International Journal of Evaluation and Research in Education (IJERE)
Vol. 15, No. 2, April 2026, pp. 1037~1050
ISSN: 2252-8822, DOI: 10.11591/ijere.v15i2.37651

Beyond numbers: a path analysis on how educational ecosystem and math interest spark excellence

Charmaigne A. Eslabra[1], Roberto G. Sagge Jr.[1], Dolly Rose F. Temelo[2], Danilo M. Parreño[1], Tedric Dave E. Senosa[1], Peter Ernie D. Paris[1], Garry C. Cachuela[3], Sybel Joy F. Labis[1], Salvador P. Bacio Jr.[1]
[1]College of Education, West Visayas State University, Iloilo City, Philippines
[2]College of Arts and Sciences, West Visayas State University, Iloilo City, Philippines
[3]College of Education, West Visayas State University-Lambunao Campus, Lambunao, Philippines

Article Info

Article history:

Received Nov 11, 2025
Revised Jan 1, 2026
Accepted Feb 23, 2026

Keywords:

Mathematics achievement
Mathematics interest
Parental involvement
Peer influence
School support

ABSTRACT

Mathematics achievement reflects a web of social, environmental, and motivational forces. This study examined how parental involvement, peer influence, and school support relate to mathematics interest and academic performance among Philippine Science High School (PSHS)–Western Visayas Campus scholars. Using a quantitative descriptive–correlational design, 251 students were selected through proportionate stratified random sampling. Data were collected through Google Forms using the 30-item mathematics interest inventory (MII) (4-point Likert; expert-validated; α=0.899), the 45-item educational ecosystem inventory (EEI) measuring family, peer, and school support (4-point Likert; expert-validated; α=0.910), and official mathematics grades as the achievement indicator. Descriptive statistics and correlation analyses were computed as prerequisites, then relationships were tested through path analysis in a structural equation modeling (SEM) framework, including estimation of direct, indirect, and mediated effects. Results indicated that parental involvement, peer influence, and school support significantly strengthened mathematics interest and were associated with higher mathematics achievement, with the final SEM demonstrating satisfactory model fit. Mathematics interest emerged as a significant mediator, particularly in the link between school support and performance, underscoring interest as a motivational conduit between context and outcomes. Recommendations include strengthening home–school partnerships, institutionalizing peer mentoring, and expanding interest-based pedagogies and opportunities, with continued program evaluation to sustain high performance in science, technology, engineering, and mathematics (STEM)-focused schools.

Corresponding Author:

Roberto G. Sagge Jr.
College of Education, West Visayas State University
Iloilo City, Philippines
Email: robertosagge@wvsu.edu.ph

1. INTRODUCTION

Mathematical proficiency underpins the development of higher-order cognitive competencies, including analytical thinking, logical reasoning, and quantitative literacy, all of which are indispensable for innovation and achievement in science, technology, engineering, and mathematics (STEM) disciplines [1]. Acknowledging its strategic importance to national development, the Department of Education's MATATAG curriculum positions STEM education as a key driver of economic competitiveness and sustainable growth [2].

Consistent with this national agenda, the Philippine Science High School (PSHS) system accords mathematics a central role in its curriculum, with the explicit aim of preparing scholars to meet the intellectual demands of an increasingly complex and technologically driven global landscape [3], [4]. This commitment is operationalized through intensive instructional exposure, such as the delivery of Mathematics-1 five times a week, reflecting PSHS's mandate to cultivate advanced scientific literacy and analytical rigor among its students.

Despite the extensive literature on mathematics achievement, prior studies have often examined parental involvement, peer influence, school support, and learner-related factors in isolation, or have treated these influences as broadly additive without testing how they operate together within an integrated explanatory model. Moreover, much of the available evidence is drawn from non-residential or general school settings, where students' daily home contact, routines, and support structures differ substantially from those in STEM boarding schools. As a result, there remains limited empirical clarity on how these socio-ecological factors jointly shape mathematics outcomes in residential STEM environments, and whether their effects are transmitted through affective mechanisms such as mathematics interest.

However, despite this sustained institutional emphasis, persistent challenges in student engagement and mathematics achievement remain evident. This issue is not confined to the Philippine Science High School–Western Visayas Campus (PSHS–WVC) but mirrors broader national trends. International large-scale assessments, most notably the Programme for International Student Assessment (PISA), consistently indicate that Filipino learners perform among the lowest globally in mathematics, with a substantial proportion failing to attain basic proficiency in problem-solving and logical reasoning [5].

Alarmingly, similar patterns emerge even within PSHS, an academically selective system, where internal readiness assessments frequently report mean mathematics scores ranging from 50% to 55% [6]. These findings suggest that underperformance cannot be sufficiently explained by curricular rigor, instructional time, or student selectivity alone, thereby directing attention toward non-cognitive and contextual determinants of learning. The contemporary educational landscape further exacerbates these challenges. The heightened academic demands characteristic of 21st-century schooling expose students to increased cognitive load, compressed schedules, and sustained performance pressure, which are associated with elevated levels of stress, anxiety, sleep disruption, and declining academic focus [7]. Such conditions have been shown to undermine engagement and achievement, particularly in cognitively demanding subjects such as mathematics, while simultaneously widening socioeconomic and achievement disparities [8].

Within this context, the residential school model of PSHS–WVC presents a distinctive environment in which these pressures are intensified. While the model enhances peer interaction and institutional immersion, it also constrains direct parental involvement, rendering students more dependent on peer networks and school-based support systems. Consequently, mathematics performance in this setting emerges from the complex interaction of internal psychological processes and external socio-environmental influences, with the residential context amplifying their reciprocal effects [9]–[11]. Yet, empirical work that explicitly models these intertwined influences within STEM boarding schools remains limited, particularly in terms of testing integrated direct-and-indirect pathways rather than reporting broad associations.

Against this backdrop, the present study examines the influence of socio-ecological and affective factors on the mathematics performance of scholars at the PSHS–WVC. Specifically, it investigates how parental involvement, peer influence, school support, and grade level shape students' interest in mathematics and, in turn, their academic outcomes. Existing empirical evidence suggests that environmental supports exert both direct and indirect effects on achievement, frequently operating through affective pathways such as interest, motivation, and self-belief [12], [13]. Supportive learning environments foster confidence and engagement, while sustained interest in mathematics promotes persistence, resilience, and adaptive coping in the face of academic difficulty [14]–[16]. From this perspective, mathematics achievement is best conceptualized as a dynamic outcome of interacting environmental, emotional, and motivational processes rather than as a product of instructional exposure alone [17].

To theoretically anchor these relationships, the study integrates social cognitive theory and Bronfenbrenner's ecological systems theory into a unified conceptual framework. Social cognitive theory posits that academic achievement results from reciprocal interactions among personal beliefs, behavioral engagement, and environmental conditions, with self-efficacy functioning as a central determinant of learning outcomes [18]. Within this framework, mathematics interest operates as a critical mediating construct that links internal dispositions to observable academic behaviors, as students with stronger confidence and positive affect toward mathematics are more likely to engage deeply, persist through difficulty, and achieve higher levels of performance [19]. Complementing this perspective, Bronfenbrenner's ecological systems theory situates learning within nested and interconnected systems of influence, ranging from immediate interactions with peers, teachers, and dormitory life (microsystem) to the relational linkages among these contexts (mesosystem), such as home–school communication and peer–teacher collaboration

[20], [21]. In the residential setting of PSHS–WVC, these systems converge with heightened intensity, creating a learning ecology in which peer norms, collaborative practices, and institutional support structures play a particularly salient role.

Building on this integrated theoretical lens, the study proposes that mathematics interest mediates the relationship between environmental supports parental involvement, peer influence, and school support—parental involvement, peer influence, and school support—and academic performance, while contextual factors such as curricular intensity and scholar tier level moderate these pathways. This model recognizes that identical support mechanisms may yield differential effects depending on students' academic load, stress exposure, and coping capacity [22], [23]. By elucidating both the mechanisms and conditions under which socio-ecological and affective factors interact, the study seeks to advance a more nuanced understanding of mathematics achievement within specialized, high-demand educational contexts and to inform the development of targeted, context-sensitive interventions that extend beyond purely pedagogical reform.

The novelty of this study lies in its holistic and integrative approach to understanding mathematics performance within a residential STEM environment such as PSHS–WVC. Unlike earlier research that concentrated on cognitive or instructional determinants, this study bridges psychological and ecological perspectives, emphasizing how mathematics interest mediates the effects of environmental influences in a setting where students live, study, and socialize primarily on campus. By foregrounding the interdependence of mathematics interest, peer and school supports, and the intensified microsystem and mesosystem dynamics of a residential school, the study offers a comprehensive framework for explaining why some students thrive under pressure while others struggle. Ultimately, the findings are expected to inform the development of student-centered, evidence-based strategies that promote both academic success and psychological wellness. Through this synthesis, the research contributes to a deeper understanding of mathematics learning as both a cognitive and emotional process, shaped by the dynamic interaction between the individual and their learning ecology, an insight crucial for sustaining excellence and well-being in high-performing educational institutions like PSHS–WVC.

This study sought to determine how parental involvement, peer influence, school support, and mathematics interest collectively and individually affected the mathematics performance of scholars at the PSHS–WVC. It aimed to provide deeper insights into the ways social and motivational factors interact to shape students' academic achievement. In pursuit of this objective, the study was guided by the following research questions:

- What are the prevailing levels of parental involvement, peer influence, school support, mathematics interest, and mathematics achievement among the scholars of the PSHS?
- Which structural model most accurately represents the relationships among parental involvement, peer influence, and school support and students' mathematics achievement, specifically distinguishing: i) their direct effects on mathematics achievement and ii) their indirect effects on mathematics achievement through mathematics interest as a mediating variable?

2. METHOD

2.1. Research design

This study sought to assess the levels of parental involvement, peer influence, school support, mathematics interest, and mathematics achievement among scholars of the PSHS–WVC. It further aimed to determine the most appropriate structural model that represents the patterns of association among these variables, including both direct and indirect relationships, in relation to students' mathematics performance. To address these objectives, the study employed structural equation modeling (SEM) with path analysis as the primary analytical technique. Path analysis is a robust statistical approach for examining complex relational structures by estimating the magnitude and direction of associations among variables, including indirect pathways through mediating constructs. Procedure ensured that scholars from each tier level and gender group were adequately represented, thereby strengthening the generalizability and methodological rigor of the study.

2.2. Respondents

The respondents were 251 randomly selected PSHS–WVC scholars in Metropolis Avenue, Iloilo City, chosen through proportionate stratified random sampling to ensure representation across strata. The minimum required sample size was first computed using G*Power for multiple linear regression with five predictors, assuming medium effect size (f^2=0.15), α=0.05, and power=0.95, which yields N=138 as the minimum (i.e., the smallest N that meets the specified power and error rates) [24]. Because the analysis also involves path analysis/SEM, adequacy was further checked against SEM-focused power and lower-bound guidance, where sample needs depend on model complexity, desired power, and effect sizes; notably, power-based and model-structure lower-bound approaches support using samples well above minimal regression counts when estimating covariance-structure models [25], [26]. Moreover, simulation evidence shows that

SEM solutions become more stable (power, bias, and proper solutions) as N increases and that many common SEMs often benefit from samples around/above 200, depending on conditions [27]. Therefore, the achieved N=251 is adequate because it exceeds the G*Power minimum (138) and aligns with SEM guidance favoring larger samples for stable parameter estimation and model testing.

2.3. Data gathering instrument

To systematically capture the quantitative data required for this study, three primary data sources were utilized: two standardized Likert-scale questionnaires and one set of official academic records. These instruments were selected to ensure comprehensive measurement of the core variables such as mathematics interest, educational ecosystem factors, and mathematics achievement and were subjected to expert validation and reliability testing to guarantee methodological rigor.

2.3.1. Mathematics interest inventory

The mathematics interest inventory (MII) was used to assess the level of interest in mathematics among PSHS scholars. The instrument was anchored in the four-phase model of interest development proposed by Michaelis and Weintrop [28], emphasizing the advanced stages in which curiosity becomes self-regulated and transforms into a stable personal interest that drives deeper learning. The MII consisted of 30 statements such as 15 positively worded and 15 negatively worded adapted from the tool developed by Sangkula [29]. Responses were recorded on a 4-point Likert scale: 1 (strongly disagree), 2 (disagree), 3 (agree), and 4 (strongly agree). Negatively phrased items were reverse-coded to maintain consistency in interpretation. To establish the instrument's content validity, it was evaluated by three experts in mathematics education, and appropriate revisions were made in accordance with their feedback.

2.3.2. Educational ecosystem inventory

The educational ecosystem inventory (EEI) was administered to measure the level of educational support perceived by the scholars. Adapted from the work of Zhuang and Liu [30], the EEI comprised 45 items organized into three core dimensions: family support, peer influence, and school support. Each dimension contained 15 statements, of which 8 were positively phrased and 7 were negatively phrased. Similar to the MII, responses were rated on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree), with reverse scoring applied to negatively worded items to ensure interpretive accuracy. The EEI underwent expert validation by three registered guidance counselors, all of whom hold doctoral degrees in philosophy, to ensure clarity, content relevance, and construct validity.

To establish the reliability of both instruments, a pilot test was conducted using one randomly selected section from each grade level through simple random sampling. The pilot test yielded Cronbach's alpha values of 0.899 and 0.910 for the MII and EEI, respectively. The questionnaires were distributed electronically through Google Forms, and the results were statistically analyzed to confirm their internal consistency.

2.3.3. Official academic records

It served as the basis for measuring mathematics achievement, which was derived from the scholars' actual mathematics grades obtained from institutional records. These data complemented the self-report measures and provided an objective indicator of students' academic performance. The integration of these instruments, as summarized in Table 1, allowed the study to triangulate self-reported affective and contextual data with actual academic outcomes. This alignment ensured that the analysis captured not only students' interest and perceived support systems but also how these factors translated into measurable achievement in mathematics. By clearly defining the variables, response scales, and levels of measurement, the study established a solid quantitative foundation for subsequent statistical analyses and interpretation of results.

Table 1. Instruments, variables, and level of measurement

Instruments	Variables with indicators		Responses/Likert scale	Level of measurement
MII	Mathematical interest		3.26–4.00 "very high," 2.51–3.25 "high," 1.76–2.50 "low," and 1.00–1.75 "very low"	Interval
EEI	Educational ecosystem	Peer influence Parental involvement School support	3.26–4.00 "very high," 2.51–3.25 "high," 1.76–2.50 "low," and 1.00–1.75 "very low"	Interval Interval Interval
Official academic data	Mathematics achievement		1.00–1.12 "excellent," 1.13–1.62 "very good," 1.63–2.12 "good," 2.13–2.62 "satisfactory," 2.63–3.50 "fair," and 3.51–4.50 "failed on condition"	Ratio

2.4. Procedure and intervention

The study was conducted in three systematic stages such as the preliminary phase, data collection, and data analysis to ensure methodological rigor, ethical compliance, and the validity of findings.

2.4.1. Preliminary phase

Prior to data collection, the researcher completed the required ethical review process under the PSHS system and obtained formal approval from both the institutional research and ethics committees. Authorization to conduct the study was likewise secured from the school administration, including the campus director, the curriculum and instruction division chief, and the mathematics unit head. Following approval, the research instruments underwent a comprehensive validation process to ensure their accuracy, clarity, and appropriateness for the study's objectives. The MII and the EEI were evaluated by a panel of experts in education and psychology. Their feedback guided the refinement and revision of the instruments to strengthen their content validity and alignment with the study constructs. A pilot test was then conducted among a small group of students who were not part of the main sample to assess the instruments' reliability and internal consistency. Once validation was confirmed, the researcher distributed an information sheet to participants detailing the study's purpose, procedures, and ethical considerations. Informed consent forms were also provided, emphasizing voluntary participation, confidentiality, and the right to withdraw at any stage without academic repercussions. The final data collection schedule and venue were communicated via email using blind carbon copy (BCC) for privacy, complemented by in-person reminders.

2.4.2. Data collection phase

The data collection was carried out at the new auditorium of the PSHS–WVC. Before administration, the researcher discussed the study's objectives, importance, and data protection measures, reiterating that participation was voluntary and that all responses would remain anonymous and confidential, in accordance with institutional ethical standards. Each participant was assigned a unique quick response (QR) code that linked directly to two online questionnaires: the MII and the EEI. By scanning the code, participants accessed the survey forms through Google Forms and submitted their responses electronically. The data were automatically compiled in Google Sheets, where the researcher reviewed entries for missing or inconsistent responses. Incomplete submissions were either clarified or excluded to maintain data integrity. After verifying the responses, the researcher obtained authorization from the school registrar to access the participants' mathematics grades for the first and second quarters of school year 2023–2024. To protect confidentiality, each respondent was assigned a randomly generated identification code with no personal identifiers. All names, sections, and email addresses were removed from the dataset, and both digital and printed copies of the data were securely stored in compliance with ethical research protocols.

2.4.3. Data analysis phase

The analysis of data involved the application of both descriptive and inferential statistical methods. Descriptive statistics, specifically the mean and standard deviation, were used to determine the levels of mathematics interest, mathematics achievement, and the degree of support provided by the students' educational ecosystem including parental involvement, peer influence, and school support. For inferential analysis, path analysis using SPSS AMOS was employed to investigate both the direct and indirect effects among the study variables. The overall model fit was evaluated using multiple indices: chi-square (χ^2), root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), Tucker–Lewis index (TLI), and normed fit index (NFI). Acceptable fit thresholds were established as: $p>0.05$ for the χ^2 test, RMSEA$\leq$0.08, and values of $\geq$0.90 for GFI, AGFI, CFI, TLI, and NFI. Model parsimony was further assessed using the relative chi-square to degrees of freedom ratio (χ^2/df). This systematic process ensured that data collection and analysis were conducted with precision, confidentiality, and adherence to ethical research standards, allowing the study to produce credible and reliable findings on the factors influencing students' mathematics performance.

3. RESULTS AND DISCUSSION

3.1. Levels of parental involvement, peer influence, school support, mathematics interest, and mathematics achievement

Table 2 summarizes the levels of parental involvement, peer influence, school support, mathematics interest, and mathematics achievement among the 251 respondents. The results provide a comprehensive view of the educational ecosystem that shapes students' engagement and performance in mathematics. In terms of mathematics interest, students exhibited a high level (M=2.83, SD=0.45). This suggests that they generally demonstrate enthusiasm and curiosity toward learning mathematics. High interest indicates that learners find value and enjoyment in exploring mathematical concepts, which often translates to sustained effort and perseverance in problem-solving tasks. Such interest is essential for maintaining focus and resilience when faced with challenging topics [31].

Within the educational ecosystem, the three dimensions such peer influence, parental involvement, and school support were all rated as high, reflecting a supportive social and learning environment for students. Specifically, peer influence obtained a mean score of M=2.99, SD=0.35, indicating that students perceive their classmates and friends as positive contributors to their learning process. A strong peer network often fosters collaboration, shared motivation, and constructive competition, all of which can reinforce confidence and engagement in mathematics [32]. Similarly, parental involvement registered a high level (M=2.99, SD=0.40). This finding implies that parents maintain active participation in their children's academic development, whether through encouragement, guidance, or monitoring of progress. Consistent parental support provides emotional assurance and academic direction, strengthening students' drive to perform well [33]. Meanwhile, school support showed the highest mean among the ecosystem variables (M=3.15, SD=0.37), signifying that institutional structures such as teacher guidance, instructional resources, and academic assistance play a vital role in sustaining students' motivation and confidence. A strong support system from the school promotes both academic competence and emotional stability, allowing students to thrive within a structured learning environment [34].

Regarding mathematics achievement, as measured by official academic data, students attained a good level of performance (M=1.82, SD=0.54). This reflects a generally adequate grasp of mathematical concepts and skills, though opportunities remain for further enhancement in higher-order reasoning and problem-solving. The high levels of interest, motivation, and educational support observed among the participants may have contributed to this favorable performance outcome [35], [36].

Overall, these findings reveal that students benefit from a well-rounded educational environment characterized by supportive peers, engaged parents, and responsive schools. Their strong mathematics interest and positive ecosystem interactions appear to nurture their achievement in the subject. Nonetheless, the good level of performance underscores the need for continuous academic enrichment strategies, particularly those that deepen conceptual understanding and foster analytical thinking.

Table 2. Parental involvement, peer influence, school support, mathematics interest, and mathematics achievement

Variables with indicators		N	SD	M	Interpretation
Mathematics interest		251	0.45	2.83	High
Educational ecosystem	Peer influence	251	0.35	2.99	High
	Parental involvement	251	0.40	2.99	High
	School support	251	0.37	3.15	High
Official academic data					
Mathematics achievement		251	0.54	1.82	Good

Note: the scale interpretations are detailed in Table 1

3.2. Path analysis model

Table 3 presents the statistical indices used to evaluate the goodness-of-fit of the hypothesized structural model, which delineates the direct and indirect relationships among parental involvement, peer influence, school support, and mathematics interest in predicting students' mathematics achievement. The results demonstrate that the model achieved an excellent fit with the observed data, as indicated by the absolute, incremental, and parsimonious fit measures. According to Goretzko *et al.* [37], the assessment of model fit should involve multiple indices rather than relying on a single measure to provide a more comprehensive evaluation of how accurately a theoretical model reflects the empirical data. In alignment with this recommendation, the present study employed several absolute fit indices including the χ^2, RMSEA, and GFI all of which met the established criteria for adequacy. The non-significant χ^2 value (p=0.292) indicates a minimal discrepancy between the observed and expected covariance matrices, confirming the model's stability and appropriateness [38]. Furthermore, the RMSEA value of 0.029, well below the 0.08 threshold [39], signifies an exceptionally close fit between the proposed model and the actual data. Likewise, the GFI value of 0.989 further supports this conclusion, suggesting that the model effectively explains nearly all the variance among the observed variables.

The incremental fit indices, which evaluate the model's improvement relative to a baseline (null) model, also produced highly satisfactory results. The AGFI=0.966, CFI=0.989, TLI=0.976, and NFI=0.943) all exceeded the standard cutoff value of 0.90, confirming a robust incremental fit and validating the model's explanatory strength [40]. These indices collectively suggest that the proposed model significantly enhances predictive accuracy beyond a null model.

Moreover, the parsimonious fit index, represented by the ratio of χ^2/df=1.213, falls well below the recommended upper limit of 5 [41]. This suggests that the model achieves an optimal balance between simplicity and explanatory power, effectively capturing the key relationships among the variables without introducing unnecessary complexity. Collectively, the convergence of absolute, incremental, and parsimonious fit indices offers strong evidence that the structural model provides an accurate and coherent representation of the underlying data structure.

These findings align with the results of Zulkifli *et al.* [42] who emphasized that elevated values of the CFI and TLI indicate both theoretical soundness and empirical robustness in SEM. Overall, the goodness-of-fit indices affirm that the proposed model offers an excellent representation of the interrelationships among the psychological constructs and mathematics performance. The testing and selection of the structural model were guided by a theory-driven and sequential analytic procedure grounded in existing literature on mathematics achievement and educational support systems. An initial hypothesized model was specified a priori, incorporating all theoretically supported direct and indirect pathways among parental involvement, peer influence, school support, mathematics interest, and mathematics achievement. Model estimation was performed using maximum likelihood estimation, which is appropriate given the sample size, distributional properties of the data, and the continuous nature of the observed variables.

Table 3. Fit indices and statistical measures of the structural model

Category	Measure	Acceptable values	Model's fit index
Absolute fit	X^2	>0.05	0.292
	RMSEA	<0.08	0.029
	GFI	>0.90	0.989
Incremental fit	AGFI	>0.90	0.966
	CFI	>0.90	0.989
	TLI	>0.90	0.976
	NFI	>0.90	0.943
Parsimonious fit	X^2/df	<5	1.213

Note: acceptable values are based on Zulkifli *et al.* [42]

Following estimation, the model was subjected to a comprehensive evaluation using multiple goodness-of-fit indices encompassing absolute, incremental, and parsimonious criteria. The convergence of these indices within recommended thresholds indicated that the hypothesized model adequately represented the empirical data. Consequently, no post hoc modifications, such as freeing additional parameters or correlating error terms, were introduced, as such data-driven adjustments may compromise theoretical coherence and inflate model fit artificially. Although alternative nested models were conceptually examined, the hypothesized model was retained as the final solution because it achieved an optimal balance between parsimony, explanatory power, and theoretical plausibility. This systematic and transparent model testing process strengthens the internal validity of the findings and supports the robustness of the inferred structural relationships. Meanwhile, Figure 1 illustrates the best-fitting structural model that identifies the significant pathways among five interrelated variables: school support, peer influence, parent involvement, mathematics interest, and mathematics academic performance. The model reveals how both institutional and social factors jointly contribute to students' engagement and success in mathematics.

3.3. Path analysis of the exogenous variables' direct and mediated effects on the endogenous construct

Table 4 presents the decomposition of effects among the predictor constructs such as peer influence, school support, and the mediating construct mathematics interest and the outcome variable, mathematics achievement, as outlined in the final structural model. The analysis distinguishes between direct effects, which represent the immediate impact of one variable on another, and indirect effects, which operate through mediating mechanisms such as mathematics interest. In this model, mathematics interest functions as the primary mediator transmitting part of the influence of school support to achievement, whereas peer influence contributes only a direct pathway. This provides a comprehensive understanding of how students' personal dispositions and environmental supports interact to shape their academic outcomes in mathematics.

Specifically, the table highlights how mathematics interest serves as an internal motivational driver that enhances engagement, persistence, and cognitive processing in learning. Likewise, peer influence contributes socially and emotionally by fostering collaboration, healthy competition, and shared learning experiences that strengthen academic confidence. Meanwhile, school support exerts a dual influence directly through quality instruction and resources, and indirectly by promoting parental involvement, which reinforces learning behaviors and motivation at home.

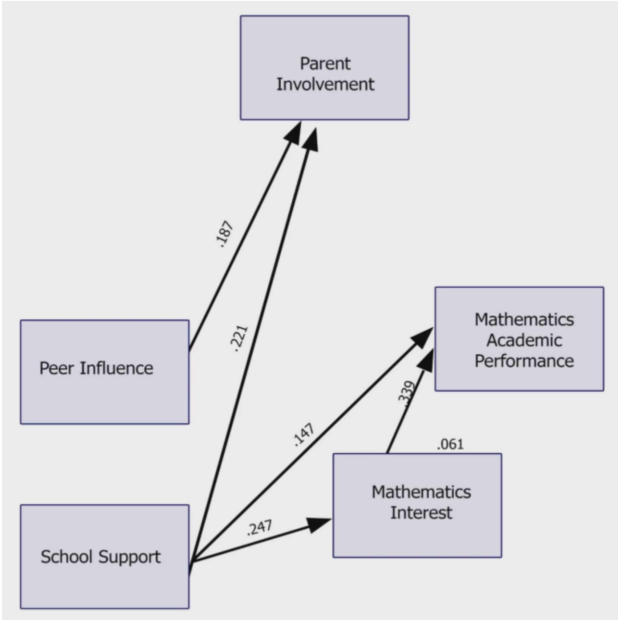

Figure 1. Best-fitting model indicating significant pathways

Table 4. Decomposition of effects between exogenous and endogenous constructs

Predictor variables	Endogenous variable	Direct effect (β)	Indirect effect (β)	Total effect (β)	p-value
Mathematics interest	Mathematics achievement	0.339		0.339	0.021
Peer influence	Mathematics achievement	0.187		0.187	0.041
School support	Parental involvement	0.221		0.221	0.026
School support	Mathematics achievement	0.147	0.084	0.231	0.039
School support	Mathematics interest	0.247		0.247	0.013

Using standardized beta coefficients (β) quantifies the magnitude and direction of relationships, where positive coefficients indicate facilitative effects and negative ones denote inhibitory influences. In this study, all coefficients were positive, showing that each variable constructively contributes to mathematics achievement. This demonstrates that motivated students, supported by peers and institutions, are more likely to perform better academically.

Overall, the findings emphasize the interconnected nature of psychological, social, and structural factors in mathematics learning. Achievement does not result from isolated influences but from the synergistic interaction of interest, peer collaboration, and school-based support systems. Strengthening these domains can foster holistic and sustainable improvements in students' mathematical competence and overall success.

3.3.1. Direct effect of mathematics interest on mathematics achievement

Mathematics interest demonstrated a strong and significant direct positive effect on mathematics achievement ($\beta=0.339$, $p=0.021$). This finding indicates that students who display genuine curiosity, enjoyment, and enthusiasm toward mathematics tend to achieve higher academic outcomes. A high level of interest encourages deeper engagement, persistence in learning, and intrinsic motivation factors that contribute to enhanced problem-solving skills and conceptual understanding. Students who find mathematics enjoyable are also more likely to invest effort, explore challenging problems, and sustain focus even in the face of difficulty [43]. This result reinforces previous research suggesting that valuing and enjoying mathematics promotes resilience, creativity, and long-term academic success [44]. Hence, cultivating students' interest in mathematics is fundamental not only for boosting performance but also for nurturing lifelong appreciation and confidence in the subject.

3.3.2. Direct effect of peer influence on mathematics achievement

Peer influence exhibited a significant direct positive effect on mathematics achievement ($\beta=0.187$, $p=0.041$). This suggests that students who interact with academically motivated peers tend to adopt productive study habits, higher motivation, and greater confidence in their mathematical abilities. Positive peer interactions often lead to collaborative learning experiences, where students exchange ideas, clarify misconceptions, and support one another's academic goals [45]. Such social dynamics reduce learning-related anxiety, enhance self-efficacy, and foster a sense of belonging in the classroom. These findings emphasize the value of peer support systems and group-based learning strategies in enhancing both academic and emotional aspects of mathematics learning [46]. Therefore, promoting positive peer environments can serve as a powerful mechanism for improving students' mathematics performance.

3.3.3. Direct effect of school support on parental involvement

School support demonstrated a significant positive direct effect on parental involvement (β=0.221, p=0.026). This indicates that when schools maintain open communication, transparency, and inclusivity, parents are more likely to engage actively in their children's educational development. Initiatives such as regular teacher-parent consultations, progress updates, and participatory school programs strengthen parents' sense of collaboration and accountability [47]. Such partnerships enable parents to provide consistent guidance and encouragement at home, reinforcing students' learning experiences. This finding highlights the importance of institutional efforts in building strong home–school connections that create a supportive ecosystem for student success [48]. When schools effectively engage parents as educational partners, they amplify both academic and socio-emotional benefits for students.

3.3.4. Direct and indirect effects of school support on mathematics achievement

School support exhibited both direct and indirect positive effects on mathematics achievement. The direct effect (β=0.147, p=0.039) indicates that a supportive school environment characterized by effective teaching, adequate learning facilities, and consistent academic guidance directly enhances students' performance in mathematics. In addition to this, school support also demonstrated an indirect effect (β=0.084) through mathematics interest, highlighting the mediating role of students' intrinsic engagement with the subject. When schools provide stimulating instructional practices and create encouraging learning conditions, they cultivate students' curiosity and enjoyment in mathematics [49]. This heightened interest subsequently promotes greater effort, persistence, and positive attitudes toward learning, which translate into improved achievement. The total effect (β=0.231) therefore underscores the dual influence of school support, both in directly improving performance and indirectly enhancing it through increased mathematical interest.

The stronger influence of school support relative to peer dynamics can be understood within the distinctive institutional context of PSHS–WVC as an elite, residential STEM school. In such settings, academic structures, curricular rigor, and institutional expectations are highly standardized and deeply embedded in students' daily routines. Teaching quality, assessment practices, access to learning resources, and structured academic support systems exert continuous and formal influence on learners' academic behaviors, often surpassing the variability of peer effects [50]. Unlike in conventional schools where peer groups may significantly shape academic norms, PSHS scholars are immersed in an environment where academic excellence is institutionally reinforced through structured schedules, close teacher monitoring, and explicit performance expectations. Consequently, institutional support mechanisms become the dominant drivers of achievement, shaping not only what students learn but also how they approach learning tasks.

Moreover, the residential nature of PSHS–WVC further amplifies the role of institutional support. Students' academic, social, and personal experiences occur largely within the same school ecosystem, blurring the boundaries between classroom instruction and informal learning spaces. Faculty guidance, access to academic facilities, and school-organized learning supports are consistently present across both formal and informal contexts, reinforcing learning behaviors beyond peer-driven interactions [51]. While peers remain important as collaborators and sources of motivation, their influence may be more homogeneous in an elite environment where students already share high academic orientation and similar achievement goals [52]. As a result, peer effects may exhibit less variability and weaker predictive power compared to the structured, sustained, and system-wide influence of school support.

3.3.5. Direct effect of school support on mathematics interest

Finally, school support demonstrated a strong and statistically significant direct positive effect on mathematics interest (β=0.247, p=0.013). This finding suggests that a supportive and well-organized academic environment characterized by competent teachers, engaging instructional practices, accessible learning resources, and continuous encouragement plays a pivotal role in fostering students' curiosity and enthusiasm for mathematics. A positive and nurturing school climate not only provides emotional security but also promotes intellectual engagement, helping shift students' perceptions of mathematics from a source of anxiety to one of enjoyment and intellectual growth [53]. When learners feel valued and supported, they are more inclined to participate actively, approach mathematical tasks with confidence, and sustain a deeper interest in the subject [54]. Hence, cultivating school environments that stimulate curiosity and reinforce positive attitudes toward learning is vital for enhancing both immediate academic performance and long-term mathematical proficiency.

High-quality instruction, carefully scaffolded learning experiences, and consistent academic feedback position the institution as the primary source of intellectual stimulation, shaping students' curiosity and engagement more powerfully than informal peer interactions. Because the school culture explicitly emphasizes academic excellence and deep cognitive engagement, institutional influences remain stable and highly salient in students' learning experiences [55]. Moreover, the relatively homogeneous academic orientation of PSHS scholars reduces the distinct impact of peer influence, as peers largely reinforce already established achievement-driven norms rather than introducing new motivational directions [56]. Combined with the residential nature of the school, where learners are continuously immersed in institution-led academic practices and expectations, school support becomes the dominant force in nurturing mathematics interest [57]. Thus, in this elite STEM-focused context, the institutional environment serves as the central catalyst for sustaining students' enthusiasm and long-term commitment to mathematics.

4. CONCLUSION

This study demonstrates that mathematics achievement among PSHS–WVC scholars is shaped by a network of interconnected factors, with mathematics interest and school support emerging as the strongest predictors through both direct and indirect pathways. Peer influence and parental involvement further reinforce these effects by strengthening motivation, discipline, and academic persistence. The findings address the research objectives by confirming that achievement in mathematics is not driven by cognitive ability alone, but by the interaction of personal engagement and supportive social–institutional contexts. In the residential PSHS setting, where academic life, peer interaction, and school structures are closely integrated, these influences are intensified, highlighting the critical role of an environment that nurtures curiosity, collaboration, and sustained engagement in mathematics. The results underscore the significance of cultivating interest-driven learning and robust school support systems as key levers for improving mathematical performance.

The study is limited by its focus on a single PSHS campus and reliance on self-reported measures, which may affect generalizability and introduce response bias. Nonetheless, the findings have important implications for policy and practice, suggesting that STEM schools should prioritize holistic strategies that integrate interest-based pedagogies, peer-supported learning cultures, and strong home–school partnerships. For PSHS specifically, interest-based pedagogies may include problem-based learning anchored on real-world STEM challenges, research-driven mathematics projects aligned with science and engineering applications, math modeling tasks connected to national development issues, and enrichment activities such as math circles or Olympiad-style collaborative problem solving. Future research may extend this structural model to other PSHS campuses or STEM-oriented schools, employ longitudinal designs to track changes in interest and achievement over time, and experimentally test the long-term impact of PSHS-aligned interest-based pedagogies. Such studies would further strengthen evidence-based interventions that support sustained excellence in mathematics within residential STEM learning environments.

ACKNOWLEDGMENT

The researchers wholeheartedly extend their deepest gratitude to the Department of Science and Technology – Science Education Institute (DOST–SEI) for its generous financial assistance and scholarship support, which made the completion of this study possible. Sincere appreciation is also given to West Visayas State University for its valuable collaboration, guidance, and endorsement throughout the conduct of the research. The researchers further acknowledge the unwavering encouragement and contributions of all individuals and institutions whose support was instrumental in the successful realization of this work.

FUNDING INFORMATION

This study was supported by the Department of Science and Technology–Science Education Institute (DOST–SEI), in collaboration with the West Visayas State University–University Research and Development Center (WVSU-URDC), through the Science Education Scholarship Program.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Charmaigne A. Eslabra	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓
Roberto G. Sagge Jr.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Dolly Rose F. Temelo	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓
Danilo M. Parreño	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓
Tedric Dave E. Senosa			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Peter Ernie D. Paris	✓	✓			✓	✓			✓	✓	✓	✓	✓	✓
Garry C. Cachuela	✓	✓			✓	✓			✓	✓	✓	✓	✓	✓
Sybel Joy F. Labis	✓	✓	✓		✓		✓		✓	✓	✓	✓	✓	✓
Salvador P. Bacio Jr.	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓

C : **C**onceptualization
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Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest associated with the conduct, authorship, or publication of this study.

DATA AVAILABILITY

The data utilized in this research were sourced from West Visayas State University and are subject to institutional access restrictions. These datasets were obtained under a licensed agreement and, as such, are not publicly accessible. However, data may be made available upon reasonable request and with prior authorization from West Visayas State University through the following link: https://docs.google.com/spreadsheets/d/1G5Kw6Kd-TUlE2KdZX9wSruBfHfaa1-5v/edit?usp=drive_link&ouid=116373956925431802880&rtpof=true&sd=true

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BIOGRAPHIES OF AUTHORS

Charmaigne A. Eslabra is a special science teacher IV at the Philippine Science High School–Western Visayas Campus, Iloilo City, Philippines. Her expertise encompasses science and mathematics education, curriculum design, instructional innovation, and learner-centered pedagogy. As a dedicated educator and researcher, she actively engages in initiatives that enhance the quality of teaching and learning in the STEM field. She has also presented and published several research works that contribute to the continuous improvement of instructional practices and student achievement. Her professional endeavors reflect a strong commitment to educational excellence and evidence-based teaching. She can be contacted at email: charmaigne.aguirre@wvsu.edu.ph.

Roberto G. Sagge Jr. is a faculty member of the College of Education–Mathematics Division at West Visayas State University, located in La Paz, Iloilo City, Philippines. He holds a Doctor of Philosophy in Science Education major in Mathematics. His research interests encompass teaching and learning initiatives in the field of mathematics education, particularly focusing on phenomenological studies, ethnomathematics, and the development of instructional materials. A passionate researcher, he has presented papers in various local, national, and international conferences and has published studies in peer-reviewed, Web of Science (WoS), and Scopus-indexed journals. He can be contacted at email: robertosagge@wvsu.edu.ph.

Dolly Rose F. Temelo is an honor graduate of the Development Academy of the Philippines (DAP) Middle Managers Class, Batch 33–Balaghan. She is an associate professor V and former Director of Quality Assurance at the College of Arts and Sciences, West Visayas State University, La Paz, Iloilo City, Philippines. Her expertise lies in statistical analysis and path modeling, with research interests centered on quantitative methods and data-driven approaches in education and the social sciences. As a dedicated academic and researcher, she has mentored numerous students and faculty in conducting empirical studies that advance evidence-based educational practices. She can be contacted at email: dollyrose.temelo@wvsu.edu.ph.

Danilo M. Parreño is an associate professor V at the College of Education, West Visayas State University, La Paz, Iloilo City, Philippines. He earned his Doctor of Philosophy in Science Education major in Mathematics from De La Salle University (DLSU). His academic specialization lies in qualitative research, with particular focus on mathematics education, instructional design, curriculum innovation, and pedagogical development. A dedicated educator and researcher, Dr. Parreño has presented numerous papers in local and international conferences. He can be contacted at email: daniloparreno@wvsu.edu.ph.

Tedric Dave E. Senosa earned his Master of Arts in Education major in Mathematics and graduated Summa Cum Laude. A top achiever, he placed 4th in the September 2023 Board Licensure Examination for Professional Teachers. His scholarly interests revolve around teaching and learning innovations, particularly in the areas of correlational research, path analysis, and educational assessment. Passionate about research, he has actively shared his work, including the presentation of his master's thesis at the 10th National Conference for Science and Mathematics Education held at the SMX Convention Center in Clark, Pampanga. He can be contacted at email: tedricdave.senosa@wvsu.edu.ph.

Peter Ernie D. Paris is an associate professor V at the College of Education, West Visayas State University, La Paz, Iloilo City, Philippines. He earned his Doctor of Philosophy in Science Education (Biology) from WVSU. Dr. Paris is the current Vice President for Administration and Finance (VPAF) and the Project Director of the DOST-SEI Consortium of WVSU, and he previously served as the Campus Administrator of the WVSU College of Agriculture. His research interests include grounded theory, materials development, science education, and citizen science. A dedicated educator and researcher, he has presented numerous papers in local and international conferences. He can be contacted at email: peterernie.paris@wvsu.edu.ph.

Garry C. Cachuela is an associate professor and the dean of the College of Education at West Visayas State University–Lambunao Campus. With an undergraduate background in Applied Mathematics and a Ph.D. in Science Education major in Mathematics, he blends mathematical rigor with a strong commitment to teacher education and innovation. He previously served as associate dean of the Graduate School of WVSU–Lambunao Campus and was a member of the Teacher Education Council of the Philippines (TEC). An active professional leader, he is also an officer of MTAP-IC and NOSTE. His research interests focus on applied mathematics, instructional materials development, and ethnomathematics, advancing culturally grounded and effective approaches to mathematics teaching and learning. He can be contacted at email: garry.cachuela@wvsu.edu.ph.

Sybel Joy F. Labis is an associate professor at the College of Education–Mathematics Education Division at West Visayas State University in La Paz, Iloilo City, Philippines. She holds a Ph.D. in Curriculum Development and a master's degree in mathematics. Her research interests include teacher education, preservice teacher preparation, artificial intelligence in education, and mathematics education. Her work explores how teachers and learners engage with emerging technologies and innovative pedagogical approaches to improve mathematics teaching and learning. She can be contacted at email: sj_labis@wvsu.edu.ph.

Salvador P. Bacio Jr. is an associate professor V at West Visayas State University in La Paz, Iloilo City, Philippines. He holds a Ph.D. in Education with a specialization in Curriculum Development. His scholarship centers on teaching and learning, particularly the development of instructional materials and the advancement of language, literature, and culture education. Dr. Bacio has presented at local, national, and international conferences and has published in international and Scopus-indexed journals. Likewise, he also serves as a peer reviewer for international and Scopus-indexed journals. Currently, he is the Director of the Sentro sa Wika at Kultura. He can be contacted at email: salvador.bacio@wvsu.edu.ph.