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Interaction Effect of Motivation and Learning Style Preferences on Grade 10 Students' Numeracy Skills in Mathematics

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Abstract
Aim: This study investigated how motivation and learning style preferences interact to influence Grade 10 students' numeracy skills in mathematics. It sought to clarify the relationship between motivational factors, learning styles, and numeracy proficiency, with the goal of informing student-centered and differentiated teaching strategies.
Methodology: This study employed a descriptive correlational design. Participants were Grade 10 students from three national high schools in President Quirino, Philippines, during the 2024–2025 academic year. Learning styles were identified using the VARK questionnaire, and motivation was assessed via an Expectancy-Value-Cost model-based survey. Numeracy skills were measured through a standardized test. Data collected in March 2025 were analyzed using descriptive statistics, Pearson correlation, and ANOVA to explore variable relationships and interaction effects, with significance set at 0.05.
Results: Based on the two-way factorial analysis, there is a statistically significant interaction between students' motivation levels (MS) and their learning style preferences (LSP) in relation to numeracy skills. The interaction term (MS*LSP) produced an F-value of 2.32 with a p-value of 0.044, which is below the 0.05 significance threshold. This finding confirms that the combined influence of motivation and learning style preference significantly affects students' numeracy performance.
Conclusion: There is a statistically significant interaction between motivation and learning style preferences on students' numeracy skills.
Keywords: Learning Style, Motivation, Numeracy Skills, VARK Model, Expectancy-Value-Cost Framework, Mathematics Education

INTRODUCTION

Students' learning styles profoundly influence how they best grasp mathematical concepts. While some students learn most effectively through visual aids, others benefit from auditory input, hands-on activities, or reading and writing. Alongside learning style, motivation plays a pivotal role in students' willingness to engage with mathematics and persist through challenges. Together, these factors are critical determinants of mathematical achievement.

Globally, mathematics education continues to face significant challenges. Many students struggle to develop essential numeracy skills such as problem-solving and critical thinking. The 2022 PISA results underscored widespread difficulties in applying mathematical concepts to real-world situations. In the Philippines, these challenges are particularly acute. Filipino students have consistently scored low in international assessments like TIMSS 2019, which revealed substantial gaps in numeracy skills. National Achievement Test results further confirm persistent difficulties, especially in problem-solving and critical thinking.

Locally, students at President Quirino National High School exhibit limited participation and difficulty understanding mathematical concepts despite teachers' efforts. This lack of engagement is reflected in a low average quarterly assessment score of 36.74% for the 2023–2024 school year (President Quirino National High School Data, 2024). Such outcomes are especially concerning given the abstract nature of mathematics and the importance of

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critical thinking for success. These challenges highlight the urgent need for more effective, student-centered teaching strategies.

This study draws on two primary theoretical frameworks to explore the relationship between learning styles, motivation, and numeracy skills. The first framework is the revised Expectancy-Value-Cost model. Barron and Hulleman (2015) updated the traditional Expectancy-Value model by explicitly incorporating "cost" as a key factor influencing motivation. Earlier models treated cost as a minor component, but recent research shows that perceived costs-such as effort, time, and emotional toll-significantly affect students' motivation to engage in tasks (OSU Motivation in Classrooms Lab, 2022). According to this model, a student's motivation depends on their expectancy of success, the value they place on the task, and the perceived costs involved. Understanding these dynamics is critical to addressing students' reluctance to engage with mathematics.

The VARK model, originally developed by Fleming and Baume, remains influential in contemporary research and educational technology (Abomelha & Newbury, 2024; VARK Learn Limited, 2023). Abomelha and Newbury (2024) advanced this framework by creating a VARK-based recommendation system for adaptive e-learning, illustrating how customizing educational content to students' preferred learning modalities significantly enhances engagement and personalizes the learning experience. The Peak Performance Center (2017) highlights VARK's widespread adoption, attributing its popularity to its straightforwardness and effectiveness in identifying learning preferences. Crucially, the model recognizes that learners often do not rely on a single dominant style; many are multimodal, exhibiting preferences across two (bimodal), three (trimodal), or all four (quad-modal) modalities. This adaptability enables educators to design instruction that accommodates a broad spectrum of learner needs, fostering inclusivity and improved educational outcomes (VARK Learn Limited, 2023).

Despite extensive research on learning styles and motivation, several gaps remain in understanding their combined impact on mathematics education. Most studies examine learning styles and motivation separately rather than their interactive effects on math performance. There is limited research on how different learning style preferences influence motivation specifically in mathematics. Few studies investigate how these factors affect various cognitive domains of numeracy skills, such as remembering, understanding, applying, analyzing, evaluating, and creating. Existing research predominantly focuses on primary or higher education levels, with a scarcity of studies at the secondary level in the Philippine context. Recent studies continue to apply Bloom's Taxonomy remains a widely used framework for structuring educational objectives, with recent studies demonstrating its effectiveness in mathematics education (Almulla, 2023; Khan & Ahmad, 2023; Lim & Lee, 2022).

Understanding how learning styles and motivation interact is essential for improving mathematical performance and developing critical numeracy skills. At President Quirino National High School and similar institutions, students' ongoing struggles with mathematics despite teacher efforts suggest the need for more effective, student-centered approaches. Educators increasingly recognize that accommodating diverse learning styles through varied instructional methods enhances engagement and comprehension (Amihan & Sanchez, 2023; Carvajal, et al., 2025; Dizon & Sanchez, 2020; Muńoz & Sanchez, 2023). For example, visual learners benefit from diagrams and charts, auditory learners thrive with discussions and verbal explanations, kinesthetic learners require hands-on activities and read/write learners excel through written materials and note-taking. Complementing these strategies with motivational techniques-such as real-life applications, gamified learning, collaborative problem-solving, and personalized support-can further boost student engagement and persistence.

By examining how learning styles and motivation influence student success in mathematics, this study aims to provide evidence-based insights to inform teaching strategies and interventions. Such knowledge can guide curriculum design and educational policy, ultimately improving numeracy skills among Grade 10 students. Mathematics education faces persistent challenges globally and locally, particularly in the Philippines. Students' learning styles and motivation are pivotal factors influencing their ability to understand and apply mathematical concepts. The revised Expectancy-Value-Cost model and the VARK learning styles framework offer valuable lenses to explore these factors.

Addressing the identified research gaps, especially the interactive effects of learning styles and motivation on mathematics achievement, is crucial. Tailoring instruction to diverse learning preferences and enhancing motivation through relevant, engaging strategies can significantly improve student outcomes. This study's findings are expected to contribute to more effective, student-centered mathematics education, fostering better engagement, comprehension, and critical thinking skills essential for academic success and lifelong numeracy.

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Objectives

The primary objective of this research was examine the interaction effect of learning motivation and style preferences on the numeracy skills of Grade 10 students in mathematics.

The research sought to answer the following research questions:

1. What is the learning style preference of the students in terms of:
   1.1 Visual;
   1.2 Aural;
   1.3 Read/write;
   1.4 Kinesthetic; and
   1.5 Multimodal?
2. What is the level of students' motivation in mathematics in terms of:
   2.1 Expectancy;
   2.2 Value; and
   2.3 Cost?
3. What is the proficiency level of Grade 10 students' numeracy skills in mathematics in terms of:
   3.1 Remembering;
   3.2 Understanding;
   3.3 Applying;
   3.4 Evaluating;
   3.5 Analyzing; and
   3.6 Creating?
4. Is there a significant difference in the level of students' motivation when classified according to learning style preferences?
5. Is there a significant relationship between students' motivation and their numeracy skills?
6. Does the interaction between students' motivation levels and their learning style preferences significantly affect their numeracy skills?

Hypothesis

Given the stated research problems, the following hypotheses were tested at 0.05 level of significance:

Ho_1: There is no significant relationship between students' learning style preferences and their numeracy skills.
Ha_1: There is a significant difference in the level of students' motivation when classified according to learning style preferences.
Ha_2: There is a significant relationship between students' motivation and their numeracy skills.
Ha_3: There is an interaction between students' motivation levels and their learning style preferences that significantly affect their numeracy skills.

METHODS

Research Design

A descriptive-correlational research design was employed to examine the relationships between learning style preferences, motivation, and numeracy skills.

Population and Sampling

The study population comprised 715 Grade 10 students from three public high schools in President Quirino. Stratified random sampling was used to select a sample of 251 students.

Instrument

Three instruments were used to collect data in this study. The VARK questionnaire, consisting of 16 items, assessed students' preferred learning styles across four modalities: Visual, Auditory, Read/Write, and Kinesthetic. The modified Expectancy-Value-Cost (EVC) motivation questionnaire included 10 items designed to measure students' motivational beliefs toward mathematics, capturing their expectations, perceived value, and perceived costs related to learning. Lastly, the standardized numeracy skills test comprised 40 items aligned with the first-quarter Grade 10 mathematics curriculum and structured according to Bloom's Taxonomy to evaluate students' numeracy proficiency.

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Content validity for all instruments was established through expert review by mathematics educators, ensuring that each tool accurately measured its intended construct. The EVC questionnaire was adapted from previously validated scales to maintain reliability and relevance within the local educational context.

Data Collection

Data were collected in March 2025 during regular school hours in designated classrooms at President Quirino National High School, Central Mangilala National High School, and Kalanawe II National High School. The researchers administered three paper-and-pencil instruments: the VARK questionnaire to identify learning styles, a modified Expectancy-Value-Cost survey to assess motivation, and a standardized numeracy skills test. School contact persons assisted in facilitating the sessions, and students were given ample time to complete all instruments in a quiet, controlled environment. The researchers reviewed the completed questionnaires for accuracy and completeness immediately after collection.

Treatment of Data

The gathered data, comprising responses from 251 Grade 10 students across three schools, were subjected to quantitative analysis. Descriptive statistics, including means, standard deviations, and frequency distributions, provided a profile of students' learning styles (visual, aural, read/write, kinesthetic, multimodal) and motivation levels (expectancy, value, cost). Numeracy skills were assessed across Bloom's Taxonomy (remembering to creating) using mean scores and percentages. To examine relationships, Pearson's r correlation coefficient determined the strength and direction of associations between learning styles and numeracy skills, and between motivation and numeracy skills. One-way ANOVA compared motivation levels across learning style groups. Multivariate linear regression analyzed the combined effects of learning styles and motivation on numeracy skills, including interaction effects. Findings were systematically presented in tables to enhance clarity and emphasize the significance of the results.

Ethical Considerations

Ethical approval was obtained from relevant authorities. Informed consent was obtained from participants, and data confidentiality was maintained.

RESULTS and DISCUSSION

This section presents descriptive and inferential statistics on learning styles, motivation, and numeracy skills, with results organized in tables and figures, each interpreted in relation to the research questions.

Learning Style Preference of the Grade 10 Students

The table below summarizes Grade 10 students' preferred learning styles, highlighting how they best understand and retain information.

Table 1. Learning Style Preference of the Grade 10 Students

Learning Style	***Frequency (F)***	***Percentage (%)***
Visual	*5*	*1.99%*
Aural	*56*	*22.31%*
Read/Write	*11*	*4.38%*
Kinesthetic	*30*	*11.95%*
Multimodal	*149*	*59.36%*
Total	***251***	***100%***

The results reveal that a significant majority of students, 59.36%, prefer multimodal learning, indicating that most learners benefit from a combination of different instructional methods rather than relying on a single style. This preference suggests that integrating various approaches-such as auditory, kinesthetic, and visual elements-can enhance understanding and retention for many students.

In contrast, visual learning is the least favored style, with only 1.99% of students indicating it as their primary preference. Out of 251 students, this equates to roughly four individuals who primarily learn best through visual means. This low percentage highlights that visual learning alone is not the dominant approach for most pupils

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in this group. Instead, many prefer other methods, such as listening or hands-on activities, underscoring the importance of diverse teaching strategies.

Level of Students' Motivation in Mathematics

This section examines students' motivation in mathematics by highlighting their confidence in success (expectancy), the importance they place on learning math (value), and the perceived effort or challenges involved (cost), all of which influence their engagement and performance.

Table 2. Level of Students' Motivation in Mathematics

Measures	***Mean***	***SD***	***Descriptive Rating***
Expectancy	*3.39*	*1.23*	*Moderate Level*
Value	*3.32*	*1.18*	*Moderate Level*
Cost	*4.66*	*0.51*	*Very High Level*
Overall Mean	***3.79***	***0.97***	***High Level***

Grade 10 students exhibit high math motivation (grand mean=3.79). Cost (mean=4.66) is the strongest motivational component, indicating high amount of time and effort students willingly allocate for their math abilities. Value and Expectancy have lower means 3.39 and 3.32 respectively, reflecting moderate perceived importance and confidence.

Cost outweighs value in predicting academic results. Boosting motivation involves emphasizing relevance, fostering supportive environments, and promoting a growth mindset. Self-efficacy is the strongest motivator, offering key insights into understanding and forecasting student performance.

Level of Numeracy Skills of Grade 10 Students in Mathematics

This section summarizes grade 10 students' numeracy skills across six areas: Remembering, Understanding, Applying, Evaluating, Analyzing, and Creating.

Table 3. Level of Numeracy Skills of Grade 10 Students in Mathematics

Skill	Mean	SD	Percentage (%)	Level
Remembering	8.06	1.51	80.60%	Proficient
Understanding	7.65	1.29	76.49%	Developing
Applying	6.06	1.12	75.75%	Developing
Evaluating	3.76	0.50	75.22%	Developing
Analyzing	2.25	1.08	56.27%	Beginning
Creating	1.08	0.50	36.12%	Beginning

Table 3 presents the numeracy skills of Grade 10 students across different Bloom's cognitive domains. Among the categories, Remembering has the highest weighted mean of 8.06 (80.60%) for ten-item tests, classified as Proficient. This indicates that students can recall and recognize mathematical concepts effectively.

In contrast, creating records the lowest performance, with a weighted mean of 1.08 (36.12%) for three-item tests, categorized as Beginning. This suggests that students struggle with generating original mathematical ideas and applying creative problem-solving strategies. To improve numeracy skills, educators must consider both learning styles and motivation when designing instruction.

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One-Way Analysis of Variance (ANOVA) on the Difference in the Level of Students' Motivation when Classified According to Learning Style Preferences

This section details the findings from a one-way ANOVA test conducted to examine whether students' motivation levels vary significantly according to their preferred learning styles. The analysis compares mean motivation scores across different learning style groups to identify any statistically meaningful differences, helping to understand how learning preferences impact motivation.

Table 4. Difference in the Level of Students' Motivation when Classified According to Learning Style Preferences

Source	Sum of Squares	Df	Mean Square	F-computed Value	p-value
Between Groups	6.513	4	1.628	35.151	<.001*
Within Groups	11.395	246	.046		

The analysis of variance (ANOVA) conducted to examine differences in student motivation across learning style preferences revealed a statistically significant effect ($F = 35.151$, $p < .001$), indicating that motivation levels vary depending on learning style.

This result led to the rejection of the null hypothesis, confirming that motivation is not uniform across different learning style groups. Post hoc analysis further clarified these differences: motivation levels among Aural, Kinesthetic, Read/Write, and Visual learners were statistically similar, with no significant differences observed ($p > .05$).

However, students with a Multimodal learning preference demonstrated significantly higher motivation compared to all other groups ($p < .001$ for each comparison). These positive and significant mean differences suggest that the Multimodal approach is more effective in enhancing student motivation. The findings underscore the importance of recognizing learning style preferences in educational settings and support the adoption of multimodal instructional strategies to better engage and motivate diverse learners.

One-Way Analysis of Variance (ANOVA) on the Relationship between the Motivation and the Numeracy Skills of the Students

This section shows ANOVA results assessing the relationship between student motivation and numeracy skills, revealing no significant differences across multiple groups with numerous observations, indicating variations likely due to chance.

Table 5. Relationship between Students' Motivation and their Numeracy Skills

Source	Sum of Squares	Df	Mean Square	F-computed Value	p-value
Between Groups	364.07	15	24.27	3.10	<.001*
Within Groups	1841.32	235	7.84		

The result reveals the relationship between student motivation and numeracy skills. The significant ANOVA result indicates a statistically significant relationship between the levels of motivation and numeracy performance. The observed differences in mean numeracy scores across the motivation groups are unlikely due to chance.

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This suggests that different levels or types of motivation are associated with differing levels of numeracy achievement. Further analysis, such as post-hoc tests, is needed to pinpoint which specific motivation levels or types significantly impact numeracy skills.

Two-Way Factorial Analysis on the Interaction Effect between Motivation and Learning Style Preferences on Students' Numeracy Skills

This part resents a two-way factorial ANOVA examining the interaction effect of motivation (MS) and learning style preference (LSP) on students' numeracy skills.

Table 6. Interaction Effect between Motivation and Learning Style Preferences on Students' Numeracy Skills

Source	Sum of Squares	Df	Mean Square	F-computed Value	p-value
Motivation (MS)	40.67	2	20.34	2.60	.076
Learning Style Preference (LSP)	38.52	4	9.63	1.23	.299
MS * LSP	90.70	5	18.14	2.32	*.044
Error	1870.31	239	7.83		

The table reveals a statistically significant interaction between students' motivation levels (MS) and learning style preferences (LSP) in influencing numeracy skills. While the individual effects of motivation and learning styles were not significant alone, their combined effect was significant ($F = 2.318$, $p = .044$), indicating motivation's impact on numeracy varies by learning style. The small effect size (partial eta squared = .046) suggests a modest portion of variance explained. This highlights the importance of considering both factors together, as certain motivation and learning style combinations can enhance or hinder numeracy outcomes.

Supporting research by Aventijado et al. (2020) emphasizes that recognizing and accommodating learning styles improves engagement and outcomes. Sumarigayani et al. (2022) further highlight that adapting lessons to diverse learning styles-visual, kinesthetic, auditory-using videos, hands-on activities, and discussions boosts comprehension and engagement. Their findings support multimodal teaching approaches, noting nursing students favor visual/kinesthetic styles while medical students benefit from multimodal strategies. They caution that non-tailored instruction risks disengagement, underscoring the need for diverse resources to enhance critical thinking and accessibility.

Focus group discussions with teachers reinforced these findings, reporting better numeracy outcomes when instruction aligned with both students' motivation and learning preferences. Highly motivated students excelled when teaching methods matched their preferred learning modes, underscoring the value of personalized, multimodal instruction.

Conclusions

The study highlights a significant interaction effect between motivation and learning style preferences on students' numeracy skills. Students who engaged with multimodal learning approaches demonstrated higher motivation levels, which in turn positively influenced their mathematical performance. This interaction suggests that motivation alone is insufficient; its impact on numeracy is enhanced when aligned with diverse learning styles. The combined influence of motivation and learning preferences creates a synergistic effect, improving both retention and the ability to generate original mathematical ideas. Consequently, tailored instruction that integrates multiple learning modalities while fostering motivation is essential to optimize numeracy outcomes and sustain student engagement.

Recommendations

Mathematics teachers are encouraged to design lessons that incorporate a variety of learning modes-such as visuals, discussions, hands-on activities, and written materials-to engage diverse student preferences, enhance understanding, and improve participation.

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To reduce perceived barriers to learning mathematics, departments should provide additional support resources, clarify expectations, and foster a positive and encouraging environment that lowers students' perceived effort and stress, thereby promoting persistence. Emphasizing higher-order thinking through problem-solving, project-based, and collaborative tasks can deepen students' mathematical comprehension by moving beyond rote learning. Differentiated instruction tailored to diverse learning styles can further boost motivation and academic performance by addressing individual needs.

Subject coordinators should facilitate collaborative reviews among teachers to evaluate and unify instructional practices, promoting consistency and shared best practices.

Guidance counselors, in collaboration with math teachers, should gather holistic data on student attitudes and habits to identify barriers and inform targeted interventions.

Additionally, supervisors should provide training on flexible, evidence-based teaching methods to support diverse learners effectively.

Finally, future research should explore other factors such as self-efficacy and classroom environment to better understand influences on numeracy skills beyond motivation and learning style preferences.

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