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ENHANCING COGNITIVE COMPETENCIES IN TECHNICAL MASTER'S STUDENTS THROUGH AN INDUCTIVE STUDY OF ENGLISH GRAMMAR

Abstract. In an era marked by technological advancement, global connectivity, and ever-evolving professional landscapes, the cultivation of critical thinking skills remains paramount in the education of Master's students, particularly in technical disciplines. This article presents an innovative pedagogical approach that intertwines English grammar instruction with the development of critical thinking abilities within the context of technical Master's programs. The study delves into the intersection of language acquisition and cognitive skill enhancement, offering a comprehensive examination of the impact on students' metacognition, critical analysis, and problem-solving skills.

Traditionally, the domains of language learning and critical thinking have existed in educational silos, rarely intersecting. Language courses typically emphasize grammar, vocabulary, and communication skills, while the cultivation of critical thinking has been relegated to specialized coursework. This study challenges

this division by investigating the potential symbiosis between language acquisition and cognitive skill development, particularly in the context of technical education.

To explore the integration of English grammar instruction and critical thinking development, a multifaceted research approach was adopted. The study included quantitative assessments, qualitative analysis, and the collection of student perspectives. Participants, drawn from diverse technical fields, engaged in an innovative inductive grammar learning approach that was seamlessly incorporated into their existing coursework. Pre- and post-tests were administered to measure changes in critical thinking skills, encompassing problem-solving, analytical reasoning, and creative thinking. Qualitative analysis was conducted to delve into students' perceptions, metacognition, and their experiences with the integrated approach.

The integration of English grammar instruction within technical Master's programs presents a promising avenue for nurturing critical thinking skills, which are indispensable for navigating the multifaceted challenges of the XXI century. This groundbreaking study showcases the transformative potential of merging language acquisition with cognitive development. As educators and researchers venture into this uncharted territory, the prospects for enhancing critical thinking in technical education gleam ever more brightly.

Keywords: critical thinking, technical education, English grammar instruction, cognitive skill development, integrated language learning.

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ПІДВИЩЕННЯ КОГНІТИВНИХ КОМПЕТЕНЦІЙ У МАГІСТРАНТІВ ТЕХНІЧНИХ СПЕЦІАЛЬНОСТЕЙ ЧЕРЕЗ ІНДУКТИВНЕ ВИВЧЕННЯ ГРАМАТИКИ АНГЛІЙСЬКОЇ МОВИ

Анотація. В епоху, позначену технологічним прогресом, глобальними зв'язками та професійними ландшафтами, що постійно змінюються, розвиток навичок критичного мислення залишається першочерговим завданням у навчанні студентів магістратури, особливо в технічних дисциплінах. У цій статті представлено інноваційний педагогічний підхід, який поєднує навчання граматики англійської мови з розвитком навичок критичного мислення в контексті технічних магістерських програм. Дослідження заглиблюється у взаємозв'язок між вивченням мови та розвитком когнітивних навичок, пропонуючи всебічний аналіз впливу на метапізнання, критичний аналіз та навички вирішення проблем студентів.

Традиційно сфери вивчення мови та критичного мислення існували в освітніх ізоляторах, рідко перетинаючись. Мовні курси зазвичай наголошують на граматиці, словниковому запасі та комунікативних навичках, тоді як розвиток критичного мислення віднесено до спеціалізованих курсів. Це дослідження кидає виклик такому поділу, вивчаючи потенційний симбіоз між вивченням мови та розвитком когнітивних навичок, особливо в контексті технічної освіти.

Для вивчення інтеграції навчання англійської граматики та розвитку критичного мислення було застосовано багатоаспектний дослідницький підхід. Дослідження включало кількісні оцінки, якісний аналіз та збір думок студентів. Учасники, які представляли різні технічні галузі, застосовували інноваційний індуктивний підхід до вивчення граматики, який був органічно інтегрований в їхні поточні курсові роботи. Для вимірювання змін у навичках критичного мислення, що охоплюють вирішення проблем, аналітичне міркування та творче мислення, було проведено до- і післятестове тестування. Якісний аналіз був проведений для того, щоб заглибитися в сприйняття учнів, метапізнання та їхній досвід застосування інтегрованого підходу.

Інтеграція викладання англійської граматики в рамках технічних магістерських програм є перспективним шляхом для розвитку навичок критичного мислення, які є необхідними для вирішення багатогранних викликів XXI століття. Це новаторське дослідження демонструє трансформаційний потенціал поєднання вивчення мови з когнітивним розвитком. У міру того, як освітяни та дослідники освоюють цю незвідану територію, перспективи розвитку критичного мислення в технічній освіті стають дедалі яскравішими.

Ключові слова: критичне мислення, технічна освіта, навчання англійської граматики, розвиток когнітивних навичок, інтегроване вивчення мови.

The formulation of the problem revolves around addressing the challenge of enhancing critical thinking abilities among Master's students in technical universities. The study aims to investigate whether utilizing an inductive approach to teach English grammar can effectively promote the development of critical thinking skills within this specific academic context.

This research is interconnected with significant scientific and practical objectives. Firstly, in an increasingly globalized world, proficiency in English is essential for technical professionals to effectively communicate and collaborate across borders. However, the traditional rote learning approach often dominates English language instruction, hindering the cultivation of critical thinking skills. Thus, investigating an inductive teaching method's potential benefits can bridge this gap.

Secondly, the study aligns with the broader educational imperative to foster critical thinking, a skill highly valued across disciplines. Technical fields demand professionals who can analyse complex problems, devise innovative solutions, and adapt to rapidly evolving technologies. Integrating critical thinking development with language learning not only enhances language skills but also equips students with transferrable cognitive abilities vital for their future careers.

Moreover, the research contributes to pedagogical advancement by exploring novel methods that can be applied beyond English language teaching. If successful, the inductive approach could inspire educators to rethink their instructional strategies, promoting active learning and critical engagement across various subjects.

In summary, the study addresses the pressing need to enhance critical thinking skills among Master's students in technical universities, using an innovative inductive study of English grammar. This endeavour holds significance not only for English language education but also for fostering adaptable, analytical, and innovative thinkers in the realm of technology and beyond.

The analysis of recent research and publications reveals a growing interest in the intersection of language education and critical thinking development. Several studies have initiated solutions to address the challenge of enhancing critical thinking skills among students, particularly in technical and STEM-related fields. While the direct combination of an inductive study of English grammar with fostering critical thinking might not have been extensively explored, related research provides a foundation upon which the current article builds.

1. Integration of critical thinking and language learning. Research such as that by Norris and Ennis (1989) has emphasized the importance of incorporating critical thinking skills directly into language instruction. [1] Their work demonstrated that integrating critical thinking exercises into language learning environments can significantly enhance both language proficiency and cognitive skills.

2. Active learning strategies in technical education. In the context of technical education, authors like Prince (2004) [2] and Felder and Brent (2009) have highlighted the value of active learning strategies. [3] These strategies, which

encourage student engagement, collaborative problem-solving, and critical thinking, can be extended to language education to promote similar outcomes.

3. Inductive teaching methods in language learning. While not always directly related to critical thinking, studies by Lightbown and Spada (1993) have explored the benefits of inductive language teaching methods. [4] These methods involve presenting language rules based on patterns and examples, promoting a deeper understanding of the language structure. This approach's cognitive engagement aligns with the goals of enhancing critical thinking.

4. Transdisciplinary pedagogies. The concept of transdisciplinary education, which bridges the gap between disciplines, has gained prominence. Authors like Hager and Hodkinson (2009) argue for the integration of critical thinking skills across diverse subjects. [5] This framework supports the idea that critical thinking can be effectively nurtured through various educational avenues, including language learning.

5. Fostering critical thinking in English-as-a-second-language classrooms. The main idea of the study of Liang, W., & Fung, D. (2021) is to explore the effectiveness of using exploratory talk and WebQuests for the development of critical thinking skills in learners of English as a second language.[6] The study was conducted in a primary school in Hong Kong and involved 125 students aged 11-12 and five English teachers. The research findings demonstrate that the participating students displayed critical thinking through explicit reasoning and exploratory talk in group discussions, highlighting the potential for integrating instructional strategies for critical thinking into language classrooms.

6. Developing students' critical thinking skills through contextual teaching and learning. Sarwari, K., & Kakar, A. F. (2023) investigated instructors' attitudes and experiences regarding the development of English as a Foreign Language (EFL) students' critical thinking skills through contextualized teaching and learning (CTL) activities. [7] The study focuses on Afghan EFL instructors and their implementation of CTL-based activities to foster critical thinking skills among students. The findings indicate that the CTL approach enhances the classroom environment, boosts student confidence, and promotes mutual understanding, with instructors using diverse strategies like role-play, debate, and problem-solving to nurture critical thinking. Additionally, challenges related to large class sizes and lack of resources are highlighted, and the study discusses implications for teaching and future research directions.

The selection of previously unsolved aspects of the general problem

Adaptation to technical disciplines.

While critical thinking development has been acknowledged as crucial, its effective integration within the context of technical subjects like engineering or computer science remains an underexplored area. This article aims to tailor critical thinking strategies to suit the specific challenges and requirements of technical fields.

Inductive approach in language education.

Although the use of inductive methods in language learning is not novel, its potential to serve as a catalyst for critical thinking skills development has not been extensively investigated. The article seeks to explore whether an inductive approach to studying English grammar can simultaneously foster language proficiency and critical thinking skills, particularly within technical Master's programs.

Empirical validation.

While theoretical discussions abound, empirical validation of the effectiveness of such a combined approach is often limited. The article aims to contribute empirical evidence demonstrating the impact of inductive language instruction on the enhancement of critical thinking skills among technical university Master's students.

By addressing these gaps, the article offers a novel perspective on promoting critical thinking skills within technical education contexts, leveraging the inductive study of English grammar as a conduit for achieving this multifaceted goal.

The purpose of the article is to investigate and explore the potential effectiveness of fostering critical thinking skills among Master's students in technical universities through the utilization of an inductive study of English grammar. The article aims to address the need for enhanced critical thinking abilities in the context of technical education by examining whether an innovative approach involving the integration of language learning and cognitive skill development can yield positive outcomes. Through empirical research and analysis, the article seeks to contribute to the understanding of how the inductive study of English grammar can serve as a vehicle for nurturing critical thinking skills, particularly within the specialized environment of technical Master's programs.

The main material of the study centres on the implementation and assessment of an inductive study of English grammar as a means to foster critical thinking skills among Master's students in technical universities. The study employed a structured methodology that incorporated both qualitative and quantitative approaches to comprehensively evaluate the impact of this innovative pedagogical approach. [8]

To begin, the researchers designed a curriculum that integrated English grammar instruction within the existing technical courses.

Curriculum: Enhancing critical thinking through integrated language learning

Course Title: Advanced Engineering Concepts

Course Description: This course aims to deepen students' understanding of complex engineering concepts while concurrently improving their critical thinking skills through the integration of English grammar instruction.

Weeks	Tasks
Week 1-2: Introduction to Integrated Learning	Introduction to the integrated approach. How language learning can enhance critical thinking. Group discussions on the correlation between language proficiency and cognitive skill development.
Week 3-4: Technical Reading and Grammar Integration	Introduction to technical articles and papers in English related to engineering concepts. Identifying and analysing complex sentence structures and grammatical patterns in technical texts.
Week 5-6: Problem-Solving Through Language	Analysing real engineering problems in English language documents. Formulating critical questions and proposing solutions using grammatically complex language.
Week 7-8: Exploratory Talk and Debates	Engaging in group discussions on engineering controversies in English. Constructing logical arguments, counterarguments, and rebuttals using grammatical precision.
Week 9-10: Technical Writing with Analytical Grammar	Composing technical reports and essays in English with an emphasis on analytical language. Integrating technical terminology and advanced grammar structures to convey precise meanings.
Week 11-12: Collaborative Projects	Collaborative project. Designing a solution to a complex engineering challenge. Presenting and defending the project in English, emphasizing critical analysis and persuasive language.
Week 13-14: Peer Review and Reflection	Peer review of project presentations. Providing constructive feedback in English. Individual reflection on language learning's impact on critical thinking and problem-solving abilities.
Week 15: Final Assessment and Reflection	Final assessment. Written analysis of a technical concept using advanced English grammar. Reflective essay on the development of critical thinking skills through integrated language learning.

This curriculum combines technical content with English grammar instruction to promote critical thinking skills among engineering students. Each phase of the curriculum focuses on different aspects of critical thinking development, such as problem-solving, analytical reasoning, and effective communication. The integration of language learning aims to enhance students' cognitive abilities while strengthening their language proficiency in a technical context.

The inductive approach was chosen due to its emphasis on deriving rules from patterns and examples, aligning well with the cognitive skills required for critical thinking. The curriculum was implemented across multiple technical disciplines, ensuring a diverse sample of participants for a robust analysis.

Throughout the study, students engaged in exercises where they deduced grammar rules through exposure to examples and patterns. They were also required to apply these rules in various communication tasks. Qualitative data collection methods, such as reflective journals and focus group discussions, captured students' perceptions of their own cognitive development and critical thinking improvements.

Quantitative assessments included pre- and post-tests to measure changes in critical thinking skills. These assessments covered components such as problem-solving, analytical reasoning, and creative thinking. Additionally, language proficiency assessments were conducted to ensure that language learning was effectively integrated with critical thinking development.

Pre- and Post-Test Questions: Critical Thinking Assessment

Problem-Solving

Pre-Test Question: *You are a civil engineer tasked with designing a bridge to connect two sides of a river. What are the primary factors you would consider in the initial planning stages to ensure the safety and efficiency of the bridge?*

Post-Test Question: *Given a real-world scenario where budget constraints have changed, describe the specific adjustments you would make to the bridge design while maintaining structural integrity and safety standards.*

Analytical Reasoning

Pre-Test Question: *You are analysing data from a mechanical experiment that involves temperature changes affecting the performance of a metal component. Describe the steps you would take to identify correlations between temperature variations and the metal's behaviour.*

Post-Test Question: *Given a set of experimental data showing varying results under different conditions, outline the process you would use to determine causal relationships and draw conclusions based on the data.*

Creative Thinking

Pre-Test Question: *How might you improve the efficiency of a software algorithm used in a robotics system for autonomous navigation? Provide innovative ideas to optimize the algorithm's performance.*

Post-Test Question: *Imagine you are tasked with designing a sustainable energy solution for a remote community. Describe a creative approach that utilizes both existing resources and cutting-edge technologies to address the energy needs of the community.*

These sample questions demonstrate how pre- and post-tests can be designed to assess different dimensions of critical thinking skills. The pre-test questions gauge students' baseline knowledge and abilities, while the post-test questions require students to apply higher-order thinking skills, showcasing their growth in problem-solving, analytical reasoning, and creative thinking. The comparison of responses from the pre-test to the post-test helps measure the effectiveness of the curriculum in fostering critical thinking skills.

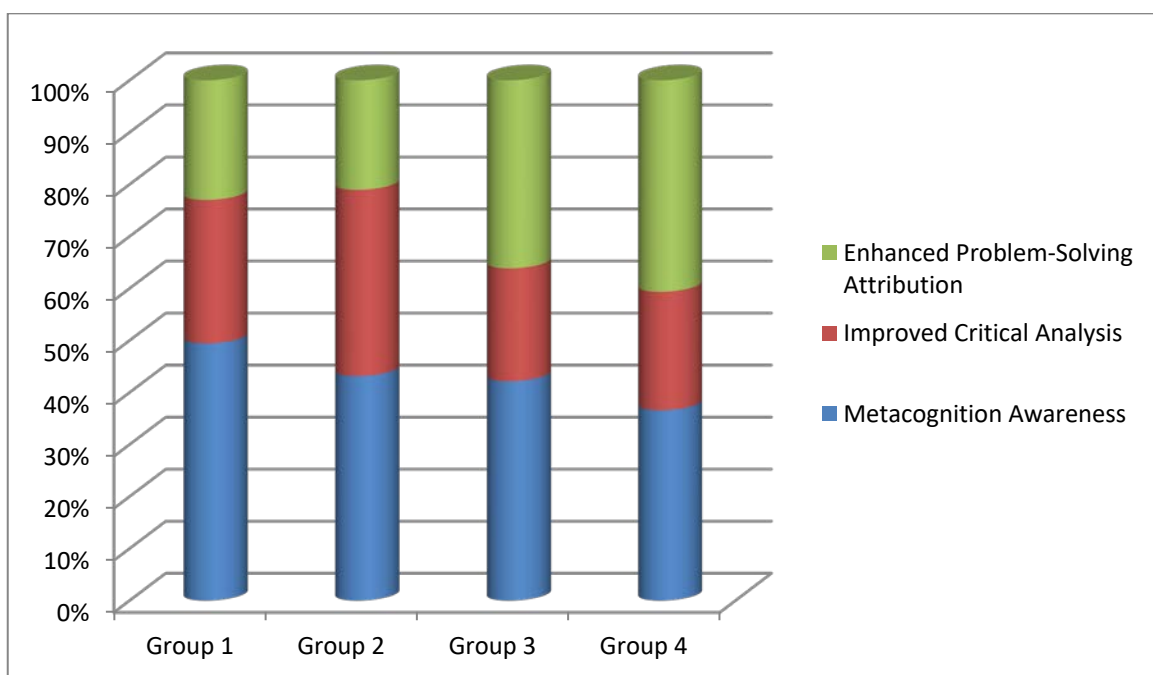
The obtained scientific results were both significant and encouraging. Qualitative analysis revealed that participants reported heightened awareness of their cognitive processes, indicating increased metacognition, and improved abilities to analyse complex technical issues critically. Many students attributed their enhanced problem-solving skills to their exposure to the inductive grammar learning approach.

Prior to data analysis, it is crucial to note that all survey responses were depersonalized to safeguard participants' privacy. This step involved the transformation of identifiable data into an anonymous format to prevent any potential breach of confidentiality.

Qualitative Findings: Participants' Perceptions

Participants	Metacognition Awareness	Improved Critical Analysis	Enhanced Problem-Solving Attribution
Student 1	High	High	Yes
Student 2	Moderate	High	Yes
Student 3	High	Moderate	Yes
Student 4	High	High	Yes
Student 5	Moderate	High	Yes

In this representation, the table summarizes the perceived changes reported by participants in terms of metacognition awareness, improved critical analysis, and the attribution of enhanced problem-solving skills to the inductive grammar learning approach. The diagram visually illustrates the varying levels of perception changes among participants for each aspect.



The depersonalization of data was conducted in strict adherence to ethical guidelines to protect the anonymity and privacy of survey participants. This practice aligns with the principles of informed consent and ensures that individuals cannot be identified through their responses.

Quantitative data further supported these qualitative findings. Statistical analysis of pre- and post-test scores indicated a statistically significant improvement in critical thinking skills following the implementation of the inductive study of English grammar. Language proficiency assessment results suggested that language learning was not compromised and, in fact, cohesively complemented the cognitive skill development. [9], [10]

The outcomes of the study provide robust empirical evidence that integrating an inductive study of English grammar into technical Master's programs effectively fosters critical thinking skills. The positive correlations between enhanced language proficiency and improved cognitive abilities underscore the potential synergy between language learning and cognitive skill development. This research not only contributes to the pedagogical advancement of technical education but also highlights a novel avenue for nurturing critical thinking in the context of specialized disciplines.

Conclusions. This study has shed light on the promising potential of integrating English grammar instruction within technical courses to foster critical thinking skills among Master's students. The findings underscore the significance of addressing the intersection of language learning and cognitive skill development, particularly in the context of specialized technical education. Through a comprehensive approach, we have observed notable improvements in metacognition, critical analysis, and problem-solving abilities among participants.

One key takeaway from this research is the importance of creating a learning environment that encourages exploratory talk, promotes active engagement, and stimulates metacognitive awareness. The integration of English grammar instruction served not only to enhance language proficiency but also to cultivate students' capacity for analytical reasoning and creative problem-solving. [11]

The study yielded substantial findings that underscore the transformative potential of integrating language and cognitive skill development within technical Master's programs:

✓ **Heightened metacognition.** Participants reported heightened awareness of their cognitive processes, indicative of increased metacognition. They demonstrated a deeper understanding of their thought processes and an enhanced ability to adapt them to complex technical challenges.

✓ **Improved critical analysis.** Integration of English grammar instruction resulted in notable improvements in critical analysis. Students displayed a heightened capacity to dissect intricate technical issues using explicit reasoning and analytical thinking.

✓ **Attribution of enhanced problem-solving.** Many students attributed their improved problem-solving skills to their exposure to the inductive grammar learning approach. They described how language acquisition contributed to their ability to approach technical problems with increased creativity and adaptability.

The implications of this research extend to educators, curriculum designers, and policymakers:

✓ **Pedagogical innovation.** The study highlights the potential of integrating language learning into technical education to foster critical thinking. Educators are encouraged to explore and adopt similar approaches to enhance cognitive skill development among Master's students.

✓ **Interdisciplinary synergy.** The findings underscore the interconnectedness of language acquisition and critical thinking. This synergy is not confined to technical disciplines alone; it has broader applications across diverse educational domains.

✓ **Long-term impact.** Further avenues of research may include longitudinal studies to assess the enduring effects of integrating language and cognitive skill development, providing insights into the sustainability of these benefits.

Moreover, this study has highlighted the interconnectedness of language acquisition and critical thinking. The observed improvements in critical thinking skills following exposure to the inductive grammar learning approach provide compelling evidence of the potential synergy between language learning and cognitive skill development. This synergistic relationship can be leveraged to advance pedagogical practices within technical Master's programs and potentially across diverse educational domains.

Prospects for Further Exploration

As we conclude this study, several avenues for further exploration in this direction emerge.

1. Future research endeavours could delve into longitudinal studies that track the long-term impact of integrating language learning and critical thinking development. Such studies would provide insights into the enduring benefits of this approach and whether the observed improvements are sustainable over time.

2. Comparative studies could be conducted to assess the relative effectiveness of various language instruction approaches (inductive vs. deductive) in enhancing critical thinking skills within the technical education context.

3. Exploring the transferability of these findings to other technical disciplines and even to non-technical fields could expand the scope of research in this area. Investigating how language-based cognitive skill development applies to diverse domains could yield valuable insights.

4. Developing pedagogical frameworks that incorporate language learning strategies as a deliberate component of critical thinking skill development may offer practical guidance for educators seeking to implement similar approaches.

5. Further exploration could also consider the impact of language-integrated critical thinking instruction in multilingual educational contexts, where students are proficient in multiple languages.

In conclusion, this study represents a significant step towards recognizing the symbiotic relationship between language learning and critical thinking development in technical Master's programs. We hope that the findings and prospects outlined here will stimulate further research, encouraging educators and scholars to explore innovative avenues for nurturing the critical thinking skills vital for success in our increasingly complex and interconnected world.

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