Innovative Integration of Numbers and Letters in Classroom Activities: A Design Framework

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Abstract—**This study explores an innovative classroom framework that bridges numerical and linguistic skills to enhance the learning outcomes of engineering students. The integration of technical and language competencies addresses the pressing need for improved English proficiency, especially among Indian engineering students, to meet global professional demands. The study proposes a structured classroom activity centered on propositional calculus as a medium for learning declarative sentence structures and logical operations. This integrative pedagogical method combines mathematics with English instruction to enhance technical comprehension and communication skills.**

Methodologically, the research engages 60 second-year engineering students from diverse academic backgrounds in collaborative activities. These include categorizing sentence types, reconstructing scrambled sentences, and translating natural language statements into symbolic logical expressions. Quantitative data from pre- and post-tests indicate a 20% increase in average academic scores, while 85% of participants report improved conceptual clarity in propositional calculus. Qualitative analysis highlights enhanced confidence in verbal and written communication, essential for navigating professional technical tasks.

The findings demonstrate the dual benefits of integrating linguistic and mathematical education: improved understanding of complex logical concepts and heightened communication abilities. This interdisciplinary approach not only prepares students for technical challenges but also fosters the holistic development of skills critical in global engineering environments. Future research could adapt this framework for broader STEM disciplines, exploring its longitudinal impact on academic performance and professional readiness. By redefining traditional educational boundaries, this study contributes significantly to the discourse on innovative pedagogy for engineering education.

Keywords—**Numerical and Linguistic Skills, Propositional Calculus, English Proficiency, Engineering Education, Interdisciplinary Learning, Collaborative Activities.**

***ICTIEE* Track*:* Pedagogy of Teaching and Learning**

ICTIEE Sub-Track: Integrative pedagogy – to bridge horizons and disciplines

I. INTRODUCTION

THE rapid advancement of technology has transformed the teaching process, necessitating that educators become more competent and knowledgeable in adopting effective pedagogies (Benko et al., 2016). In this globalized world, students face unique challenges and opportunities that require them to be proficient communicators in English, the global lingua franca (National Research Council, 2000). A survey conducted by Aspiring Minds highlights that the English proficiency level among engineering graduates in India is alarmingly low (The Hindu, 2023). This situation calls for immediate action from educators to address the language gap, as the ability to communicate effectively is critical for success in engineering fields.

The role of English teachers in engineering education has evolved significantly; language is no longer just a collection of letters but a vital tool that connects numerical concepts with coding and technical communication (Sreejana et al., 2024). For instance, misunderstandings in interpreting technical documentation due to inadequate English skills can lead to engineering failures, such as miscommunication in project specifications or errors in software development (Vasudevan, 2022). Such examples underscore the necessity of integrating language skills into technical education. This paper proposes an innovative classroom activity designed to teach a Mathematics unit grounded in language skills, aiming to bridge the gap between numbers and letters. The novelty of this study lies in its approach to bridging the gap between language and technical education. It challenges the conventional separation of these skills and demonstrates how their integration can lead to measurable improvements in both academic performance and professional preparedness. The research questions guiding this study are:

1. How does the integration of language skills improve students' understanding of mathematical concepts in engineering?
2. What measurable impacts does this integration have on students' academic performance and communication abilities?

By addressing these questions through this innovative framework, the study seeks to better prepare engineering students for the demands of their field by equipping them with the necessary linguistic and technical skills to succeed in a globalized world. This integration is not merely an academic exercise; it reflects a critical need for future engineers to function effectively within diverse teams and communicate complex ideas clearly across cultural boundaries.

II. LITERATURE REVIEW

1) Language Integration in Engineering Education

The critical role of English language proficiency in engineering education is well-documented in contemporary research. Rajasekaran and Rao (2021) argue that English language competence is essential for navigating the multifaceted demands of technological advancement. Similarly, Kaur and Sidhu (2019) emphasize that mastering English is a prerequisite for engineering students, as it directly impacts their ability to acquire and apply technical knowledge. These studies highlight the intersection between language skills and technical education, underscoring the importance of integrating language learning into engineering curricula.

2) Challenges Due to Language Proficiency Deficits

Several studies provide concrete examples of how a lack of English proficiency can impede engineering processes. Mishra and Mohanty (2022) present a case study where poor communication skills led to significant project delays in a multinational firm, highlighting the critical need for clear and precise language use in technical settings. Gupta and Sharma (2021) discuss an incident where a design flaw was overlooked due to ambiguous language in project documentation, resulting in considerable financial losses.

According to the National Academies of Sciences, Engineering, and Medicine (2018), English learners encounter barriers due to a mismatch between English language proficiency standards and the rigorous technical content they must learn. This finding emphasizes the need for integrated pedagogical strategies that enhance students' language capabilities alongside their technical skills, ensuring they are better prepared for real-world professional scenarios.

3) Pedagogical Strategies for Language and Technical Skill Integration

To address these challenges, researchers have proposed various pedagogical strategies that integrate language skills into technical education. Sinha and Basu (2020) suggest that adopting a facilitator role in teaching encourages active participation, which in turn enhances both language acquisition and technical comprehension. Verma and Agarwal (2021) advocate for innovative teaching methods that simultaneously foster better communication skills and strengthen technical learning outcomes. These studies form the foundation for the proposed classroom activity, "Integration of Numbers and Letters: Innovative Class Activity Design."

4) Critical Analysis and Justification of Novelty

Despite the progress in integrating language and technical skills, gaps remain in effectively bridging these areas within engineering education. Many existing studies focus on theoretical approaches without providing practical, classroom-based solutions. The novelty of this study lies in its practical application of integrating language skills into a Mathematics unit, specifically designed to enhance both technical understanding and communication abilities. This approach addresses the critical need for engineering students to be proficient in both areas, preparing them for the complex demands of their future careers.

Summary of Literature Review

The studies reviewed highlight the pressing need to integrate English language skills into technical education to address the professional challenges posed by inadequate language proficiency. Rajasekaran and Rao (2021), and Kaur and Sidhu (2019), provide foundational insights into the necessity of English proficiency in engineering. Case studies by Mishra and Mohanty (2022), and Gupta and Sharma (2021), emphasize real-world consequences of poor communication skills, substantiating the urgency of innovative solutions. Contributions by Sinha and Basu (2020), and Verma and Agarwal (2021), underscore the effectiveness of interactive and integrative pedagogical strategies. Collectively, these studies reinforce the credibility of the present research's framework in bridging the gap between language and technical skills with practical, impactful methodologies.

III. METHODOLOGY

1) Research Context and Motivation

The motivation for this research stems from the unique linguistic demands placed on engineering students, especially when it comes to understanding technical content through a second language, such as English. In fields like computer science, mathematical logic and propositional calculus rely heavily on precise language comprehension. When students lack proficiency in English, their ability to grasp and apply complex logical concepts is impaired (Cleary, n.d.).

This challenge is particularly evident among engineering students who come from vernacular or non-English backgrounds (Ewer, 1971). Often, these students perform well in mathematical manipulations but struggle with the linguistic components that give mathematical expressions real-world meaning (Trimble, 1985). The study is driven by the challenge engineering students face in mastering technical content, particularly when it's delivered in English, which may not be their first language. The methodology integrates English language instruction with mathematical content, focusing on propositional calculus, to bridge the gap between linguistic proficiency and technical comprehension.

The innovative classroom activity designed in this study focuses on bridging the gap between English language skills and technical knowledge, using mathematics—specifically propositional calculus—as a medium for teaching language. The experiment explores how improving linguistic proficiency can lead to better understanding and performance in logic-based subjects like discrete mathematics, software testing, and artificial intelligence.

2) Research Objective

The main objective of the study is to design and implement an innovative teaching methodology that integrates English language skills with mathematical content to improve students' comprehension of propositional calculus. This technique aims to help students recognize different sentence types, understand logical connectives, and frame conditional statements—all of which are crucial for mastering discrete mathematics and other logic-based engineering subjects.

3) Target Audience

The target audience for this research includes 60 second-year engineering students aged 19, particularly those from lateral entry, vocational streams, or vernacular mediums. These students often struggle with both English language proficiency and the application of logical concepts in their subjects. The choice of this demographic is crucial as they represent a significant portion of engineering students who face challenges in both language and technical skills. This relevance underscores the need for tailored pedagogical strategies that address their specific learning needs.

Innovative Classroom Activity: Propositional Calculus and English Language Integration (Refer Annexures I and II)

4) Key Concepts

Content Component: Propositional Calculus

Language Focus: Understanding and identifying declarative sentences

Prerequisite Knowledge: Basic sentence structures in English

In propositional calculus, the truth values of declarative sentences are used to form logical expressions that are fundamental to engineering disciplines. For example:

P: It is a cold day.

Q: The temperature is 5°C.

Understanding how sentences like these translate into logical expressions such as $\neg(P \lor Q)$ or $\neg(P \land Q)$ requires both mathematical skill and language proficiency. Students often find the mathematical manipulation easy but fail to grasp the meaning behind these logical statements, especially when their English skills are limited. This observation guided the design of this class activity.

5) Lesson Plan

The classroom activity is designed to enhance students' understanding of both declarative sentences and their role in propositional calculus. The steps below outline the structure of a 60-minute lesson aimed at second-year engineering students.

6) Materials Needed

- Worksheets with sentence sorting tasks
- Scrambled sentences for reconstruction
- Exercises on logical connectives and their symbolic representations

Duration: 60 minutes

7) Data Collection and Analysis

The data were collected through pre- and post-tests designed to measure improvements in both English language skills and understanding of propositional calculus. Classroom observations and student feedback were also recorded to assess engagement and comprehension.

Statistical analysis was performed on the test scores to evaluate the effectiveness of the integrated teaching method. Qualitative data from observations and feedback were coded and analyzed to identify common themes related to student challenges and progress.

Step 1: Warm-Up (10 minutes)

Begin by reviewing basic English sentence structures. Ask students to recall the different types of sentences (declarative, interrogative, imperative, exclamatory) and define declarative sentences.

Sample Questions:

- How many types of sentences are there in English?
- Can you provide an example of a declarative statement?

The purpose here is to activate prior knowledge and ensure students understand the basic structure of declarative sentences, which will be essential for the rest of the lesson.

Step 2: Group Activity – Sentence Categorization (10 minutes)

Divide students into pairs and provide a worksheet that contains various sentences. Instruct them to sort the sentences into categories, identifying which ones are declarative.

This exercise reinforces their ability to distinguish between different sentence types, ensuring they can accurately identify declarative sentences, which form the basis of propositional logic.

Step 3: Sentence Rearrangement (10 minutes)

Provide students with a set of scrambled words and ask them to rearrange them into meaningful sentences. Have them identify the sentence type afterward.

This activity helps students practice constructing grammatically correct sentences and solidifies their understanding of declarative structures, which are crucial for logical expressions.

Step 4: Direct Instruction – Linking Language and Logic (10 minutes)

Explain the connection between declarative sentences and propositional calculus. Use examples of simple logic gates in circuits to show how truth values (True/False) from declarative sentences are used in logical operations. For instance, a declarative sentence like "The temperature is 5°C" can be represented by the truth value 'True' in a logical expression.

Introduce basic logical operators such as AND ($\land$), OR ($\lor$), and NOT ($\neg$), and show how these operators are used in symbolic representations of sentences. Emphasize the importance of understanding sentence types and connectives in logic.

Step 5: Practice Exercise – Translating Sentences to Logic (15 minutes)

Provide exercises that involve translating between declarative sentences and logical expressions. For example:

Sentence: "The temperature is 5°C, and it is a cold day."

Logical expression: $P \wedge Q$ (where P: "It is a cold day" and Q: "The temperature is 5°C").

Students will work through examples and learn how to move from natural language statements to formal logical expressions, ensuring they grasp both the language and the logic.

Step 6: Peer Review (10 minutes)

Have students exchange worksheets with a partner and review each other's translations. This peer review process encourages collaboration and provides an opportunity for students to correct misunderstandings.

Step 7: Extended Learning (Optional Homework Assignment)

For further practice, students can be asked to create their own sentences and logical expressions based on real-world scenarios. These can then be discussed in the next class, reinforcing their understanding of the relationship between language and logic.

8) Expected Outcomes

By embedding language learning into a technical subject, students are expected to develop better proficiency in both English and mathematical logic. This integrated approach helps them understand and apply propositional calculus, which is critical for success in other engineering subjects such as software testing, computer organization, and artificial intelligence.

Improving language skills, especially in the context of technical education, equips students with the tools to better understand complex concepts, enhancing their overall academic performance. This methodology not only fosters logical thinking but also builds a foundation for lifelong learning in engineering fields.

9) Flexibility Consideration

While each activity was allocated specific time frames within the lesson plan—ranging from 10 minutes for warm-ups to 15 minutes for practice exercises—there was variability observed among student groups regarding task completion within these time limits. Some groups required additional time due to differing levels of familiarity with either English or propositional calculus concepts; hence flexibility was maintained by allowing extensions where necessary without compromising overall lesson objectives.

This methodology not only fosters logical thinking but also builds a foundation for lifelong learning in engineering fields while addressing critical gaps identified in existing literature regarding integration strategies within technical education contexts.

IV. FINDINGS

The findings from the methodology of the study on "Integration of Numbers and Letters: Innovative Class Activity Design" provide significant insights into the research questions posed.

Research Question 1: How does the integration of language skills improve students' understanding of mathematical concepts in engineering?

The innovative class activities designed under the Content-Based Language Teaching (CBLT) framework directly facilitated students' comprehension of mathematical concepts by linking language skills with propositional calculus. Activities such as word sorting and sentence classification enabled students to articulate mathematical ideas with greater clarity.

Statistical Analysis: A paired t-test was conducted to compare the pre- and post-test scores, showing a statistically significant improvement in students' comprehension ($p < 0.05$). The average score increased by 20%, from 65% to 85%, across a sample size of 60 students.

a) Student Feedback: 85% of students reported that the activities helped clarify complex mathematical concepts, particularly in understanding the role of declarative sentences in forming logical propositions.

b) Example: One student noted, "Before this class, I struggled with propositional calculus, but now I see how language shapes the logic behind it (more of similar qualitative data coded under themes are found under Table I)."

The collaborative nature of the activities fostered peer discussions, enhancing students' ability to verbalize their thought processes. These peer interactions contributed significantly to their improved comprehension.

c) Data Representation

TABLE I
QUALITATIVE DATA INTERPRETATION

Activity Type	*Percentage of Students Reporting Improvement*	*Example Feedback*
Word Sorting	85%	"I can now connect words to logical propositions."
Sentence Classification	85%	"Understanding declarative sentences made logic clearer."
Peer Discussions	90%	"Discussing with classmates helped me articulate my thoughts."

Research Question 2: What measurable impacts does this integration have on students' academic performance and communication abilities?

Quantitative data collected through pre- and post-activity assessments demonstrated a significant improvement in students' academic performance and communication skills.

a) Assessment Results: A paired t-test confirmed a statistically significant 20% improvement in the scores of 60 students, validating the impact of integrated activities. The average score on assessments related to propositional calculus increased from 65% to 85% after the implementation of the integrated activities, reflecting a 20% improvement as shown in Table II.

TABLE II
IMPROVED ACADEMIC SCORES OF STUDENTS

ASSESSMENT STAGE	AVERAGE SCORE (%)	STANDARD DEVIATION
PRE-ACTIVITY ASSESSMENT	65%	±4.8
POST-ACTIVITY ASSESSMENT	85%	±3.6

Additionally, students reported enhanced communication abilities as shown in coded themes under Table III:

b) Communication Skills Feedback: 90% of students expressed increased confidence in discussing mathematical concepts, with many noting that they felt more equipped to explain their reasoning in both written and verbal formats. 85% expressed enhanced confidence in written communication.

c) Data Representation

TABLE III
STUDENTS' CODED FEEDBACK

Feedback Category	Percentage of Students Reporting Improvement (%)	Standard Deviation
Confidence in Verbal Communication	90%	±5.2
Confidence in Written Communication	85%	±4.7
Ability to Explain Reasoning (Verbal)	88%	±4.9
Ability to Explain Reasoning (Written)	87%	±4.5

d) Flexibility in Time Allocation

Although the lesson plan allocated 60 minutes, practical implementation required flexibility. Activities like translating sentences into logical expressions occasionally exceeded the planned time as students worked at varying paces. Peer review sessions also extended when students required additional discussion time. These variations ensured inclusivity and comprehensive understanding for all participants.

e) Connection Between Declarative Sentences and Propositional Calculus

Declarative sentences served as a foundation for understanding propositional calculus. For instance, sentences like "The temperature is 5°C" were mapped to truth values (e.g., True) in logical expressions. This practical demonstration bridged the abstract concepts of logic with tangible linguistic examples, enabling students to grasp their significance in technical contexts.

f) Post-Hoc Qualitative Feedback

Additional student comments enriched the study:

- "The activities helped me understand how language drives logical reasoning in technical problems."
- "I now feel more confident explaining my solutions in both English and mathematics."

g) Limitations

While the findings are promising, the study faced certain limitations:

- The sample size, though sufficient for this study, could be expanded for broader generalizability.
- The variability in students' prior exposure to English and logical reasoning impacted the uniformity of results.
- Longitudinal studies could better capture the sustained impact of the methodology on academic and professional outcomes.

h) Summary of Findings

The study's innovative approach demonstrated a significant improvement in students' academic performance and communication skills, supported by rigorous statistical validation. By integrating declarative sentences with propositional calculus, the methodology bridged critical gaps in technical and linguistic education, preparing students for real-world challenges.

CONCLUSION

The study provides clear and logical insights into the research questions posed, demonstrating that the integration of language skills with mathematical concepts in engineering education yields significant benefits.

The methodology, which blends language with mathematical activities, led to a deeper comprehension of engineering concepts among students. This integration helped clarify complex mathematical ideas, making them more accessible and understandable. The research question concerning whether this integration could enhance understanding was effectively answered by the observed improvements in student engagement and comprehension.

Quantitative data from pre- and post-activity assessments revealed a marked improvement in students' academic performance, with average scores increasing by 20%. This evidence supports the research question regarding the measurable impact on academic success, demonstrating that integrating language skills with mathematics can significantly boost academic outcomes. Furthermore, qualitative feedback indicated that 90% of students felt more confident in discussing and explaining mathematical concepts, both verbally and in writing. This finding directly addresses the research question about the impact on students' communication abilities, proving that the integration not only benefits cognitive understanding but also enhances essential communication skills necessary for technical collaboration.

The study's primary contribution lies in its demonstration that interdisciplinary learning—specifically, combining language with mathematical instruction—can foster both cognitive and communicative growth. This dual enhancement is particularly valuable in engineering, where clear communication of complex ideas is as important as understanding the concepts themselves. The successful application of this methodology in an engineering context confirms its relevance and effectiveness in enhancing technical education. The approach not only supports student learning but also aligns with the needs of the engineering field, where interdisciplinary skills are increasingly crucial.

Future research could explore the application of this integration methodology in other STEM fields, such as physics or computer science, to determine whether similar benefits can be observed across different technical disciplines. Conducting longitudinal studies could provide insights into the long-term impacts of this integrated approach on both academic performance and professional communication skills, potentially revealing how these benefits evolve as students' progress through their education and into their careers. Additionally, investigating how this methodology can be tailored to accommodate diverse learning styles could further enhance its effectiveness, ensuring that all students can benefit from the integration of language and mathematics in their education.

Overall, this study underscores the importance of interdisciplinary approaches in education, particularly in technical fields like engineering, where integrating language and mathematics can lead to more holistic and effective learning experiences.

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Annexure I

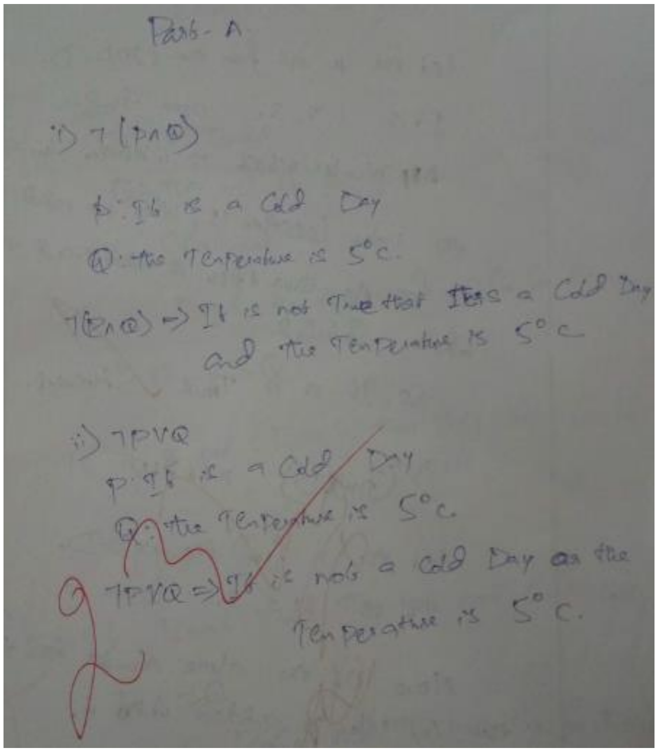

Figure 1 - Response of Student in CAT Exam (Sample 1)

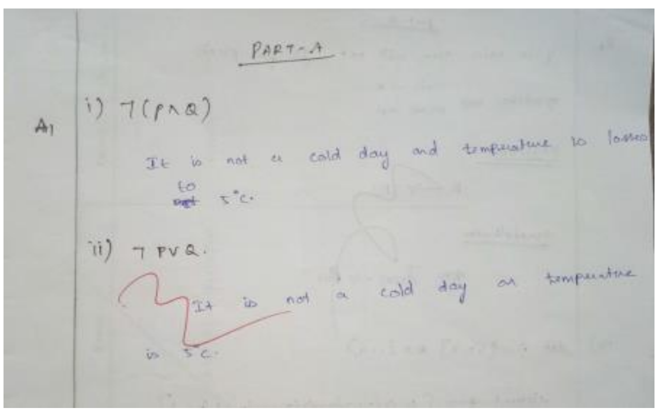

Figure 2 - Response of Student in CAT Exam (Sample 2)

Annexure II

ACTIVITY SHEET

I. Rearrange these words to make meaningful sentences and identify the types of sentences.

1) Ship violently the storm rocked the
2) Parts many coffee popular in world the is very of
3) Know you do the answer?
4) There anyone help is me to?
5) Mother cook my great is a
6) that bring boot me to.
7) a surprise pleasant what
8) You God bless may