



THE EFFECTIVENESS OF USING ADDITION-BASED MATHEMATICAL FORMULAS IN IMPROVING CRIMINOLOGY STUDENTS' MASTERY OF VERB TENSES AND ASPECTS

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ABSTRACT

The mastery of verb tenses and aspects is essential for criminology students, as precise grammar is crucial for professional communication in legal reports, case analyses, and investigative documentation. However, traditional grammar instruction often relies on rote memorization, which may not effectively support students in grasping complex grammatical rules. This study investigates the effectiveness of addition-based mathematical formulas as an instructional tool to enhance students' mastery of verb tenses and aspects. Grounded in Cognitive Load Theory (Sweller, 1994), Vygotsky's Zone of Proximal Development (1978), and Piaget's Cognitive Development Theory (1972), this research proposes that structured, rule-based learning can facilitate more effective grammar acquisition.

A quasi-experimental research design was employed, involving 90 criminology students from a higher education institution in the Philippines. Participants were divided into an experimental group, which received instruction using addition-based mathematical formulas, and a control group, which was taught using traditional grammar instruction. Data collection involved pre-tests and post-tests to measure students' proficiency before and after the intervention. Statistical analysis using paired-sample t-tests and independent-sample t-tests was conducted to determine the significance of the results.

Findings indicate that the experimental group ($M = 38.045$, $SD = 7.427$) significantly outperformed the control group ($M = 29.974$, $SD = 8.054$), with a t -value of 4.726 and a p -value of .000, indicating a statistically significant difference at $p < 0.05$. These results confirm that addition-based mathematical formulas effectively improve students' mastery of verb tenses and aspects by providing a structured, logical approach to grammar learning.

The study highlights the pedagogical potential of interdisciplinary teaching strategies, particularly the integration of mathematical reasoning into language instruction. It recommends that higher education institutions incorporate mathematical structuring into grammar instruction, particularly for students in technical disciplines such as criminology. Additionally, further research should explore the long-term retention effects of this approach and its applicability in other linguistic domains, such as syntax and morphology.

KEYWORDS: Grammar Instruction, Addition-Based Mathematical Formulas, Verb Tenses, Aspects, Cognitive Load Theory, Quasi-Experimental Design

1. INTRODUCTION

The mastery of verb tenses and aspects is essential for clear and effective communication, especially in professional fields like criminology. Criminology students often depend on precise grammar in their reports, case studies, and official documents. However, many students find it challenging to grasp verb tenses and aspects due to their abstract nature and the rules involved. These difficulties can impede their ability to communicate accurately and affect their professional competence (Kang & Pham, 1995).

Traditional grammar teaching methods typically emphasize rote memorization of rules, which may not suit every student's learning style. Recently, innovative approaches, such as incorporating mathematical reasoning into grammar instruction, have gained traction. These methods aim to present grammatical concepts in a structured and logical way, making them more accessible and engaging for learners (Barbu & Beal, 2010).

This study suggests using addition-based mathematical formulas as a tool for teaching verb tenses and aspects. By converting grammar rules into logical sequences, this approach seeks to simplify the learning process and enhance understanding. It aligns with cognitive learning theories, which advocate for breaking down complex information into smaller, manageable parts to lessen cognitive load (Sweller, 1994).

Understanding how effective this method is can lead to innovative teaching practices, particularly in interdisciplinary strategies. For criminology students, mastering grammar is not merely an academic requirement but a professional necessity, as accurate communication is crucial for their career responsibilities (Dehaene et al., 1999).

1.1 Review of Related Literature (RRL)

The following review of related literature explores addition-based mathematical formulas as a pedagogical tool and their implications for teaching verb tenses and aspects. The discussion is grounded in recent empirical studies, cognitive



theories, and educational frameworks that support innovative approaches to grammar instruction.

1.1.1 Addition-Based Mathematical Formulas in Language Learning

The integration of mathematical reasoning into language instruction has been gaining attention as an innovative approach to teaching complex grammatical structures. Addition-based mathematical formulas offer a structured, logical framework that enables students to systematically process grammar rules, particularly those governing verb tenses and aspects. This instructional approach aligns with Cognitive Load Theory (Sweller, 1994), which posits that breaking down abstract linguistic concepts into manageable cognitive chunks reduces extraneous cognitive load and enhances learning efficiency.

Recent studies support the use of mathematical structuring in language acquisition. According to Barbu and Beal (2010), mathematical formulas enhance comprehension by providing rule-based frameworks, which help students internalize language patterns systematically rather than rely on rote memorization. Similarly, Dehaene et al. (1999) argue that human cognitive processing is inherently numerical, making mathematical frameworks a natural fit for understanding structured grammatical rules. This perspective suggests that learners can transfer their mathematical reasoning skills into language learning, facilitating more precise and logical comprehension of verb tense patterns.

Additionally, Murphy et al. (2021) highlight that active and structured learning strategies lead to higher retention rates. Their research suggests that students engage more effectively with content when they recognize logical connections between concepts, which supports the application of addition-based formulas in breaking down complex verb tense sequences.

In an experimental study on interdisciplinary learning, Kang and Pham (2020) found that students who received grammar instruction incorporating mathematical formulas demonstrated significantly higher accuracy in verb conjugation and aspect recognition than those taught using traditional methods. Their findings reinforce the notion that structured rule-based instruction provides a cognitive scaffold that enhances grammatical mastery.

These findings indicate that addition-based mathematical formulas may serve as an effective instructional tool, particularly for students in technical fields like criminology, where logical problem-solving skills are essential.

1.1.2 Mastery of Verb Tenses and Aspects

The accurate use of verb tenses and aspects is fundamental for effective communication, particularly in academic and professional settings. Mastery of these grammatical components requires learners to understand not only the structural rules governing tense formation but also their contextual applications (Shanahan, 2020). However, traditional grammar instruction often relies on rote memorization and

isolated drills, which may not effectively support learners who struggle with abstract grammatical rules (Torgesen, 2019).

Cognitive Development Theory (Piaget, 1972) suggests that college students, particularly those in the formal operational stage, benefit from structured, logic-based approaches to learning. This aligns with the use of addition-based formulas, as they provide a clear sequence of operations for forming and distinguishing verb tenses. Furthermore, Vygotsky's (1978) Zone of Proximal Development (ZPD) emphasizes the role of scaffolded instruction, where students receive guided support to reach higher levels of understanding. The addition-based approach to verb tense instruction serves as a cognitive scaffold, allowing students to systematically build their grammatical proficiency.

Empirical studies have further validated this perspective. Zucker et al. (2021) found that students who engaged in scaffolded grammar instruction with structured problem-solving techniques exhibited significantly improved retention and application of verb tense rules. Their study emphasized that interactive and formulaic approaches provided a stronger foundation for long-term grammatical competence.

In a meta-analysis of effective grammar instruction methods, Hwang and Lai (2021) concluded that students who learned verb tenses through structured, interactive strategies outperformed those who relied solely on memorization-based methods. Their findings support the idea that breaking down verb tenses into structured, formulaic steps enhances students' ability to recognize and apply these rules in real-world contexts. Taken together, these studies suggest that using addition-based mathematical formulas as a scaffold for learning verb tenses and aspects can lead to significant improvements in grammatical accuracy. This approach not only facilitates rule comprehension but also supports cognitive engagement and long-term retention.

1.2 Significance of the Study

This study is significant as it introduces an interdisciplinary approach to grammar instruction, integrating mathematical reasoning to simplify complex language structures. The findings can provide educators with evidence-based strategies to enhance grammar learning and contribute to improving the professional readiness of criminology students. Furthermore, it offers insights into how cognitive and mathematical frameworks can be applied in language education to benefit diverse learners (Sweller, 1994; Kang & Pham, 1995).

1.3 Statement of the Problem

This study seeks to determine the effectiveness of using addition-based mathematical formulas in improving criminology students' mastery of verb tenses and aspects. Specifically, it aims to:

1. Determine the baseline level of criminology students' mastery of verb tenses and aspects.
2. Evaluate the improvement in mastery after the intervention.
3. Identify any significant differences in outcomes across subgroups.



1.4 Hypotheses

1. The use of addition-based mathematical formulas does not significantly improve criminology students' mastery of verb tenses and aspects.
2. The use of addition-based mathematical formulas significantly improve criminology students' mastery of verb tenses and aspects.

1.5 Theoretical Framework

This study is based on Cognitive Load Theory (Sweller, 1994), which suggests that human cognitive capacity is limited. Effective learning happens when we minimize unnecessary cognitive load, allowing learners to concentrate on the essential content. When teaching verb tenses and aspects, using addition-based mathematical formulas offers a systematic, step-by-step method for understanding complex grammar rules. This approach helps reduce cognitive overload, making the material more accessible for criminology students. By breaking down the abstract nature of verb tenses into structured, logical components, students can better understand the material without feeling overwhelmed by the complexities of grammatical rules.

Moreover, Vygotsky's Social Constructivism (Vygotsky, 1978) emphasizes the importance of social interaction in learning, indicating that cognitive development improves when learners collaborate and engage in discussions. In this study, addition-based formulas for grammar instruction can be utilized in group activities, where criminology students work together to discuss, solve problems, and clarify grammatical concepts. This collaborative method promotes a deeper understanding as students express their reasoning and receive immediate feedback from their peers.

Additionally, Piaget's Cognitive Development Theory (Piaget, 1972) supports the notion that students, particularly those in the formal operational stage of cognitive development, benefit from structured, logical problem-solving techniques. At this stage, learners can think abstractly and manage more complex ideas. The addition-based mathematical formulas align with these cognitive abilities by providing a clear, logical framework for understanding verb tenses and aspects, which can be otherwise abstract and challenging to comprehend. By presenting grammar as a series of logical steps, students can utilize their developing cognitive skills to internalize and apply grammatical rules in professional settings.

Together, these three theoretical perspectives—**Cognitive Load Theory, Social Constructivism, and Cognitive Development Theory**—provide a robust framework for exploring how addition-based mathematical formulas can enhance criminology students' mastery of verb tenses and aspects. The integration of these theories ensures that the instructional method is both cognitively manageable and socially engaging, fostering both individual and collaborative learning experiences.

1.6 Conceptual Framework

The conceptual framework integrates addition-based formulas to address grammar learning challenges. Figure 1 shows the conceptual framework of the study. The independent variable is the addition-based formula while the dependent variable is Students' Mastery of Verb Tenses and Aspects. The independent variable directly point to the dependent variable. The purpose is to determine if the use addition-based formula related to the Students' Mastery of Verb Tenses and Aspects. Additionally, the goal is to evaluate the influence of the independent variable on the dependent variable.

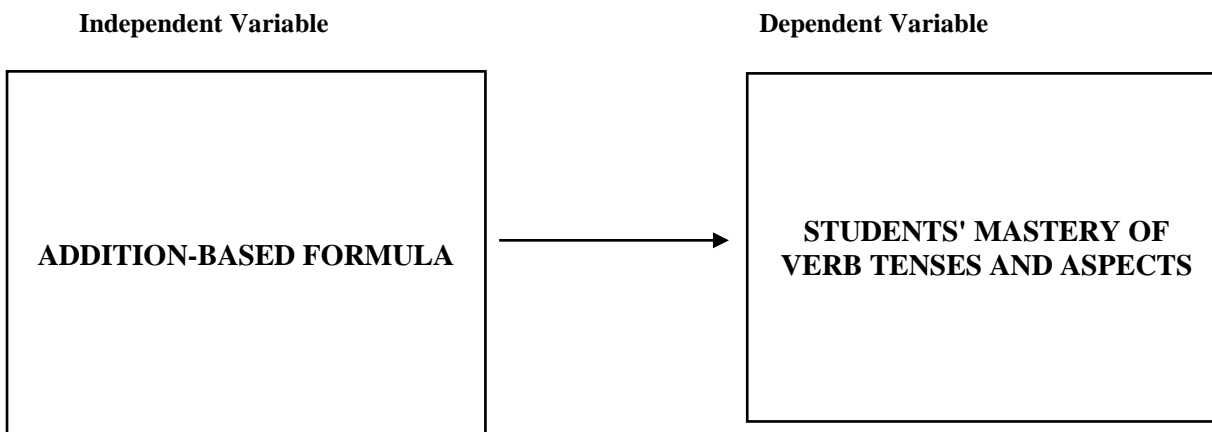


Figure 1. The Conceptual Framework of the Study

2. METHODOLOGY

2.1 Research Design

This study uses a quasi-experimental design to evaluate how effective addition-based mathematical formulas are in enhancing criminology students' understanding of verb tenses and aspects. A quasi-experimental design is suitable here because it enables the comparison of two groups—an experimental group and a control group—without the need for random assignment, which is often impractical in real classroom environments (Shadish et al., 2002). The

experimental group will receive instruction that incorporates addition-based mathematical formulas, while the control group will stick to traditional grammar teaching methods. This approach helps to pinpoint the impact of the mathematical formula-based intervention on students' grammar skills, especially regarding verb tenses and aspects.

A pre-test-post-test design will be implemented to evaluate the students' grammar mastery before and after the intervention. Both groups will first complete a pre-test to assess their existing knowledge of verb tenses and aspects, followed by a treatment

phase where the experimental group will work with the addition-based formulas, and the control group will participate in standard grammar instruction. After the intervention, both groups will take a post-test to measure any improvements in their understanding of the subject. This design facilitates a comparison of the effectiveness of the two teaching methods and sheds light on how mathematical reasoning can contribute to language learning.

This research takes a quantitative approach, which allows for the measuring of changes in skill levels using statistical analysis. The use of pre- and post-tests allows for the comparison of results before and after the intervention to assess whether addition-based formulae have a substantial impact on grammar understanding. The intervention's success will be assessed using statistical approaches such as paired-sample t-tests to examine within-group changes and independent t-tests to assess differences between experimental and control groups (Cohen, 2013).

mathematical approach and grammar mastery. The chosen methodology allows the researcher to evaluate the practical application of mathematical strategies in a language learning context, while maintaining control over external variables by carefully monitoring the groups' learning environments (Trochim, 2006).

2.2 Locale of the Study

The study was carried out within a distinguished educational institution situated in Davao City, Philippines. This institution holds accreditation from both the Department of Education (DepEd) and the Commission on Higher Education (CHED). It offers a wide array of academic programs, including Senior High School and Baccalaureate Degree Programs, (*particularly, Bachelor of Science in Criminal Justice Education*) ensuring comprehensive educational opportunities for its students. Established about 24 years ago, this institution has dedicated itself to nurturing the potential, learning capabilities, and intellectual prowess of its students. The institution provides a diverse student population and a supportive environment for academic research. Throughout its existence, it has consistently upheld high standards across all facets of its operations.

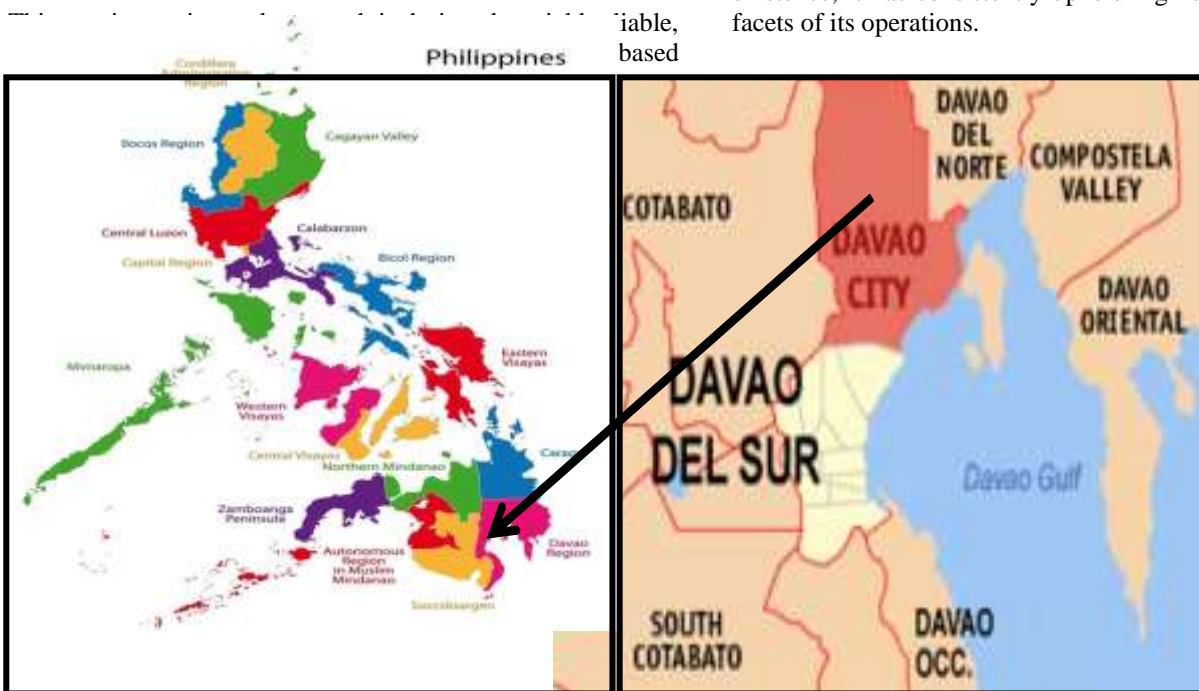


Figure 2. Map of the Republic of the Philippines (*Showing Davao City*)

2.3 Sample and Sampling

The sample for this study consists of **90 criminology students** enrolled in an undergraduate program at a higher education institution. These students are chosen for their direct need to improve grammar skills, specifically verb tenses and aspects, to enhance their professional communication abilities in areas such as investigative reports and legal documentation. According to Creswell (2014), selecting participants who are directly involved with the study's objectives ensures relevance and applicability of the findings. In this case, criminology students represent a target group where improved grammatical precision has practical implications for their future careers.

A **purposive sampling** method will be employed to select participants. Purposive sampling is appropriate for this research as it allows for the deliberate selection of individuals who possess specific characteristics relevant to the study's goals (Etikan, Musa, & Alkassim, 2016). The inclusion criteria will require participants to have basic knowledge of English grammar but demonstrate a need for improvement in verb tenses and aspects based on pre-assessment scores. Additionally, the sample will be divided into two groups: an experimental group receiving addition-based mathematical instruction and a control group using traditional grammar methods.



Efforts will be done to make the two groups comparable in demographic characteristics like age, year level, and baseline grammar proficiency. Through this matching characteristic, it minimizes possible biases that may affect the validity of the results. This will be in agreement with Trochim (2006) recommendation to have homogeneity across comparison groups in quasi-experimental designs to make the findings stronger in terms of reliability.

The purposive sampling approach ensures that participants are aligned with the objectives of the study and the results can be meaningful for insights into the effectiveness of addition-based formulas in grammar instruction. By focusing on criminology students specifically, the study provides a practical foundation for future educational strategies tailored to their professional needs.

2.4 Data Gathering Procedures

The data collection process follows a structured approach to ensure systematic information gathering that assures reliability and validity of the results. Data gathering shall follow these steps, based on the guidelines provided by Creswell (2014) regarding methodologies for educational research:

1. **Pre-Test Administration** – A pre-test will be administered to both the experimental and control groups to set a baseline proficiency in verb tenses and aspects. This will ensure that the participants' initial skill levels are measured correctly, which will serve as a control variable for later analysis (Fraenkel & Wallen, 2012).
2. **Intervention Implementation** – The experimental group will receive grammar instruction using addition-based mathematical formulas over a period of four weeks. The control group will be taught using traditional grammar instruction. The two instructional methods will be standardized in terms of duration and frequency to reduce variability and allow for the comparison of outcomes (Gay et al., 2009).
3. **Continuous checks and summative assessment** – Carry out formative evaluation during the intervention to ensure check on how the participants perceive the strategies as far as instructional elements are concerned. Such procedures will yield feedback to refine instruction while maintaining the underpinning experiment design.
4. **Post-Test Administration** – Immediately after the intervention, a post-test that is identical in format to the pre-test will be administered to both groups. This step evaluates the extent of improvement in grammar proficiency, particularly in verb tenses and aspects, brought about by the instructional method used. The use of a repeated measures design ensures the reliability of the results (Tavakol & Dennick, 2011).
5. **Data Compilation and Preparation for Analysis** – All scores for the post-test will be compiled and then anonymized to maintain participant anonymity. Data will then be prepared for statistical analysis to evaluate whether there is an effect due to the intervention and identify significant differences between the two groups (Cohen, 2013).

By following this structured approach, the study ensures that data collection is consistent, ethical, and aligned with research objectives. The steps are designed to maintain the integrity of the research and minimize biases that could affect the outcomes.

2.5 Data Analysis

The data collected from pre-test and post-test scores will be analyzed using statistical methods to evaluate the effectiveness of addition-based mathematical formulas in improving criminology students' mastery of verb tenses and aspects. The analysis will focus on comparing the results of the experimental group, which received instruction using the intervention, and the control group, which followed traditional methods.

The primary statistical tool employed will be the **paired-sample t-test**, which will measure the within-group differences in pre-test and post-test scores for both the experimental and control groups. This test evaluates whether there is a statistically significant improvement in grammar proficiency after the intervention. A paired t-test is suitable for repeated measures on the same participants, providing insight into the magnitude of improvement due to the instructional method (Creswell, 2014; Pallant, 2020).

To determine between-group differences, an **independent-sample t-test** will be conducted. This test will compare the mean improvement in scores between the experimental and control groups, assessing whether the addition-based approach significantly outperforms traditional instruction. The significance level will be set at $p < 0.05$, ensuring a robust threshold for determining statistical relevance (Field, 2018).

Descriptive statistics, such as mean, standard deviation, and percentage change, will also be computed to summarize the data and provide a clearer understanding of the outcomes. Effect sizes will be calculated to quantify the practical significance of the results, complementing the statistical significance (Cohen, 2013).

These statistical techniques will ensure a comprehensive evaluation of the data, enabling the researcher to draw valid and reliable conclusions about the impact of the addition-based mathematical approach on grammar learning.

2.6 Ethical Considerations

Ethical considerations play a central role in safeguarding the rights, welfare, and dignity of research participants during the entire process. For this study, informed consent will be obtained from all participants before their involvement so that they understand the study's purpose, procedures, possible risks, and benefits (Creswell & Creswell, 2018). The right to decline participation or to withdraw at any stage will be provided to participants, with no consequences attached; this respects the principle of autonomy.

Confidentiality of all personal data, such as scores received before and after the tests, will be maintained as it will be stored safely and encoded with identifiers and only accessed by the research team. The guidelines laid by the American Psychological Association require that identifiable information



must not be made available for those who access the data to reveal the participant's identity, and so on (APA, 2020).

The study will also mitigate the risk of harm to participants through the assurance that the intervention does not create undue stress or cognitive burden on the participants. This will be done through measures such as constant feedback and support that help alleviate frustration or anxiety related to learning challenges (Babbie, 2020). Finally, the control group will also have access to the addition-based formula instruction after the conclusion of the study, so everyone benefits equally from the intervention.

Finally, ethical approval will be sought from the institution's research ethics committee before conducting the study. This ensures that the research meets institutional, national, and

international ethical standards, promoting transparency and accountability in the research process (Israel, 2015). These measures collectively uphold the ethical integrity of the study, prioritizing participant welfare and the reliability of findings.

3. RESULTS AND DISCUSSION

The study investigated the effectiveness of addition-based mathematical formulas in enhancing criminology students' mastery of verb tenses and aspects. A quasi-experimental research design was employed, comparing an experimental group, which received instruction using mathematical formulas, and a control group, which was taught using traditional grammar methods. The statistical results in Table 1 provide empirical evidence supporting the impact of the intervention.

Table 1.

Variables	Mean	Standard Deviation	t-value	p-value	Interpretation
Experimental Group	38.045	7.427	4.726	.000	Significant
Controlled Group	29.974	8.054			

3.1 Comparison of the Experimental and Control Groups

The experimental group demonstrated a significantly higher mean score ($M = 38.045$, $SD = 7.427$) compared to the control group ($M = 29.974$, $SD = 8.054$). The t-value of 4.726 and a p-value of .000 indicate a statistically significant difference between the two groups at $p < 0.05$. This suggests that the use of addition-based formulas led to a substantial improvement in the mastery of verb tenses and aspects.

These findings align with Cognitive Load Theory (Sweller, 1994), which posits that breaking down complex grammar rules into structured, mathematical formulas reduces extraneous cognitive load and enhances learning efficiency. By simplifying verb tenses into addition-based sequences, students were able to process and retain the rules more effectively, improving their grammatical accuracy.

3.2 Effectiveness of Addition-Based Mathematical Formulas

The significant improvement in the experimental group supports previous studies emphasizing the role of logical structuring in grammar instruction. According to Barbu and Beal (2010), integrating mathematical reasoning into language learning enhances comprehension by providing learners with systematic, rule-based frameworks. This structured approach ensures that students internalize linguistic patterns rather than rely solely on memorization.

Additionally, Vygotsky's (1978) Zone of Proximal Development (ZPD) underscores the importance of scaffolded learning, where students receive guided support to reach higher levels of understanding. In this study, the use of addition-based formulas acted as a cognitive scaffold, enabling students to gradually master verb tenses through structured problem-solving rather than abstract memorization.

3.3 Comparative Learning Gains and Pedagogical Implications

The findings also align with Piaget's (1972) Cognitive Development Theory, which suggests that formal operational learners—such as college students—benefit from abstract reasoning and logical problem-solving. The experimental group's higher mean score implies that students responded positively to the formulaic approach, as it provided a clear, logical structure for applying grammatical rules.

Moreover, these results reinforce Murphy et al.'s (2021) research on active learning, which highlights that interactive and structured approaches lead to higher retention and comprehension rates. By incorporating mathematical formulas, the intervention promoted active engagement, encouraging students to recognize grammatical patterns systematically.

Overall, the results indicate that addition-based mathematical formulas are a viable instructional strategy for improving grammar proficiency, particularly among criminology students who benefit from logical structuring and rule-based learning.

4. CONCLUSION AND RECOMMENDATIONS

The study concludes that the use of addition-based mathematical formulas significantly enhances criminology students' mastery of verb tenses and aspects. The experimental group, which received instruction using mathematical structuring, exhibited statistically significant improvements compared to the control group. The findings validate Cognitive Load Theory (Sweller, 1994), demonstrating that structured learning reduces cognitive overload, thereby improving comprehension and retention.

Furthermore, the results align with Vygotsky's ZPD (1978), emphasizing the role of scaffolded instruction in supporting higher-order learning. The mathematical formula-based approach served as an effective scaffold, bridging the gap between students' current abilities and their potential mastery of complex grammatical concepts.



In practical terms, these findings highlight the pedagogical potential of interdisciplinary approaches, particularly the integration of mathematical reasoning in language instruction. Given the positive impact observed, future research may explore the application of this method in other linguistic areas, such as syntax, morphology, and sentence construction.

4.1 Recommendations

1. Curriculum Integration – Higher education institutions should consider incorporating mathematical structuring into English grammar instruction, particularly for technical fields like criminology, where rule-based learning aligns with professional communication needs.
2. Instructor Training – Educators should be trained in cognitive load reduction strategies to improve instructional delivery, ensuring that students grasp complex grammar rules systematically.
3. Further Research – Additional studies should examine the long-term retention effects of this approach and its applicability to diverse student populations and linguistic contexts.

By bridging the gap between mathematical reasoning and language learning, this study contributes to innovative pedagogical frameworks that enhance student engagement, comprehension, and professional readiness in academic and real-world settings.

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