International Journal of Basic and Applied Sciences, 14 (5) (2025) 936-943

International Journal of Basic and Applied Sciences

Website: www.sciencepubco.com/index.php/IJBAS
https://doi.org/10.14419/mpj7dg13
Research paper

Mediation Role of Learning Styles Influencing Students' Beliefs and Attitudes Toward Mathematics on Their Performance in Solving Word Problems

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Received: July 9, 2025, Accepted: September 15, 2025, Published: September 30, 2025

Abstract

The mediation role of learning styles was examined, influencing students' beliefs in Mathematics and attitudes toward Mathematics on their performance in solving word problems in Mathematics in the Modern World (MMW). It aimed to assess students' beliefs and attitudes, identify dominant learning styles (visual, auditory, kinesthetic), evaluate their performance in solving word problems, determine the mediating effects of learning styles, and propose instructional strategies aligned with these styles to enhance engagement and performance. Employing a descriptive-correlational design with Structural Equation Modeling (SEM), the study involved freshman students enrolled in the first semester of the academic year 2023–2024 at Batangas State University, the National Engineering University. The data were collected using Cronbach alpha-validated instruments with high reliability: learning styles (0.916), beliefs (0.963), and attitudes (0.916). In addition, student performance in solving word problems was measured through a researcher-made test with a Kuder-Richardson Formula 21 (KR-21) reliability coefficient of 0.832. Findings revealed significant associations among students' beliefs, attitudes, learning styles, and performance. Significantly, specific learning styles mediated the influence of beliefs and attitudes on problem-solving success. Based on these insights, evidence-based instructional strategies were recommended to match students' preferred learning styles, aiming to foster deeper engagement and improved performance in solving word problems.

Keywords: *Attitudes toward Mathematics, Beliefs in Mathematics, Instructional strategies, Learning styles in Mathematics, and Performance in solving word problems*

1. Introduction

Educational institutions play a vital role in enhancing Mathematics education by equipping both teachers and students with the tools necessary for academic success. Providing professional development and fostering a growth mindset empowers educators to implement innovative strategies while helping students embrace challenges as opportunities for intellectual development. Mathematics in the Modern World (MMW) emphasizes interdisciplinary, real-world applications that aim to make learning more relevant, inclusive, and engaging.

As a faculty member-researcher at Batangas State University, The National Engineering University (BatStateU The NEU), the author is well-positioned to explore students' challenges in MMW, particularly in solving word problems. Based on direct experience in teaching and research, the researcher observed that students often struggle with transitioning from theoretical concepts to practical applications. This difficulty is not unique to BatStateU. The NEU; similar concerns have been reported across Philippine higher education institutions. National and international assessments also show a consistent trend: students perform well in procedural tasks but face difficulties in solving complex word problems requiring higher-order thinking.

In this context, it is important to clarify the difference between learning styles and learning modalities to avoid confusion. Learning styles refer to an individual's preferred way of processing and engaging with information. For instance, Fleming's VARK model defines four primary learning styles: Visual (preference for diagrams and imagery), Aural (preference for listening and discussion), Read/Write (preference for text-based input and output), and Kinesthetic (preference for hands-on and experiential learning) (Fleming & Baume, 2006). On the other hand, learning modalities pertain to the channels or sensory modes through which learning can occur (e.g., visual, auditory, tactile/kinesthetic), but they do not necessarily capture a learner's preference. In other words, modalities describe the means of delivering instruction, while styles reflect the individual preferences in receiving and processing information.

Building on this distinction, literature confirms that students' beliefs in Mathematics and attitudes toward Mathematics significantly affect their engagement and performance. Positive beliefs and a growth mindset encourage perseverance and problem-solving (Hidayatullah & Csikos, 2022; Takunyaci, 2021), while negative beliefs foster fixed mindsets that hinder learning. Teachers' positive attitudes further contribute to supportive learning environments (Goos & Geiger, 2021). In addition, when considered alongside these affective factors, learning styles such as visual, auditory, and kinesthetic have been shown to influence students' comprehension, thereby making differentiated instruction essential (Johnson & McCabe, 2021; Wu & Li, 2021).

Instructional strategies aligned with students' learning styles have also demonstrated effectiveness in supporting word problem solving. Almuwaiziri et al. (2023) found that children who created their own visuals during problem-solving performed better than those who relied solely on provided diagrams, suggesting that self-generation fosters deeper understanding. Similarly, Billman et al. (2023) reported that the use of virtual manipulatives and graphic organizers notably improved students' independence and accuracy when solving proportion and multistep problems, which are often embedded in deceptive and digit-based tasks. Nasution et al. (2022) demonstrated that verbalizing thought processes during problem-solving in a Think-Aloud Pair Problem Solving (TAPPS) model enhanced learners' understanding of mathematical reasoning by making cognitive steps explicit. Such approaches also promote metacognition, enabling students to monitor and adapt their strategies. For kinesthetic learners, Cosentino et al. (2023) showed that students who physically walked number lines developed greater fluency in integer operations, which are foundational in digit-based problems. Furthermore, embodied learning research from Multidisciplinary Digital Publishing Institute (MDPI, 2023) and ResearchGate (2023) highlights how touch-tracing diagrams and gesture-based explanations improve spatial awareness and cognitive flexibility—both essential in decoding misleading or complex word problems.

However, despite these promising applications, the learning styles framework has been critiqued in educational psychology. Pashler et al. (2008) argued that there is little empirical evidence supporting the effectiveness of tailoring instruction to match individual learning styles, noting that much of the existing evidence is anecdotal or methodologically limited. More recent critiques echo that the "matching hypothesis" lacks robust validation, and rigidly adhering to learning styles may oversimplify the complexities of how students learn (Newton, 2015; Aslaksen & Lorås, 2019). These critiques suggest a need for caution: while learning-style-informed strategies may provide useful entry points for engagement, they should be integrated with evidence-based practices such as metacognitive training, explicit instruction, and collaborative problem-solving to more effectively enhance mathematical learning.

Cognitive and affective factors such as reasoning ability, self-confidence, and anxiety also influence students' problem-solving performance. Heuristic strategies and logical reasoning help students deconstruct complex tasks (Schoenfeld, 2021), while confidence and positive emotions improve persistence (Brown & Green, 2021). Effective instructional practices, including explicit teaching, collaborative learning, and think-aloud strategies, further support student success (Polya, 2020; McKnight & Hughes, 2020).

The Structural Equation Modeling (SEM) was employed to better understand these complex interactions. SEM is an advanced analytical method that integrates factor analysis and regression to examine theoretical models involving mediators and indirect effects (Schumacker & Lomax, 2021). In this study, it was used to analyze how learning styles mediate the relationship between students' beliefs in Mathematics and attitudes toward Mathematics, and their performance in solving word problems.

Specifically, it aimed to:

1. Assess the students' level of agreement regarding their beliefs in Mathematics and their attitudes toward Mathematics.
2. Determine the extent to which learning styles in Mathematics are manifested among students, with focus on visual, auditory, and kinesthetic dimensions.
3. Evaluate the level of students' performance in solving word problems in Mathematics in the Modern World.
4. Identify the learning styles that mediate the influence of students' beliefs in Mathematics and attitudes toward Mathematics on their performance in solving word problems.
5. Propose evidence-based instructional strategies aligned with students' learning styles to enhance their engagement and improve performance in solving word problems.

This study was based on several theoretical frameworks: Experiential Learning Theory by Kolb (1984); Constructivist Learning Theory developed by Dewey, Piaget, Vygotsky, Bruner, and Gagné; and Affective-Cognitive Consistency Theory (1956) by Rosenberg. These frameworks provided a strong foundation for examining the interconnected roles of beliefs, attitudes, learning styles, and academic performance in solving word problems.

2. Conceptual Framework

In this study, the conceptual framework is based on well-established educational and psychological theories that support the relationships among the core variables: beliefs in Mathematics, attitudes toward Mathematics, learning styles in Mathematics, and performance in solving word problems.

Learning styles in Mathematics, serving as the mediating variable, are supported by Kolb's Experiential Learning Theory (1984). This theory outlines a four-stage learning cycle, which includes concrete experience, reflective observation, abstract conceptualization, and active experimentation, as it corresponds to the visual, auditory, and kinesthetic learning styles. It provides a lens through which students' preferences and strategies in approaching and solving word problems can be better understood.

Beliefs in Mathematics, as one of the independent variables, are based on Constructivist Theory as articulated by Dewey, Piaget, Vygotsky, Bruner, and Gagne. This perspective sees learners as active constructors of knowledge rooted in prior experience. It highlights the importance of self-efficacy, perception of subject relevance, and students' internal frameworks in shaping their mathematical understanding.

Attitudes toward Mathematics as another independent variable are supported by Rosenberg's Affective-Cognitive Consistency Theory (1956). This theory claims that there is a logical alignment between individuals' beliefs and their emotional responses. Positive attitudes, when consistent with strong beliefs, can enhance engagement and persistence in problem-solving tasks, thereby influencing performance outcomes.

The dependent variable is the performance in solving word problems in Mathematics in the Modern World (MMW). This outcome is influenced directly by students' beliefs and attitudes, and indirectly through the mediating role of their learning styles, to come up with evidence-based instructional strategies.

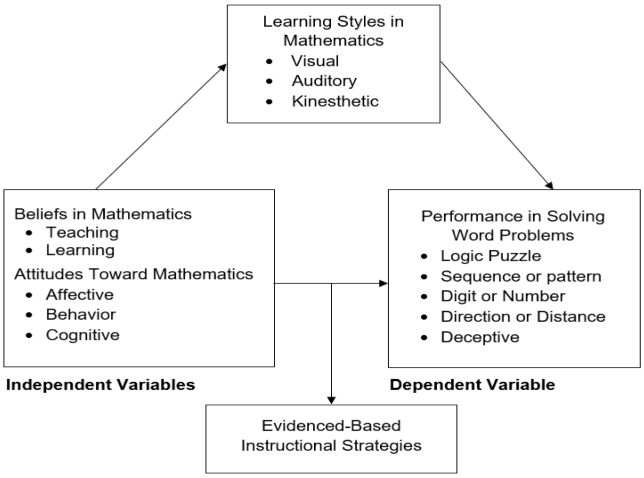

Fig. 1: Research paradigm

Figure 1. Research paradigm illustrating the relationships among beliefs in Mathematics and attitudes toward Mathematics (independent variables), learning styles in Mathematics (mediating variable), and performance in solving word problems (dependent variable). The framework is grounded in Constructivist Theory (Dewey, Piaget, Vygotsky, Bruner, & Gagne), Rosenberg's Affective-Cognitive Consistency Theory, and Kolb's Experiential Learning Theory, and analyzed using Structural Equation Modeling (SEM). This SEM is a powerful statistical approach that captures both direct and indirect effects, offering comprehensive insights to inform targeted, evidence-based instructional strategies in solving word problems.

3. Methodology

A descriptive-correlational design was utilized in describing and analyzing the relationships among students' beliefs in Mathematics, attitudes toward Mathematics, learning styles in Mathematics, and their performance in solving word problems. The design was appropriate for examining the direct and indirect effects among the variables, particularly the mediating role of learning styles.

To determine the population of the study, the researcher sought permission from the Heads for Registration Offices of the five (5) constituent campuses of Batangas State University, The National Engineering University (BatStateU, The NEU). An estimated sample size of 610 freshman students enrolled in the course during the first semester of academic year 2023–2024 was considered. Using the Raosoft online sample size calculator at a 99% confidence level and 5% margin of error, the required sample size was determined. A simple random sampling technique through a random name generator was used. Out of 610, only 599 were able and willing students who participated in the study.

Three researcher-developed instruments were used: (1) a 30-item questionnaire on learning styles in Mathematics (visual, auditory, kinesthetic) using a five-point Likert scale; (2) a 20-item beliefs in Mathematics questionnaire using a four-point Likert scale; and (3) a 40-item attitudes toward Mathematics questionnaire, also on a four-point Likert scale. All instruments underwent expert validation to ensure clarity, relevance, and content validity. Reliability was established through a pilot test with 100 students who had taken Mathematics in the Modern World in the First Semester of 2022–2023. Cronbach's alpha values indicated excellent internal consistency: 0.916 (learning styles), 0.963 (beliefs), and 0.916 (attitudes).

Students' performance in solving word problems was assessed using a researcher-developed multiple-choice test (logic, sequences, digit-based problems, directions, and deceptive problems) scored dichotomously (1 = correct, 0 = incorrect). The first pilot administration (February 14–28, 2024) via Google Forms with 100 students assessed clarity, flow, timing, and cognitive appropriateness. Item analysis determined difficulty, discrimination, and validity; weak items were revised or removed. A second trial (March 14–25, 2024) with another 100 students established reliability using KR-21, yielding 0.832, indicating good internal consistency. Revisions were incorporated into the final version.

The validated instruments and final word problem test were administered online via Google Forms from April 1–24, 2024, to freshman students enrolled in Mathematics in the Modern World. Ethical protocols were observed: participants were informed of the study's purpose, voluntary nature, and right to withdraw without consequence. Digital informed consent was obtained, and confidentiality and anonymity were ensured through non-collection of personally identifiable information and secure handling of data. Responses were analyzed in aggregate for academic purposes only.

4. Results And Discussion

The study employed Structural Equation Modeling (SEM) using SmartPLS and the Statistical Package for Social Sciences (SPSS) to analyze the data, which led to the following key findings. Nonetheless, certain limitations should be noted, such as potential biases from the self-reporting of learning styles and the inherent inability of a cross-sectional design to establish causality. Furthermore, the diversity of students' academic backgrounds (e.g., STEM vs. non-STEM majors) was not fully considered, which limits the extent to which the findings of this study can be generalized.

Assessment of the Freshman Students on Beliefs in Mathematics and on Attitudes toward Mathematics. The assessment of freshman students' beliefs and attitudes toward Mathematics, focusing on both teaching and learning dimensions as well as affective, behavioral, and cognitive domains, is presented in Table 1. Results indicate a general agreement across all categories, suggesting that students hold positive perceptions about Mathematics and recognize its value, though emotional responses reveal moderate enthusiasm and lingering apprehension

Table 1: Assessment on Beliefs in Mathematics and on Attitudes toward Mathematics

Beliefs in Mathematics	Composite Mean	Standard Deviation	Verbal Interpretation
Teaching	3.43	0.428	Agree
Learning	3.43	0.464	Agree
Attitudes toward Mathematics	**Composite Mean**	**Standard Deviation**	**Verbal Interpretation**
Affective	2.71	0.516	Agree
Behavior	3.25	0.359	Agree
Cognitive	3.08	0.419	Agree

The freshman students expressed their agreement with positive beliefs in Mathematics, as reflected by composite mean scores of 3.43 in both teaching and learning belief dimensions, with standard deviations of 0.428 and 0.464, respectively. These findings indicate a strong endorsement of structured guidance, critical thinking, and real-world application in Mathematics education. Such results are consistent with existing literature highlighting the role of teacher beliefs (Goos & Geiger, 2021), the impact of cultural context (Garii & Okumu, 2020), and the effectiveness of collaborative teaching approaches (Sun et al., 2023). In terms of learning beliefs, students demonstrated a growth-oriented mindset, emphasizing critical thinking and practical application. These perspectives align with the studies of Pongsakdi et al. (2019) and Yilmaz and Bas (2021), which emphasize the significance of strong mathematical beliefs and self-efficacy in enhancing problem-solving capabilities.

Regarding attitudes toward Mathematics, students showed mild to moderate agreement across three domains. The affective domain yielded a composite mean score of 2.71 (SD = 0.516), indicating mixed emotions, combining interest and enjoyment with residual discomfort or anxiety. This emotional ambivalence reflects the complex nature of students' affective experiences in Mathematics, as noted by Hannula (2020). The behavioral domain scored higher, with a composite mean of 3.25 (SD = 0.359), signifying a clear willingness to engage in learning and skill development, although with some hesitancy when faced with advanced tasks. These findings underscore the importance of fostering positive behavioral engagement to strengthen confidence and participation, as emphasized by Hwang and Son (2021). Meanwhile, the cognitive domain recorded a composite mean of 3.08 (SD = 0.419), indicating that students generally recognize the value and relevance of Mathematics. This aligns with findings by Ma and Lee (2021) and Hidayatullah and Csikos (2022), which link positive cognitive attitudes to persistence and success in mathematical problem-solving.

In general, freshman students exhibited positive beliefs and attitudes toward Mathematics, especially in recognizing its importance and engaging with learning tasks. However, the presence of emotional unease and confidence gaps suggests a need for targeted interventions and supportive strategies that promote emotional resilience and self-assurance in mathematical learning contexts.

Extent of Visual, Auditory, and Kinesthetic as Learning Styles in Mathematics. In Table 2, the extent to which freshman students adopt various learning styles in Mathematics, specifically visual, auditory, and kinesthetic, is shown. The results reveal a strong preference for the visual learning style, while auditory and kinesthetic styles are moderately utilized, indicating that students often engage with visual strategies but occasionally incorporate auditory and hands-on methods in their learning process.

Table 2: Extent of the Learning Styles in Mathematics

Learning Style	Composite Mean	Standard Deviation	Verbal Interpretation
Visual	3.70	0.509	Often
Auditory	3.44	0.418	Sometimes
Kinesthetic	3.49	0.503	Sometimes

In the three identified learning styles in Mathematics, the visual learning style emerged as the most preferred by freshman students, with a composite mean score of 3.70 and a standard deviation of 0.509. This indicates a strong inclination toward instructional strategies that incorporate diagrams, charts, written materials, and quiet study environments. The findings suggest that students perceive visual methods as effective tools for understanding and retaining mathematical concepts. These results are consistent with the findings of Johnson and McCabe (2021) and Adu and Duku (2021), who highlighted the positive impact of visual learning in enhancing student engagement and academic performance through targeted instructional techniques.

In comparison, the auditory learning style received a composite mean score of 3.44 with a standard deviation of 0.418, indicating a moderate preference. Students demonstrated occasional reliance on auditory strategies such as verbal explanations, repetition, and group discussions. While these methods were perceived as somewhat beneficial, they may not be sufficient on their own to fully support comprehension of mathematical concepts. These results are in line with the studies of Brown and Green (2021) and Azizah et al. (2021), who emphasized the importance of differentiated instruction that incorporates a blend of auditory techniques with other learning styles to address diverse learner needs and strengthen mathematical problem-solving skills.

Similarly, the kinesthetic learning style showed a moderate preference, with a composite mean score of 3.49 and a standard deviation of 0.503. This suggests that students appreciate hands-on activities and real-world applications that allow them to actively engage with and internalize abstract mathematical ideas. The findings support previous studies by Wu and Li (2021) and Kaur and Bhaskaran (2020), which demonstrated the effectiveness of kinesthetic strategies in promoting cognitive flexibility and deeper conceptual understanding. Although kinesthetic approaches encourage engagement, their moderate preference underscores the need for integration with visual and auditory techniques.

Overall, these findings highlight the importance of multimodal and personalized teaching approaches that incorporate visual, auditory, and kinesthetic strategies to create a more inclusive and effective Mathematics learning environment.

Freshman Students' Performance in Solving Word Problems. Table 3 presents the performance of freshman students in solving various types of word problems in Mathematics in the Modern World.

The overall performance of freshman students in solving word problems was assessed as fair, with an average score of 57.97%. However, performance varied across different types of problems. In deceptive word problems, students scored below the average of 62.67%, suggesting a developing capacity for critical thinking and analytical reasoning. While they showed some ability to identify and navigate misleading information, they encountered difficulties in employing advanced strategies and uncovering hidden complexities. These findings echo the observations of the National Research Council (2020), White and Mitchell (2020), and Mendoza and Bautista (2023), who emphasized the interplay of emotional regulation, collaboration, and analytical thinking in effective problem-solving, highlighting the need for instructional strategies that address both cognitive and affective domains.

Table 3: Performance in Solving Word Problems

Word Problems	Average Score (%)	95% Confidence Interval (Lower, Upper)	Verbal Description
Logic Puzzle	58.50	(58.46, 58.54)	Fair
Sequence or Pattern	57.50	(57.46, 57.54)	Fair
Digit or Number Related	55.67	(55.63, 55.71)	Fair
Direction or Distance	55.50	(55.46, 55.54)	Fair
Deceptive	62.67	(62.63, 62.71)	Below Average
Overall Average Score (%)	57.97	(57.93, 58.01)	Fair

In logic puzzle word problems, students achieved a fair score of 58.50%, reflecting partial proficiency in applying structured reasoning and systematic approaches. This result aligns with the recommendations of Polya (2020), McKnight and Hughes (2020), and Thompson and Wu (2021), who advocate for strategic frameworks and think-aloud protocols to enhance students' logical reasoning and adaptability. Similarly, performance in sequence or pattern-based problems was fair, with a fair score of 57.50%, indicating challenges in higher-order pattern recognition and inferential skills, as noted by Jensen and Blanchard (2022).

The performance in digit or number-related problems and direction or distance-related problems yielded fair scores of 55.67% and 55.50%, respectively. These scores suggest students had difficulty with numerical decomposition and spatial reasoning. Rodriguez and Kim (2023) and Ng and Lee (2020) emphasized the utility of visual learning tools and instructional aids in supporting comprehension in these domains. Furthermore, Mathematics anxiety may have influenced students' confidence and problem-solving strategies, as discussed by Villanueva and Cruz (2020).

The fair performance across various types of word problems highlights the need for targeted pedagogical interventions. Emphasizing collaborative learning, visual representation, and analytical thinking strategies could support the development of more effective problem-solving skills. These results underscore the importance of adopting diverse and student-centered instructional approaches to improve learners' proficiency in solving a wide range of mathematical word problems.

Mediation Analysis of the Learning Styles in Mathematics that Influence Beliefs and Attitudes to Performance in Solving Word Problems. In Figure 2, the hypothesized model result was presented. This model showed the effects of beliefs in Mathematics and attitudes toward Mathematics on performance in solving word problems as mediated by learning styles in Mathematics.

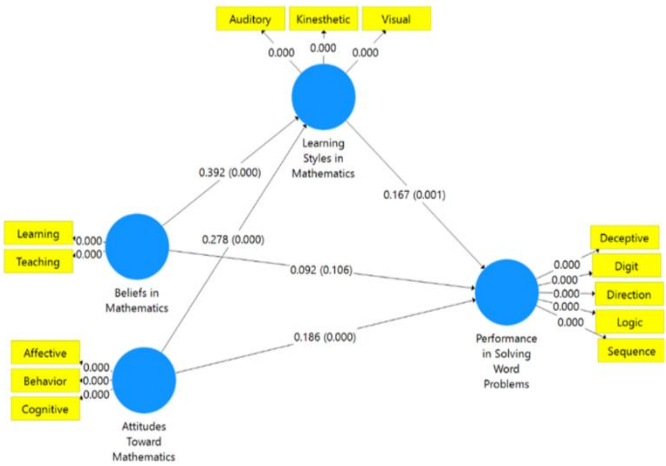

Fig. 2: Hypothesized Model Result

Notes: Values outside parentheses = Standardized Path Coefficient (β) or regression weights. Values inside parentheses = p-value (Significance Level)

The mediation results between the independent variables and the performance in solving word problems are summarized in Table 4. It indicated significant relationships between key variables and students' performance in solving word problems. In this analysis, Attitudes toward Mathematics (ATM) and Beliefs in Mathematics (BM) served as independent variables, with Learning Styles in Mathematics (LSM) serving as a mediating latent variable.

Table 4: Summary for the Mediation Results between the Influencing Factors and the Performance in Solving Word Problems

IV	Mediator	DV	Type	Coefficient	t-value	p-value	Effect Size (β)	VI
ATM	LSM	PSWPs	Partial	0.278	6.972	0.000	0.28 (medium)	S
BM	LSM	PSWPs	Partial	0.392	8.349	0.000	0.39 (medium-large)	S

Legend:
IV = Independent Variable
ATM = Attitude toward Mathematics
DV = Dependent Variable
BM = Beliefs in Mathematics
VI = Verbal Description
PSWPs = Performance in Solving Word Problems
S = Significant

Learning styles partially mediated the beliefs-performance ($\beta = 0.392$, $p < 0.001$) and attitudes-performance ($\beta = 0.278$, $p < 0.001$) relationships, accounting for 39% and 28% of variance, respectively. In addition, beliefs in Mathematics have a t-value = 8.349 and an effect size (β) of 0.39 (medium-large), while attitudes toward Mathematics have a t-value = 6.972972 and an effect size (β) of 0.28 (medium), indicating that both have a significant partial mediation effect. These results suggest that learning styles significantly mediate the influence of beliefs and attitudes on mathematical performance, particularly in solving word problems.

This mediation underscores the critical role of students' psychological profiles, as learning styles shape how beliefs and attitudes manifest in actual problem-solving behavior. These findings align with the work of Azizah et al. (2021), who concluded that learning styles significantly affect mathematical engagement, especially when instruction is adapted to students' preferred modalities. Likewise, Shulman and Williams (2020) emphasized that integrating diverse learning preferences into instructional planning fosters inclusivity and enhances student connection with mathematical content.

In essence, the results confirm that both attitudes and beliefs in Mathematics exert a meaningful indirect influence on performance via students' learning styles. This highlights the necessity of designing personalized instructional strategies that not only account for learners' cognitive styles but also aim to cultivate positive attitudes and beliefs toward Mathematics. Further investigation is encouraged to explore how these variables interact over time and to develop targeted interventions that enhance mathematical performance through psychological and pedagogical alignment.

Proposed Evidence-based Instructional Strategies for Students' Preferred Learning Styles in Solving Word Problems. Table 5 presents evidence-based instructional strategies tailored to support the solving of word problems in Mathematics in the Modern World, aligned with students' preferred learning styles and relevant teaching implications.

Table 5: Evidence-Based Instructional Strategies for Solving Word Problems

Learning Style	Instructional Strategy	Solution Support	Implications of Teaching
Visual	Use of self-constructed visualizations (e.g., drawing diagrams, number lines) and virtual manipulatives with graphic organizers	*Spatial Support*. It helps students visually organize relationships in direction and sequence problems, and uncover structure in deceptive formats	Teachers should encourage students to draw their own models and use digital visual tools to enhance pattern detection, spatial reasoning, and comprehension of complex word problems. Integration of visual aids should be standard in problem-solving instruction.
Auditory	Implement think-aloud protocols and structured peer discussions during problem-solving	*Reasoning Reinforcement*. It encourages verbal articulation of logical steps for logic, deceptive, and digit problems	Teachers should incorporate think-aloud strategies and collaborative discussion sessions to make mathematical reasoning explicit. These methods help auditory learners reflect on solution processes and clarify misunderstandings in problem structure.
Kinesthetic	Use embodied gestures, touch-tracing of diagrams, and movement-based number lines (e.g., body walking number lines)	*Inference Boost*. It engages body memory and spatial interaction to enhance solving of direction, digit, and deceptive problems.	Teachers should design Mathematics activities that integrate physical movement and gestures to connect abstract Mathematics with bodily experience. Tactile or movement-based tasks make problem features more tangible and support memory retention.

To effectively support students in solving various types of word problems (deceptive, digit-based, direction-oriented, logic, and sequence), instructional strategies should be aligned with their preferred learning styles: visual, auditory, and kinesthetic. Recent literature emphasizes the importance of differentiated, modality-based approaches to improve both engagement and achievement.

For visual learners, strategies such as self-constructed visualizations, number lines, and virtual manipulatives paired with graphic organizers significantly enhance comprehension. These tools enable students to organize problem elements, identify spatial relationships, and visually track patterns—especially crucial in sequence and direction word problems. Almuwaiziri et al. (2023) found that children who created their own visuals during problem-solving performed better than those who relied solely on provided diagrams, suggesting that self-generation fosters deeper understanding. Similarly, Billman et al. (2023) reported that the use of virtual manipulatives and graphic organizers notably improved students' independence and accuracy when solving proportion and multistep problems, which are often embedded in deceptive and digit tasks.

Auditory learners benefit from think-aloud protocols and structured peer discussions, which foster verbal processing and collaborative reasoning. These strategies are particularly effective for logic, digit, and deceptive problems, where clear articulation of steps, clarification of misunderstandings, and listening to others' approaches can illuminate the underlying structure of complex problems. Nasution et al. (2022) demonstrated that verbalizing thought processes during problem-solving helped learners better understand mathematical reasoning by making cognitive steps explicit. Such approaches also promote metacognition, enabling students to monitor and adapt their strategies.

For kinesthetic learners, incorporating embodied gestures, touch-tracing, and movement-based activities (such as walking number lines) enhances engagement and supports retention in problems involving direction, digit, and deceptive formats. These physical interactions with mathematical concepts create multisensory experiences that link abstract reasoning to concrete movement. Cosentino et al. (2023) showed that students who physically walked number lines developed greater fluency in integer operations, which are foundational in digit-based problems. Furthermore, embodied learning research from Multidisciplinary Digital Publishing Institute (MDPI, 2023) and ResearchGate (2023) highlights how touch-tracing diagrams and gesture-based explanations improve spatial awareness and cognitive flexibility—both essential in decoding misleading or complex word problems.

In terms of instructional implications, these findings underscore the importance of personalizing teaching approaches. Teachers should embed visual tools regularly in lessons, facilitate verbal reasoning activities, and design kinesthetic tasks that make abstract concepts tangible. By adopting these evidence-based strategies, educators can better support diverse learners in developing the confidence and skills necessary to solve different types of word problems effectively.

5. Conclusions and Recommendations

On the aforementioned findings, the researcher draws the following conclusions:

1. The freshman students expressed positive beliefs and attitudes toward Mathematics, which suggests strong agreement on the influencing factors and learning styles in Mathematics, and showed positive attitudes toward Mathematics.

2. The freshman students frequently used visual learning styles in Mathematics, sometimes used auditory learning styles, and to a moderate extent used kinesthetic learning styles.
3. The freshman students' performance in solving word problems was generally fair (57.97%) across most of the topics, such as logic puzzles, sequences or patterns, digit or number-related, and direction or distance-related, though their performance in deceptive problems is below average.
4. The mediation analysis revealed that attitudes toward Mathematics and beliefs in Mathematics significantly influenced performance in solving word problems, with learning styles in Mathematics acting as a significant partial mediator for both, enhancing their direct and indirect effects.
5. The evidence-based instructional strategies aligned with students' preferred learning styles (visual, auditory, and kinesthetic) demonstrated significant potential in enhancing students' engagement and performance in solving word problems involving deception, digits, direction, logic, and sequences.

Based on the foregoing findings and conclusions, the researcher puts forward the following recommendations for consideration:
1. Educational institutions should foster a positive mathematical environment through engaging teaching methods, real-life applications, and positive reinforcement; provide training programs that equip Mathematics teachers to understand and address freshman students' attitudes and learning styles; and implement support programs like mentoring, peer tutoring, and confidence-building workshops to develop students' positive attitudes and reduce Mathematics anxiety.
2. Educators should incorporate evidence-based visual, auditory, and kinesthetic instructional strategies tailored to students' preferred learning styles to cater to diverse learning preferences, enhance engagement, and improve the overall performance of freshman students in Mathematics in the Modern World, particularly in solving word problems involving deceptive digits, direction, logic, and sequences.
3. Reflective exercises and continuous constructive feedback should be integrated into the curriculum to help freshman students identify their strengths, monitor their progress, and reinforce positive attitudes toward learning.
4. Further studies are strongly encouraged to explore additional mediating factors like alternative learning styles, including reading/writing and multimodal approaches that may strengthen the relationship between students' attitudes toward Mathematics and their performance in solving word problems, enabling educator-researchers to design more targeted and inclusive strategies that support diverse learners in higher education.

Scientific Insight and Implications.

The students' "fair" performance level (57.97%) indicates that while learning styles provide some explanatory value, they are not sufficient to account for the complexity of students' mathematical achievement. This suggests that other cognitive and affective factors, such as metacognitive training, problem-solving strategies, and motivation, may play a significant role in improving performance outcomes. The data, therefore, underscores the need for instructional approaches that move beyond accommodating learning preferences to fostering deeper self-regulation, critical thinking, and reflective practices in Mathematics learning.

From a scientific perspective, this insight emphasizes the multidimensional nature of learning and performance, aligning with contemporary frameworks in educational psychology that integrate cognition, affect, and metacognition. It implies that interventions focusing solely on learning styles may not yield significant improvements unless they are complemented by strategies that strengthen students' awareness of their own thinking processes and capacity for adaptive learning. The moderate achievement level signals that more comprehensive educational models are necessary—ones that take into account the interplay of beliefs, attitudes, and metacognitive skills alongside instructional design.

Looking ahead, future research should consider longitudinal designs to examine how shifts in students' beliefs and attitudes toward Mathematics influence their performance across time. Such studies would provide valuable evidence on whether positive changes in mindset and emotional disposition lead to sustainable gains in problem-solving skills and overall achievement. Moreover, longitudinal data would allow educators and policymakers to design more targeted interventions, such as integrating growth mindset training, reflective practice exercises, or structured metacognitive instruction, thereby addressing the limitations highlighted by the current findings and ultimately fostering long-term academic success.

Future Research Directions.

This study should explore how scaling strategies, such as institution-wide faculty training programs, can be applied for future research to enhance the implementation of evidence-based teaching practices. Investigating the effectiveness of structured professional development initiatives aimed at equipping faculty with skills in differentiated instruction, metacognitive strategy training, and motivational scaffolding could provide valuable insights into how these interventions influence student learning outcomes. Large-scale studies across different campuses or academic units would also help determine the transferability and sustainability of such approaches.

Another promising direction lies in addressing the current research gap by examining hybrid models that combine learning styles with self-regulated learning frameworks. While learning styles may offer insights into students' preferences, incorporating self-regulated learning emphasizes students' ability to monitor, control, and adapt their learning strategies. Future studies should evaluate whether integrating these two perspectives produces synergistic effects, leading to improved problem-solving skills, deeper engagement, and higher achievement in Mathematics and related disciplines.

Finally, longitudinal and experimental designs should be employed to test the impact of these hybrid and scaled interventions over time. Tracking changes in student performance, attitudes, and metacognitive awareness across multiple semesters or academic years would provide stronger evidence of causality and long-term benefits. This line of inquiry would not only bridge theoretical gaps but also generate actionable recommendations for policy and practice, ultimately guiding institutions in creating more holistic and effective models of teaching and learning.

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