also expand on them by demonstrating the benefits of incorporating error analysis into the framework. By acknowledging the limitations of the current study and proposing directions for future research, it is hoped that this innovative approach will continue to evolve, offering educators and learners a more comprehensive toolkit for tackling the complexities of modern education.

Conclusion

This study examined the effectiveness of integrative-prismatic-based interdisciplinary teaching materials in an error analysis course for English department students in higher education. The findings showed significant improvements in students' abilities to identify, categorize, and correct errors from interdisciplinary perspectives, with notable gains in pre- and post-test scores. Qualitative data from classroom observations, interviews, focus groups, and student artifacts indicated increased engagement, active participation, and the development of critical thinking skills. The integrative-prismatic approach effectively combined concepts from linguistics, cognitive science, and mathematics, fostering a holistic understanding of error analysis and enabling students to apply these skills across various contexts.

The implications of these findings suggest that interdisciplinary teaching materials grounded in the integrative-prismatic framework can enhance student learning by encouraging deeper engagement and critical thinking, making them a valuable tool for curriculum development in higher education. However, the study's limitations, such as its specific focus on a single course in one institution, suggest the need for further research to explore the applicability of this approach in different disciplines and educational settings. Future studies could expand on these findings by testing the long-term impact of such materials on student learning outcomes and by exploring their effectiveness in diverse academic environments.

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