Path Model of Mathematics Achievement in Senior High School

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Abstract

This study aimed to construct a path model on the factors influencing the mathematics achievement of Senior High School students. In particular, this study focuses on five subject components: Junior High School (JHS) math experience, JHS grade point average, attitudes toward mathematics, self-efficacy, and anxiety. The causal relationships and relative strengths of the direct and indirect relationships were explored for the sets of exogenous and endogenous variables using path analysis. The results unveiled an acceptable fit for the path model of the mathematics achievement in Senior High School. It indicated that students' mathematics achievement was influenced directly by JHS math general point average and mathematics anxiety; and indirectly by JHS math experience, attitudes, and self-efficacy. Moreover, the path model revealed that the JHS math grade point average exhibited the strongest influence on students' mathematics achievement. This suggests that a greater emphasis on developing basic mathematics skills and building a solid foundation at the Junior High School level leads to a better comprehension of higher mathematics.

Keywords

Path analysis, mathematics achievement, path model, senior high school

Modelo de Trayectorias de Rendimiento en Matemáticas en la Escuela Secundaria Superior

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Resumen

El objetivo de este estudio fue construir un modelo de trayectoria sobre los factores que influyen en el rendimiento en matemáticas de los estudiantes de secundaria. En particular, este estudio se centra en cinco componentes temáticos: experiencia en matemáticas en la escuela secundaria (JHS), promedio de calificaciones de JHS, actitudes hacia las matemáticas, autoeficacia y ansiedad. Se exploraron las relaciones causales y las fortalezas relativas de las relaciones directas e indirectas para los conjuntos de variables exógenas y endógenas mediante análisis de ruta. Los resultados revelaron un ajuste aceptable para el modelo de trayectoria del rendimiento en matemáticas en la escuela secundaria superior. Indicó que el rendimiento matemático de los estudiantes estaba influenciado directamente por el promedio general de calificaciones de matemáticas de JHS y la ansiedad matemática; e indirectamente por la experiencia, actitudes y autoeficacia en matemáticas de JHS. Además, el modelo de ruta reveló que el promedio de calificaciones de matemáticas de JHS exhibió la influencia más fuerte en el rendimiento de matemáticas de los estudiantes. Esto sugiere que un mayor énfasis en el desarrollo de habilidades matemáticas básicas y la construcción de una base sólida en el nivel de la escuela secundaria conduce a una mejor comprensión de las matemáticas superiores.

Palabras clave

E ducation is essential to a society's advancement, and educational institutions must deliver a high-quality education that advances the nation's development objectives. The pursuit of excellence is a fundamental objective in Philippine education, aiming to produce competent individuals who can drive social and economic progress, ultimately enhancing people's quality of life.

Sutaria, referenced by Hajilan (2016), claims that improving educational standards is a necessary component of quality education since it fosters excellence in education and life. Higher standards require changes in the inputs, procedures, and outcomes of education and the students, the curriculum's content, and its applicability. Every educational institution should place a high priority on improving students' knowledge, skills, and competency since doing so creates a route for a better future. In the pursuit of excellence, mathematics education holds significant responsibilities. It must mold students into responsible and knowledgeable individuals with the basic skills and competencies required to participate effectively in everyday life. Moreover, mathematics education should prepare students for advanced education and the workforce, enabling them to make valuable contributions to society. However, despite the practicality of mathematics in daily life, various factors can adversely affect students' understanding, analysis, and application of mathematical concepts, ultimately impacting their achievement in the subject.

Several studies have shed light on multiple factors influencing student performance in mathematics. These factors encompass negative experiences with mathematics (Vukovic et al., 2013), attitude (Capuno et al., 2019; Casinillo et al., 2020), disposition (Llagas, 2021), as well as anxiety and self-efficacy (Riboroso et al., 2018). The existence of such factors underscores the complexity of addressing low academic achievement in mathematics, posing a challenge for mathematics educators to identify solutions that can help students improve their mathematical abilities (Ayebale et al., 2020). Enu (2015) noted that educators, trainers, and researchers have long been interested in exploring the variables that significantly contribute to learners' academic achievement. These variables can originate from within or outside the school environment and impact the quality of students' academic performance.

Multiple factors converge to influence the learning of mathematics, including school, classroom, student, and teacher-related elements. According to Mensah et al. (2013), the seriousness with which mathematics is taught has a considerable impact on student's achievement. Consequently, the researcher in this context aims to conduct a study utilizing path analysis to establish causal relationships between students' mathematics achievement and various factors, such as their mathematics experience in Junior High School, mathematics general point average, attitude, attitudes toward mathematics, self-efficacy, and anxiety. Using this approach, the study seeks to develop a comprehensive set of measures for assessing and evaluating the mathematics achievement of Senior High School students.

The main concern of this study is to provide educators an opportunity to develop, modify, and redirect their roles in improving students' achievement in mathematics. The estimated path analysis model holds the potential to guide educational authorities in designing appropriate and effective educational development programs, particularly those focused on enhancing teaching effectiveness. Furthermore, the study's findings can encourage further research that delves into different variables influencing students' mathematics achievement, ultimately leading to

developing strategies for future actions within schools, families, and communities to address the problem of low mathematics achievement rates.

Addressing these issues is consistent with the framework for educational growth goals established by school administration and teachers' academic preparation and training. These elements are crucial to teaching-learning, fostering an environment where educators can effectively comprehend and value students' behavior, culture, and nature.

Objectives of the Study

This study aimed to construct a path model on the factors influencing the mathematics performance of Senior High School students of the University of Northern Philippines, School Year 2018 - 2019.

Specifically, it sought to (1) describe the mathematics-related parameters of the students in terms of JHS math experience, JHS math general point average, attitudes toward mathematics, mathematics self-efficacy, and mathematics anxiety; (2) describe the mathematics achievement of Senior High School students; (3) determine the significant relationship between the identified factors and the mathematics achievement of the students; and (4) construct a path model that explains the mathematics achievement of Senior High School students.

Theoretical Framework

It is generally acknowledged that academic achievement is a complex phenomenon influenced by various factors, both directly and indirectly. Extensive research has been conducted to identify the predictors of academic performance, with numerous studies exploring different factors (Stewart, 2000). Although the relationship between student factors and mathematics performance has been widely investigated, it is still essential to look into the aspects that affect students' mathematics performance (Balbalosa, 2010).

The corpus of extant research consistently supports the theory that socioeconomic, psychological, and environmental factors impact student performance (Hijazi & Naqvi, 2006). Fitzallen et al. (2014) also discovered that various factors, including mathematics self-concept, mathematics anxiety, attitude toward mathematics, mathematics self-efficacy, and the influence of instructors and peers, impact secondary school students' mathematics achievement. In a study published in 2017, Acharya highlighted several interconnected factors leading to low performance in mathematics among public school students. The study focused on the under-recognition of students' needs and interests and their prior knowledge and proficiency in mathematical concepts as essential contributors to inferior mathematics achievement.

Another vital aspect of student-related factors is their prior knowledge of mathematics. The foundational knowledge of mathematics at the lower secondary level plays a pivotal role in determining students' performance. Adequate mathematics pre-knowledge serves as the infrastructure for students' overall development in mathematics. Students who do not have the

necessary background knowledge sometimes need more enthusiasm for learning and struggle to perform at higher levels. Throughout their secondary school careers, students frequently struggle with mathematics due to a lack of prior knowledge (Acharya, 2017).

Additionally, a study by Allen (2001) found a significant relationship between participants' prior exposure to mathematical content and math anxiety. Math anxiety was moderately correlated with participants' experiences with a specialization in math. However, for individuals in the math specialization, pedagogical experiences in the mathematics classroom did not significantly correspond with math anxiety. Participants without a math specialty revealed a weak link between their pedagogical experiences and arithmetic anxiety. The study found that participants' encounters with mathematical material, whether they were math specialists or not, strongly predicted math anxiety.

Stewart's (2000) study on the ecological model of family, individual, and school effects on academic achievement indicated that students' academic success was primarily influenced by their prior academic performance. This result aligns with other research that reported a strong relationship between eighth and twelfth grades. According to the study, achievement patterns are established early in school and continue to affect academic performance throughout high school.

In addition, Riboroso et al. (2018) discovered a substantial link between students' mathematical self-efficacy and the number of mathematics classes they took in high school. According to the study, students taking more math classes in high school have stronger self-efficacy. This link might be explained by more exposure to the topic because knowledge breeds confidence. The study also found a substantial relationship between math self-efficacy and average high school grades. These results suggest that individuals who perform well in mathematics in high school exhibit stronger confidence and assertiveness toward the subject in their college years due to a solid foundation. The relevance of high school preparation for academic performance at the college level was demonstrated by Muir (2012), who emphasized a favorable association between high school preparation and college course grades.

Schenkel (2009) highlighted a study by Hammouri that looked at motivational and attitude factors concerning math achievement. The researcher found that attitudes can affect how much effort is put into a work, how long it takes to complete it, how high the expectations are, and how much time is spent on it. Therefore, a student's favorable attitude toward mathematics may help them succeed and achieve greater proficiency. According to Hammouri, who was cited by Schenkel (2009), there are several significant positive effects, including attitude towards math and self-perception of math's importance, confidence in math ability, attitude towards math, educational aspiration, and self-perception of math's importance, attitude towards math and educational aspiration on math achievement, and self-perception of math's importance on math achievement.

Fuller (2009) concluded that a student's aptitude for math was strongly correlated with their attitude about the subject. This finding was supported by Cayabyab, as cited by Fuller (2009), who claimed that pupils with a favorable attitude toward mathematics tend to succeed at better levels of achievement. Goe and Croft claim that people with favorable attitudes about mathematics perform better. Khatoon and Mahmood also discovered a positive association between attitudes toward mathematics and mathematical achievement. However, opposing

findings were reported by Bayaga and Wadesango (2014), who found no connection between students' attitudes about mathematics and their academic success in the subject.

Liu and Koirala (2009) examined the connection between math achievement and self-efficacy. They found a strong association between these two factors through correlation analysis, suggesting that children with higher math self-efficacy typically succeed more in math. Their survey's linear regression analysis also showed that mathematics self-efficacy might predict math achievement. According to this research, math students are more likely to succeed if they are confident in their skills.

As mentioned by Olango (2016), Zimmerman emphasizes that the environment in which work is carried out affects self-efficacy. An apprehensive classroom environment could directly impact self-efficacy and indirectly impact mathematics achievement via self-efficacy characteristics. Anxiety and self-efficacy significantly inspire students and create helpful learning environments. Pajares and Kranzler (1995), Pajares and Miller (1994), as well as Siswanti & Djalal (2018), found favorable relationships between self-efficacy and prior mathematics experience as well as between self-efficacy and mathematical fear.

Citing studies on mathematical self-efficacy, De la Rosa (2017) emphasizes the dynamic aspect of self-efficacy and how it affects students' perseverance and achievement. Students who believe they are effective mathematicians do not experience stress when working on mathematical tasks. They possess confidence in their abilities and are committed to achieving their goals. These students maintain their perseverance even in the face of poor performance, viewing setbacks as opportunities for improvement. They are willing to exert more effort and utilize available resources to succeed in attaining their goals.

Ascraft et al., quoted by Vukovic et al. (2013), hypothesize that various factors, including biological predisposition, unfavorable experiences with mathematics, dysfunctional cognitive schemata, and proximal and distal experiences, influence mathematics anxiety. Higher levels of math anxiety are linked to more unfavorable views toward mathematics, as Allen (2001) shows in his study. Math anxiety is a result of unpleasant experiences in formal education. According to Al-Agili et al. (2013), although the association is small and inconsequential, students' attitudes toward mathematics and anxiety directly and negatively affect their achievement. According to the Lou et al. study, which Siebers (2015) mentioned, pupils who perform better in mathematics exhibit lower anxiety levels, whereas those who score worse do so at higher rates.

The effects of math anxiety vary from student to student, with higher anxiety levels often resulting in unfavorable attitudes and feelings toward the subject. According to Cates and Rhymer's research (Suhas & Pandya, 2016), students with higher levels of mathematics anxiety showed less computational fluency across a range of mathematical domains.

The relationship between mathematical thinking, mathematical anxiety, and mathematical attitudes was explored by Kargar et al. in 2010. Their findings indicated a significant correlation between mathematics anxiety and mathematical thinking and attitudes scores. Students with high mathematics anxiety scored lower in these areas, while those with low mathematics anxiety scored higher. This implies that mathematics anxiety can influence students' thinking and attitudes toward mathematics. The study also shows that math self-efficacy is a significant positive predictor of accomplishment and that students with high math

self-efficacy also have high math achievement. Additionally, a significant predictor of math anxiety is math self-efficacy. Many educators agree that students' anxiety often stems from a fear of failure and a sense of inadequacy, with their performance significantly affecting the degree of anxiety they experience.

In summary, it is significant to consider a range of factors when estimating the causal model of students' mathematical achievement. Students' success in mathematics is affected by various socioeconomic, psychological, and environmental factors, as well as prior knowledge, attitudes, self-efficacy, and mathematics anxiety. Educators and decision-makers can create successful ways to improve students' mathematical achievement by thoroughly understanding these aspects and how they interact.

Conceptual Framework

The hypothesized theoretical model is shown in Figure 1. The purpose of the hypothesized model is to display the expected relationships between and among the variables graphically.

Figure 1
The hypothesized path model
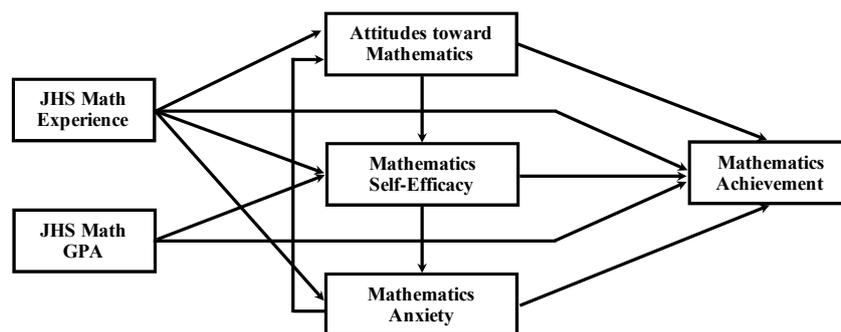
The path diagram illustrates how the independent variables [JHS math experience, JHS math GPA, attitudes, self-efficacy, and anxiety in mathematics] influence the students' mathematics achievement. It further shows the causal relationships between the profile of the students and their mathematics achievement. It elucidates the comparative strengths of direct and indirect relationships among the exogenous and endogenous variables.

Methodology

This study employed the descriptive-causal research design involving 283 Grade 11 students from the University of Northern Philippines who enrolled during the School Year 2018-2019. The primary objective was to investigate the interplay between and among the hypothesized causal factors such as JHS mathematics experience and general point average, attitudes, self-efficacy, and anxiety in mathematics, and their possible causal effect (direct and indirect) on

mathematics achievement. Path analysis was used to construct the path model of the students' mathematics performance and to understand the comparative strengths of direct and indirect relationships among the sets of exogenous and endogenous variables.

The researcher utilized a comprehensive set of validated instruments comprising four questionnaires: the Mathematical Experience Scale Questionnaire (Allen, 2001), the Attitudes toward Mathematics Scale Questionnaire (Wong & Chen, 2012), the Mathematics Self-Efficacy Scale Questionnaire (Usher & Pajares, 2009), and the Mathematics Anxiety Scale Questionnaire (Allen, 2001). In order to ensure accurate measurement, the negatively worded statements were evaluated in reverse order.

Additionally, the researcher developed a Mathematics Achievement Test designed to determine the achievement of Senior High School students in mathematics. The Mathematics Achievement Test underwent rigorous validation and reliability testing, resulting in a high-reliability coefficient (KR20) of 0.84. This coefficient indicates the test's consistency and dependability in measuring students' mathematical achievement.

Before conducting the study in the Senior High School Department, the researcher sought permission from the Principal of the Laboratory Schools at the University of Northern Philippines. The researcher obtained consent from the respondents and respected their decision, whether to participate or decline. The respondents willingly provided informed consent without coercion and expressed their desire to be part of the study. All respondents were guaranteed confidentiality and confidentiality through a written notice. Moreover, pseudonyms were assigned to protect their identities and maintain confidentiality.

The respondents were given the autonomy to choose how to respond to the research instruments. They were encouraged to provide comments or suggestions to the researchers. Additionally, they were informed that they could withdraw from the study without being asked for reasons or facing any consequences.

The collected data were entered into a spreadsheet program and underwent coding and reverse coding processes before analysis. Several statistical methods were employed to analyze and interpret the data, such as frequency and percentage, mean, correlation, and path coefficients.

The data gathered in the study were carried out using path analysis. The theoretical model presented in Figure 1 was estimated using AMOS (Analysis of Moment Structures) 23, a statistical program designed to perform structural equation modeling and path analysis procedures. AMOS calculates estimates for every path in the model represented by Beta coefficients. Using Maximum Likelihood estimation, AMOS generates estimates of all parameters not constrained to specific values and model fit indicators. Moreover, to evaluate the overall model fit, five measures were used, namely: $p < 0.05$, <3.0, $CFI > 0.95$, $GFI > 0.95$, and $RMSEA < 0.08$.

Results and Discussion

Mathematics-Related Parameters of the Students

Table 1 presents the mathematics-related parameters of the students along with the different exogenous and endogenous variables.

Table 1

Mathematics-Related Parameters of the Students

Variable	Mean	Interpretation
JHS Mathematics Experience	03.28	Good
JHS Math General Point Average	89.04	Very Satisfactory
Attitudes toward Mathematics	03.38	Neither Positive Nor Negative
Mathematics Self-Efficacy	03.23	Confident
Mathematics Anxiety	03.05	Moderately Anxious

As presented in the table, students acquired a "Good" (M=3.28) learning experience in mathematics during their Junior High School. Hence, students had a "Very Satisfactory" performance with a mean rating of 89.04%. This shows that students performed well in Mathematics during their Junior High School days. These findings highlight the positive outcomes achieved by the students in their mathematics education. The combination of a good learning experience and a high-performance percentage indicates that the students demonstrated a strong understanding of the subject matter and could apply their knowledge effectively. These results underscore the education system's effectiveness in providing students with a solid foundation in mathematics, which is crucial for their academic and future success (Chen & Cheng, 2013; Fhloinn et al., 2014).

As to the endogenous variables, it is clear from the table that students' perceptions of their attitudes toward mathematics were neutral, as evidenced by a mean rating of 3.38. This shows that students have neither positive nor negative discernment on their attitudes toward their ability to do mathematics, how they enjoy mathematics, the use of Information Technology in support of their learning in mathematics, their traits about flexibility in problem-solving, and their beliefs about the usefulness and relevance of mathematics to their daily life.

According to Sa'ad and Sadiq's study from 2014, it was identified that enhancing performance in mathematics within the study area could be achieved through various means. These include fostering a positive attitude, motivation, and proper guidance, employing effective teaching methods, providing adequate teaching materials, additional classrooms, and suitable furniture, and establishing libraries and mathematical laboratories. Consequently, it is essential to implement strategies that promote a positive attitude towards mathematics early on in a student's academic journey. Doing so can create a strong foundation and cultivate a genuine interest in the subject, leading to increased motivation, improved performance, and a lifelong appreciation for mathematics.

Meanwhile, the table further revealed that students perceived a "Confident" (M=3.23) level in mathematics. The finding suggests that the most significant source of the students'

mathematics self-efficacy was their vicarious experience. Students build their self-efficacy beliefs through observing others. In this sense, it reveals that students who constantly observe significant people such as their classmates, peers, and adults can affect their mathematics self-efficacy. It further unveils that if students' peers succeed in math, they believe they can also succeed. This phenomenon is closely related to Bandura's social cognitive theory (1986), which emphasizes the role of observational learning and social modeling in forming people's beliefs. Interestingly, Kitsantas, Cheema, & Ware (2011) highlighted the importance of educators strongly emphasizing boosting students' self-efficacy in mathematics, regardless of their initial proficiency levels.

Furthermore, the table revealed that students were "Moderately Anxious" in mathematics, as proved by a mean rating of 3.05. These findings support the notion that students' anxiety, stress, worry, or apprehension towards manipulating numbers and resolving mathematical problems were moderate. It also implies that even while the students may not be apprehensive about mathematics, they exhibit a real apprehension or discomfort when handling numbers and resolving some mathematical issues. According to Aldrup et al. (2020), this moderate level of anxiety can affect their ability to learn and perform in mathematics.

All math students and educators should be aware of the effects of mathematics anxiety (Finlayson, 2014). This shows that encouraging successful mathematics education requires overcoming math fear. As a result, it is critical to help students who experience moderate math anxiety. Their nervousness can be reduced, and their confidence can be boosted by offering a compassionate and supportive learning atmosphere. To help students adopt a positive attitude toward mathematics, teachers can employ tactics like breaking complex tasks down into smaller, manageable steps, providing additional guidance and resources, and encouraging a growth mentality (Lai et al., 2015).

In addition, the study conducted by Cadorna et al. (2016) highlighted the importance of parental support, encouragement, and motivation in addressing math anxiety. This is in line with the findings of the Lai et al. (2015) study, which emphasizes the significance of managing anxiety levels related to learning mathematics when implementing interventions to address mathematical learning challenges.

Mathematics Achievement of Senior High School Students

The table below presents the Mathematics achievement of Senior High School students.

Table 2

Mathematics Achievement of Senior High School Students

Students' Achievement	Content							
	Functions		Rational Functions		Inverse, Exponential & Logarithmic Functions		As a whole	
	f	%	*f*	%	*f*	%	*f*	%
90 – 100 (O)	148	52.30	57	20.14	80	28.27	75	26.50
85 – 89 (VS)	43	15.19	32	11.31	53	18.73	58	20.49
80 – 84 (S)	34	12.01	38	13.43	61	21.55	52	18.37
75 – 79 (FS)	17	6.01	40	14.13	39	13.78	40	14.13
< 75 (DNE)	41	14.49	116	40.99	50	17.67	58	20.49
Total	*283*	*100.00*	*283*	*100.00*	*283*	*100.00*	*283*	*100.00*
Statistic								
Highest	100		100		100		100	
Lowest	65		62		64		67	
Mean	86.93		79.93		84.28		83.28	
SD	9.86		10.59		8.65		8.24	
Descriptive Rating	VS		FS		S		S	

Of particular interest is the mean level of mathematics achievement of the Senior High School students. These students have achieved a "Satisfactory" level in mathematics, as attested by a mean rating of 83.28%. It means that the students have developed the fundamental knowledge, skills, and core understanding with little guidance from the teacher or some assistance from peers.

Furthermore, the students have exhibited varying levels of achievement in specific areas of General Mathematics. The results demonstrate a "Very Satisfactory" level (86.93%) in Functions, a "Fairly Satisfactory" level (79.93%) in Rational Functions, and a "Satisfactory" level (84.28%) in Inverse, Exponential, and Logarithmic Functions. The results indicate that the students developed fundamental knowledge and skills on Functions and Inverse, Exponential & Logarithmic Functions. Hence, students can independently apply their core understanding in these content areas through authentic performance tasks with minimal teacher assistance.

However, in Rational Functions, students need more knowledge, skills, and core understanding. They require assistance throughout the completion of authentic tasks in this particular area.

Significant Relationship between the Identified Factors and the Mathematics Achievement of the Students

Table 3 presents the correlation coefficients matrix for the predictor variables and the student's mathematics achievement.

Table 3

Correlation Coefficients for Predictor Variables and Students' Mathematics Achievement

Predictor Variables	B	C	D	E	Mathematics Achievement
A. JHS Mathematics Experience	.491**	.596**	.524**	.480**	.342**
B. JHS Mathematics GPA		.338**	.397**	.228**	.374**
C. Attitudes toward Mathematics			.648**	.525**	.267**
D. Mathematics Self-Efficacy				.606**	.248**
E. Mathematics Anxiety					.261**

**Significant at 0.01 level

The findings from the correlation analysis demonstrate the presence of statistically and positive relationships between the students' mathematics at 0.01 level. It can be noted that all assumed relationships between each pair of exogenous and endogenous variables are statistically significant. This suggests that these variables play an influential role in shaping students' performance in mathematics.

One of the significant predictor variables is JHS (Junior High School) mathematics experience. This suggests that the amount and quality of mathematics education received by students in their junior high school years notably impact their subsequent mathematics achievement. Students with more extensive exposure to mathematics during this period may have developed a stronger foundation, positively influencing their performance in later stages.

Secondly, JHS mathematics general point average emerges as another significant predictor variable. This finding reveals that students' overall performance in mathematics during junior high school, as reflected by their general point average, is closely linked to their subsequent mathematics achievement. A higher general point average indicates a greater mastery and understanding of mathematical concepts, contributing to improved performance in future mathematics endeavors.

Furthermore, attitudes toward mathematics are also identified as a significant predictor variable. This finding underscores the importance of students' attitudes and perceptions toward the subject. Positive attitudes, such as interest, enthusiasm, and motivation, can foster a conducive learning environment and enhance students' engagement with mathematics. Conversely, negative attitudes, such as fear or disinterest, may hinder students' progress and limit their potential for success in this domain.

Another influential predictor variable is mathematics self-efficacy. Self-efficacy refers to an individual's belief in their abilities to accomplish tasks in a specific domain. Students with

higher mathematics self-efficacy tend to approach mathematical challenges with confidence and perseverance. Their belief in their capabilities positively affects their motivation, problem-solving skills, and overall performance in the subject.

Lastly, mathematics anxiety is found to be a significant predictor variable. Mathematics anxiety refers to tension or apprehension when faced with mathematical tasks. This finding highlights the detrimental impact of anxiety on students' mathematics achievement. High levels of mathematics anxiety can impair cognitive functioning, hinder problem-solving abilities, and decrease overall performance in the subject. Addressing and mitigating mathematics anxiety among students is crucial for fostering a positive learning environment and promoting better mathematics outcomes.

Path Model of Mathematics Achievement of Senior High School Students

After a series of regression analyses using AMOS and deleting non-significant paths from the hypothesized model, it unveils a path model for the mathematics achievement of Senior High School students, as depicted in Figure 2. The model yields an acceptable fit of data as evidenced by p=0.023, χ^2/df =2.612, CFI=0.986, GFI=0.985, and RMSEA=0.076.

Figure 2
Path model of mathematics achievement of the students
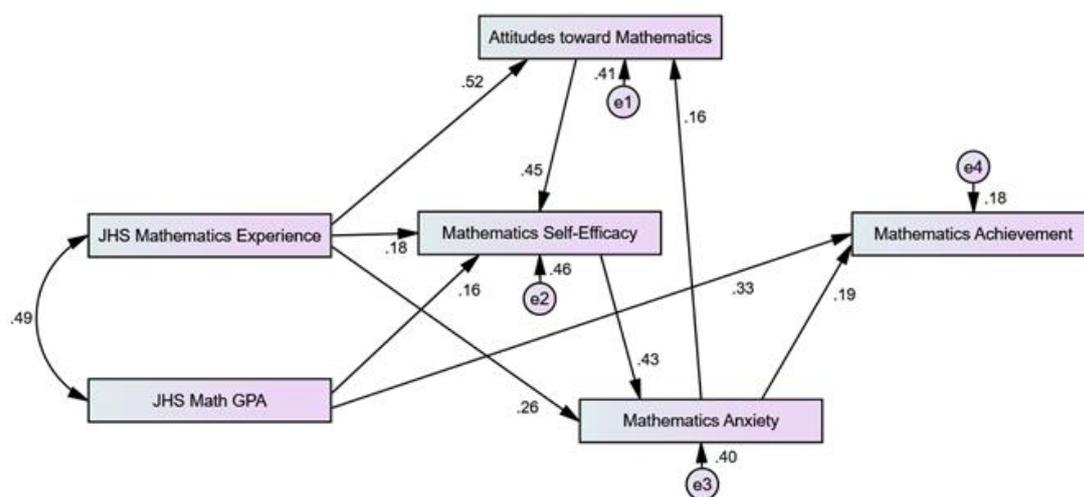
p	χ^2	df	χ^2/df	CFI	GFI	RMSEA
0.023	12.934	5	2.612	0.986	0.985	0.076

Results show that the squared multiple correlations (R^2) of 0.18 indicate that the model explained 18% of the total variance of students' mathematics achievement. This means that 18% of students' mathematics achievement is accounted for by the predictor variables in the model –JHS math experience, JHS math general point average, attitudes, self-efficacy, and anxiety in mathematics.

Table 4

Direct, Indirect, and Total Effects of Independent Variables on Students' Mathematics Achievement

Independent Variables	Direct Effect	Indirect Effect	Total Effect	R^2
JHS Math Experience	0.00	0.08	0.08	
JHS Math GPA	0.33	0.01	0.34	
Attitudes toward Mathematics	0.00	0.04	0.04	0.18
Mathematics Self-Efficacy	0.00	0.08	0.08	
Mathematics Anxiety	0.19	0.01	0.20	

Also of particular interest is the covariance between JHS mathematics experience and JHS mathematics general point average. Notably, these two variables tend to operate in tandem, with students who report having a positive and excellent math experience also achieving higher math GPAs. This suggests that mathematics experience is essential to student's academic performance during high school. The significance of mathematics experience with students' achievement aligns with previous research. For instance, Acharya (2017) conducted a study that revealed a similar trend. According to Acharya, students who lacked sufficient knowledge and did not have a desire to learn were less likely to succeed in higher levels of education. These findings highlight the importance of creating a positive learning environment and engaging students in meaningful math experiences. Educators and policymakers should consider strategies to enhance students' math experiences, which could lead to improved math performance and academic success.

Upon further analysis of the table, it becomes evident that only two hypothesized causal factors have demonstrated significant direct effects on students' mathematics achievement: Junior High School (JHS) mathematics GPA and mathematics anxiety. This finding conforms to the study of Riboroso et al. (2018), which suggests that students who excelled in mathematics in previous years tend to have a more positive attitude towards the subject at higher levels due to their solid foundational knowledge. Likewise, the finding also emanates from the study (Lou et al., as cited by Siebers, 2015), which shows that the better a student's mathematics performance is, the less mathematics anxiety they experience, and the worse a student's performance, the more mathematics anxiety they exhibit.

The significance of JHS mathematics GPA highlights the importance of a solid mathematical background acquired during earlier education. Students who perform well in mathematics during their junior high school years are more likely to influence their mathematics achievement in subsequent levels of education positively. This emphasizes the need for effective mathematics instruction and support at an early stage to establish a strong foundation. Moreover, the relationship between mathematics anxiety and achievement suggests that students' performance in mathematics is intertwined with their level of anxiety toward the subject. The findings indicate that anxiety levels tend to decrease as students' mathematical abilities improve. Conversely, students who struggle with mathematics are more prone to experiencing heightened anxiety. This supports the notion that addressing and reducing mathematics anxiety can enhance students' mathematics achievement.

Though mathematics self-efficacy and attitudes toward mathematics were hypothesized and significantly related to mathematics achievement, it is surprising to note that self-efficacy and attitudes failed to exhibit any direct effect on mathematics achievement. Nevertheless, these two predictor variables are particularly noteworthy.

First, mathematics self-efficacy is indirectly related to mathematics achievement with an indirect effect of 0.08. This suggests that mathematics self-efficacy work indirectly through mathematics anxiety. Though math self-efficacy failed to have a direct effect, it was pointed out by Kargar (2010) that math self-efficacy is a strong predictor of math anxiety, which affects students' achievement. It was also noted by Olango (2016) that math anxiety could predict self-efficacy directly and achievement indirectly through the self-efficacy factors. Thus, it suggests that students with high math self-efficacy tend to experience lower math anxiety, ultimately leading to improved mathematics achievement.

Second, attitudes toward math have an indirect effect, indicated by a magnitude of 0.04. This shows that math attitudes operate through the mediating factors of math self-efficacy and math anxiety. Consequently, students with positive attitudes are linked with higher math self-efficacy and reduced anxiety levels, resulting in better mathematics achievement.

Meanwhile, JHS math experience is also indirectly related to mathematics achievement with an effect size of 0.08. This finding demonstrates that math experience works indirectly through math anxiety. Allen's (2001) study supports this observation, highlighting a significant correlation between math experience and anxiety. These findings overwhelmingly suggest that students with a strong foundation in JHS math experience tend to exhibit lower levels of math anxiety, ultimately leading to higher mathematics achievement.

In summary, the path analysis results revealed that JHS mathematics GPA is the most potent variable effect on students' mathematics achievement, as proved by the total effect of 0.34. This finding emanates from the study of Stewart (2000) on the ecological model of family, individual, and school effects on academic achievement that the significant factor that determined the students' academic achievement was their previous achievement. It was further pointed out by Muir (2012) that high school preparation is undoubtedly relevant to the success of higher levels. Furthermore, the weakest variable's effect on students' mathematics performance is their attitudes toward the subject, as attested by the total effect of 0.04. Though it has the weakest variable effect, it must be noted that attitudes toward mathematics are significant to students' self-efficacy (Schenkel, 2009), indirectly affecting mathematics achievement.

Conclusions

In light of the study's findings, the following conclusions have been drawn: (1) Students had a good learning experience in mathematics and had a very satisfactory performance in Junior High School. Students also had neither positive nor negative attitudes toward mathematics, were confident in performing math-related tasks, and had minimal anxiety in mathematics; (2) The Senior High School students performed satisfactorily in mathematics; (3) The students' mathematics achievement was statistically and positively significant to JHS mathematics experience, JHS mathematics general point average, attitudes, self-efficacy, and anxiety in

mathematics; and (4) The path model revealed that the students' mathematics achievement was influenced directly by JHS mathematics GPA and mathematics anxiety; and indirectly by JHS mathematics experience, attitudes, and self-efficacy. It was also revealed that JHS math GPA was the strongest variable effect on students' mathematics achievement.

Recommendations

From the findings and conclusions made through this study, the researcher recommends that mathematics teachers find ways to develop students' positive attitudes toward math and boost their mathematics self-efficacy through effective teaching strategies combined with motivational techniques. School administrators, guidance counselors, and teachers should also find ways (i.e., psychological interventions) to lower the students' mathematics anxiety which can help improve students' mathematics performance. Certain interventions (e.g., remedial classes, enrichment classes, technological interventions, hands-on activities) must be prepared for students with low performance to ensure their understanding of learning competencies in mathematics, considering the different significant factors. Consequently, mathematics teachers may also continue developing basic mathematics skills and building the foundations at the Junior High School level necessary for understanding higher math levels. Furthermore, a parallel study may be conducted, including other factors that affect the students' mathematics achievement, like teacher-related and school-related factors. Lastly, a parallel study may be conducted with different environmental settings considering different population numbers to verify the path model.

References

Acharya, B. R. (2017). Factors affecting difficulties in learning mathematics by mathematics learners. *International Journal of Elementary Education, 6*(2), 8-15.

Aldrup, K., Klusmann, U., & Lüdtke, O. (2020). Reciprocal associations between students' mathematics anxiety and achievement: Can teacher sensitivity make a difference? *Journal of Educational Psychology, 112*(4), 735–750. https://doi.org/10.1037/edu0000398

Allen, D. (2001). Mathematics experience: contributing factors to the math anxiety and avoidance behaviors of female elementary school pre-service teachers.

Al-Agili, M., Mamat, M., Abdullah M. L. & Maad, H. A. (2013). Path analysis of the factors influencing students' achievement in mathematics.

Ashcraft, M.H. (2002). Math anxiety: personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185.

Awang, Z. (2012). Evaluating the fitness of a measurement model.

Ayebale, L., Habaasa, G., & Tweheyo, S. (2020). Factors affecting students' achievement in mathematics in secondary schools in developing countries: a rapid systematic review.

Balbalosa, J. F. (2010). Factors affecting mathematics performance of high school students at Quezon Colleges of Southern Philippines year 2015-2016.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs.

Bayaga, A. & Wadesango, N. (2014). Analysis of students' attitudes on mathematics achievement-factor structure approach. *Int J Edu Sci, 6*(1), 45-50.

Cadorna, E. A., Taban, J. G., & Gavino, M. (2016). Pathological fear of students in mathematics: Gender differences. *Asia Pacific Journal of Social and Behavioral Sciences*, *13*(16), 1-13.

Capuno, R., Necesario, R., Etcuban, J., Espina, R., Padillo, G., & Manguilimotan, R. (2019). Attitudes, Study Habits, and Academic Performance of Junior High School Students in Mathematics. *International Electronic Journal of Mathematics Education, 14*(3), 547-561. https://doi.org/10.29333/iejme/5768

Casinillo, L., Palen, M., Casinillo, E., & Batidor, P. (2020). Assessing Senior High Student's Learning Experiences in Mathematics. *Indonesian Journal of Educational Studies, 23*(1). https://doi.org/10.26858/IJES.V23I1.13437

Chen, You-Shyang & Cheng, Ching-Hsue. (2013). Assessing mathematics learning achievement using hybrid rough set classifiers and multiple regression analysis. *Applied Soft Computing, 13*, 1183–1192. https://doi.org/10.1016/j.asoc.2012.10.013

De la Rosa, N. (2017). A path analysis exploration of teacher's effect, self-efficacy, demographic factors, and attitudes toward mathematics among college students attending s minority serving institution in face-to-face and hybrid mathematics courses.

Enu, J., Agyma, O., & Nkum, D. (2015). Factors influencing students' mathematics performance in some selected Colleges of Education in Ghana. *International Journal of Education Learning and Development, 3*(3), 68-74.

Fhloinn, E., Fitzmaurice, O., Bhaird, C., & O'Sullivan, C. (2014). Student perception of the impact of mathematics support in higher education. *International Journal of Mathematical Education in Science and Technology, 45*(7), 953-967.

Finlayson, M. (2014). Addressing math anxiety in the classroom. Improving Schools. https://doi.org/10.1177/1365480214521457.

Fitzallen, N., et al. (2014). Factors influencing mathematics achievement among secondary school students: A review. *The Future of Educational Research,* 227–238.

Fuller, N. T. (2009). *Performance of the second year students of UNP Laboratory High School* (Unpublished master's thesis). University of Northern Philippines, Vigan City, Ilocos Sur.

Hajilan, K. (2016). Path analysis on the performance of educators in Mindanao State University-Tawi Tawi College of Technology and Oceanography. *International Journal of Scientific & Engineering Research, 15*(4), 11-21.

Hijazi, S. T. & Raza Naqvi, S. M. M. (2006). Factors affecting students' performance: A case of private colleges. *Bangladesh e-Journal of Sociology, 3*(1).

Kargar, et al. (2010). Relationship between mathematical thinking, mathematics anxiety and mathematics attitudes among University students. *Procedia Social and Behavioral Sciences 8,* 537-542.

Kitsantas, A., Cheema, J., & Ware, H. (2011). Mathematics achievement: The role of homework and self-efficacy beliefs. Journal of Advanced Academics, 22(2), 310–339. https://doi.org/10.1177/1932202X1 102200206

Lai, Y., Zhu, X., Chen, Y., & Li, Y. (2015). Effects of Mathematics Anxiety and Mathematical Metacognition on Word Problem Solving in Children with and without Mathematical Learning Difficulties. *PLoS ONE.* https://doi.org/10.1371/journal.pone.0130570

Liu, X. & Koirala, H. (2009). The effect of mathematics self-efficacy on mathematics achievement of high school students.

Llagas Jr., R.M. (2021). Prospective Filipino Teachers' Disposition to Mathematics. *Mathematics and Statistics, 9*(2), 93 - 97. https://doi.org/10.13189/ms.2021.090202

Mensah, J. K., et al. (2013). Student attitude towards Mathematics and performance: Does the teacher attitude matter?

Muir, C. (2012). An analysis of final course grades in two different entry level of mathematics courses between and among first year college students with different levels of high school mathematics preparation. *Educational Administration: Theses, Dissertations, and Student Research, 102.*

Olango, M. (2016). Mathematics anxiety factors as predictors of mathematics self-efficacy and achievement among freshmen science and engineering students. *African Educational Research Journal, 4*(3), 109-123.

Pajares, F., & Kranzler, J. (1995). Self-efficacy beliefs and general mental ability in mathematical problem-solving. *Contemporary Educational Psychology, 20*(4), 426–443. https://doi.org/10.1006/ceps.1995.1029

Pajares, F. & Miller, M. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: a path analysis. *Journal of Educational Psychology 86*(2), 193-203.

Riboroso, R., Restituto, L. Jr., & Taan, J. L. (2018). Mathematics self-efficacy and anxiety of Elementary Education students. *International Journal of Scientific & Engineering Research, 9*(11), 671-687.

Sa'ad, T., Adamu, A., & Sadiq, A. (2014). The Causes of Poor Performance in Mathematics among Public Senior Secondary School Students in Azare Metropolis of Bauchi State, Nigeria. *IOSR Journal of Research & Method in Education, 4*(6).

Schenkel, B. (2009). The impact of an attitude toward mathematics on mathematics performance.

Siebers, W. (2015). The relationship between math anxiety and student achievement of Middle School students.

Siswanti, D.N., & Djalal, N.M. (2018). The effect of self-efficacy to mathematical anxiety on Junior High School students of YDM Learning Guidance Course Makassar.

Stage, F. K., Carter, H. C. & Nora, A. (2004) Path analysis: An introduction and analysis of a decade of research. *The Journal of Educational Research*, *98*(1), 5-13.

Stewart, E. B. (2000). An ecological perspective of science and math academic achievement among African American students. *Retrospective Theses and Dissertations.* 12286.

Suhas, P. S. & Pandya , S. (2016). Factors influencing students' academic performance in mathematics. *International Journal of Education and Applied Social Sciences, 7*(3) 291-298.

Usher, E. & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Contemporary Educational Psychology, 34*(1), 89-101.

Vukovic, R., Roberts, S., & Wright, L. G. (2013). From parental involvement to children's mathematical performance: The role of mathematics anxiety.

Wong, K., & Chen, Q. (2012). Nature of an "Attitudes toward Learning Mathematics Questionnaire." *Mathematics Education Research Group of Australasia Inc.*