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A Data-Driven Approach to Mathematics Pedagogy in Bac Giang: Identifying Key Influences on Student Performance

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Abstract

This research aims to identify and quantify the relative impact of key factors influencing mathematics student performance in Bac Giang province, Vietnam. A quantitative research design was employed, utilizing a survey instrument based on a 5-point Likert scale. Participants included 500 mathematics students from 40 high schools in Bac Giang. Data analysis involved Cronbach's Alpha for reliability, Exploratory Factor Analysis (EFA) to identify underlying factors, and Ordinary Least Squares (OLS) regression to assess relationships with self-reported student performance, which, it must be noted, was also measured using a Likert Scale. The EFA revealed five key factors: Teacher Quality, Student Motivation, Learning Resources, Parental Involvement, and Classroom Environment. The OLS regression model was statistically significant, explaining 66.3% of the variance in self-reported student performance. All five factors were statistically significant positive predictors, with Teacher Quality demonstrating the most substantial relative impact. The findings highlight the multifactorial nature of perceived mathematics achievement and suggest that interventions targeting teacher quality, student motivation, resource provision, parental engagement, and classroom environment are likely beneficial. However, the reliance on self-reported performance as the dependent variable is a significant limitation, and future research should incorporate objective achievement measures. These results, nevertheless, provide a data-driven basis for pedagogical and policy recommendations in Bac Giang's specific context.

Keywords: *Mathematics Education, Student Performance, Bac Giang, Self-Reported Achievement, Factor Analysis, Regression Analysis.*

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INTRODUCTION

Mathematics education is a critical foundation for individual cognitive development and societal progress. Proficiency in mathematics equips students with essential skills in logical reasoning, problem-solving, and critical thinking, which are vital for success in a wide range of academic disciplines and future careers (National Council of Teachers of Mathematics, 2000). Moreover, a strong mathematical foundation is increasingly crucial in a technologically driven world, contributing to innovation, economic growth, and national competitiveness (OECD, 2013).

Vietnam, recognizing the importance of STEM education with mathematics as a central pillar, has prioritized improving educational quality and outcomes (MOET, 2018). However, disparities in student performance persist across different regions and socioeconomic groups, highlighting the need for targeted interventions and a deeper understanding of the factors influencing student achievement.

Bac Giang Province, a rapidly developing region in northern Vietnam, presents a unique context for examining mathematics education. The province faces specific challenges, including a diverse student population with varying levels of prior knowledge and rapid economic changes impacting family structures and educational priorities. These challenges can significantly impact student learning and create barriers to equitable educational outcomes. Notably, while Bac Giang has demonstrated remarkable success in other STEM fields, achieving a record-breaking three gold medals at the 2024 International Olympiads in Physics and Chemistry (Giap Vu Son Ha in Chemistry, and Than The Cong and Truong Phi Hung in Physics, all from Bac Giang Specialized Upper Secondary School), the province has not yet achieved comparable results in international Mathematics competitions. This discrepancy underscores the need for a focused investigation into the factors that influence mathematics performance in Bac Giang to identify potential areas for improvement and develop strategies to elevate mathematics achievement to the same level as other STEM subjects.

While numerous factors can influence student performance in mathematics, a comprehensive understanding of the specific factors at play in Bac Giang is essential for developing effective strategies to improve teaching and learning. This study focuses on five key factors consistently identified in the literature as significant influences on student achievement: teacher quality, student motivation, learning resources, parental involvement, and classroom environment.

Literature Review

This literature review examines the existing body of research on factors influencing student performance in mathematics, focusing on five key areas: teacher quality, student motivation, learning resources, parental involvement, and classroom environment. It synthesizes findings from various studies, explores relevant theoretical frameworks, and identifies gaps in the literature, particularly concerning the specific context of Bac Giang province, Vietnam.

Teacher quality is widely recognized as one of the most significant school-related factors affecting student achievement (Darling-Hammond, 2000; Rivkin et al.., 2005; Hattie, 2009). Effective mathematics teachers possess a deep understanding of mathematical content (Ball et al., 2008) and pedagogical content knowledge (Shulman, 1986) – the ability to effectively teach mathematical concepts to diverse learners. This includes skills in explaining concepts clearly, providing constructive feedback, using various instructional strategies, and adapting instruction to meet individual student needs (Hill et al., 2005). Teacher qualifications, such as certification and subject-matter expertise, have been linked to improved student outcomes (Goldhaber & Brewer, 2000). However, the relationship is complex and may depend on the specific context. Professional development is crucial for improving teacher quality, particularly in evolving curricula and pedagogical approaches (Guskey, 2000). Studies suggest that effective professional development should be sustained, content-focused, and collaborative, providing teachers with opportunities to learn from each other and reflect on their practice (Desimone, 2009). We formulate the following hypothesis regarding the relationship between teacher quality and student performance in mathematics:

> **H1:** Teacher quality is positively related to student performance in mathematics.

Student motivation is a critical factor in academic engagement and achievement. Self-Determination Theory (SDT) (Ryan & Deci, 2000) provides a widely used framework for understanding student motivation. SDT distinguishes between intrinsic motivation (doing something for its inherent satisfaction) and extrinsic motivation (doing something for external rewards or to avoid punishment). Intrinsic motivation, fostered by feelings of competence, autonomy, and relatedness, is generally associated with deeper learning and higher achievement (Deci & Ryan, 2000). Students' self-efficacy, or belief in their ability to succeed in mathematics, also plays a crucial role (Bandura, 1997; Pajares, 1996). High self-efficacy is linked to more significant effort, persistence, and resilience in facing challenges. The perceived value of mathematics in terms of its intrinsic interest and its instrumental value for future goals also influences student motivation (Wigfield & Eccles, 2000). Students who see mathematics as relevant and vital are more likely to engage in learning. Factors affecting motivation are also culturally specific and require additional study in different localities. In summary, we posit that student motivation can have a positive correlation with student performance in mathematics, as delineated below:

> **H2:** Student motivation is positively related to student performance in mathematics.

Access to adequate learning resources, including textbooks, technology, manipulatives, and other instructional materials, is essential for effective mathematics instruction (Sirin, 2005; National Research Council, 2001). High-quality textbooks aligned with curriculum standards and providing clear explanations and practice opportunities can support student learning (Schmidt et al., 2001). Technology, such as computers, calculators, and educational software, can enhance mathematics instruction by providing interactive learning experiences, visualizations, and opportunities for data analysis (Li & Ma, 2010). However, the effectiveness of technology depends on how it is integrated into instruction and teachers' ability to use it effectively (Roschelle et al., 2000). Disparities in resource access, often linked to socioeconomic status, can contribute to achievement gaps between students (Condron, 2009). Therefore, we posit that learning resources can be positively linked to student performance in mathematics, as in the following hypothesis:

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H3: Learning resources is positively related to student performance in mathematics.

Parental involvement in education has been consistently linked to improved student outcomes, including higher academic achievement, better attendance, and more positive attitudes toward school (Fan & Chen, 2001; Jeynes, 2007; Hill & Tyson, 2009). Parental involvement can take many forms, including helping with homework, communicating with teachers, attending school events, and creating a home environment that supports learning (Epstein, 1995). However, the most effective parental involvement types may vary across cultures and grade levels (Hoover-Dempsey & Sandler, 1997). For example, direct involvement in homework may be more beneficial in elementary than in high school. Cultural norms and parental beliefs about their role in education also influence the nature and extent of parental involvement (Huntsinger & Jose, 2009). Therefore, we propose the following hypothesis:

H4: Parental involvement is positively related to student performance in mathematics.

The classroom environment encompasses the learning space's social, emotional, and physical aspects and significantly impacts student engagement and learning (Fraser, 1998; Roorda et al., 2011). Effective classroom management, characterized by clear expectations, consistent rules, and positive reinforcement, creates a productive learning environment (Emmer & Evertson, 2013). Positive student-teacher relationships, characterized by warmth, respect, and trust, are associated with higher student motivation and achievement (Pianta, 1999). Opportunities for collaboration and peer interaction can also enhance learning, particularly in mathematics, where students can benefit from explaining their reasoning and working together to solve problems (Slavin, 1995; Webb, 1991). Therefore, we propose the following hypothesis:

H5: Classroom environment is positively related to student performance in mathematics.

While the literature provides extensive evidence on the importance of these five factors, several gaps remain. First, much of the research has been conducted in Western, developed countries, and the findings may not be generalized directly to other cultural contexts, such as Vietnam. Second, the relative importance of these factors may vary depending on the specific educational system, curriculum, and student population. Third, there is a need for more large-scale, quantitative studies that examine the combined effects of these factors and their interactions. Finally, few studies have specifically focused on the context of Bac Giang province, Vietnam. This study addresses these gaps by investigating the key influences on mathematics student performance in Bac Giang using a data-driven approach to identify and prioritize the most relevant factors for this specific context. The findings will contribute to a more nuanced understanding of the factors affecting mathematics education in a rapidly developing region of Vietnam and inform the development of targeted interventions and policies.

Figure 1 illustrates our research framework. It depicts the hypothesized relationships between the five independent variables (Teacher Quality - TQ, Student motivation - SM, Learning Resources - LR, Parental Involvement – PI, and Classroom Environment - CE) and the dependent variable (Student Performance in Mathematics - SPIM).

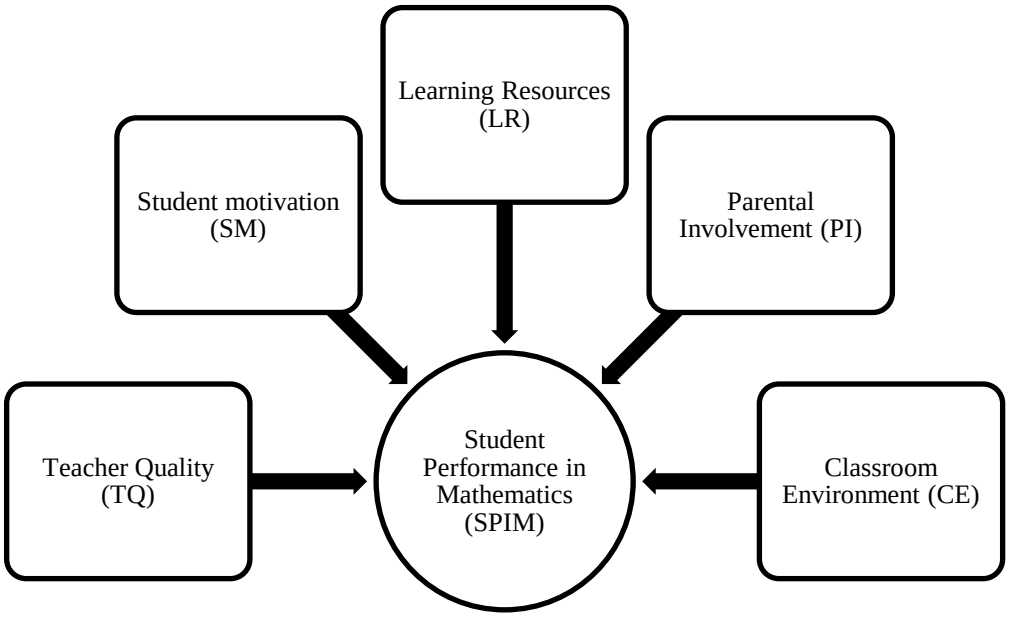

Figure 1. Research framework.

METHOD AND MATERIALS

Materials

This study employed a quantitative research design using a cross-sectional survey methodology to investigate the factors influencing mathematics student performance in Bac Giang province, Vietnam. The participants were 500 students studying mathematics at the high school level, grades 10-12, from all public and private high schools in Bac Giang province, Vietnam. The sample included students from all 37 public high schools and all three private high schools in the province. A stratified random sampling method was employed to ensure representation from each school proportionate to its student population. Students were randomly selected from mathematics classes across all grade levels within each school. Exclusion criteria included students with significant learning disabilities that would prevent them from completing the questionnaire and students who did not have parental consent for students under 18 or student assent for students 18 and over. Informed consent was obtained from parents for students under 18, and assent was obtained from all participating students.

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A self-administered questionnaire was developed based on a review of relevant literature and adapted to the local context of Bac Giang. The questionnaire employed a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to gauge student perceptions of various factors, including their self-assessed performance in mathematics. The questionnaire comprised several distinct sections. The first section focused on Teacher Quality. This section contained items designed to assess students' perceptions of their mathematics teachers' instructional practices. These items aimed to capture teacher clarity, feedback quality, and enthusiasm. Students were asked to rate their agreement with the following statements:

"My mathematics teacher understandably presents the material,"

"My mathematics teacher provides helpful feedback on my work,"

"My mathematics teacher makes an effort to understand my individual learning needs,"

Moreover, "My teacher seems genuinely excited about teaching mathematics."

The second section addressed Student Motivation. This section delved into the students' internal drive and attitudes toward mathematics. One aspect assessed was their enjoyment of the subject, with the statement, "Learning mathematics is something I find pleasurable." To gauge perceived relevance, students were asked to respond, "I see the importance of mathematics for my future goals." Another item focused on self-belief, prompting students to reflect, "I am capable of achieving high marks in mathematics." Finally, the questionnaire also explored students' dedication, stating, "I usually complete my Math homework.".

The third section explored Learning Resources. This section examined the availability and quality of resources supporting students' mathematics learning. Students agreed with the statement, "The necessary textbooks for my mathematics course are readily available to me." Access to technology was another focus, with the item, "I have the opportunity to use computers or other technology to assist in my mathematics learning." Furthermore, support was considered, prompting students to comment, "When I struggle with mathematics, I know where to find help." The suitability of materials was investigated, reflected in the statement "Materials used in the classroom match my learning ability.". Finally, home study was gauged by saying, "I have access to the internet for studying at home.".

The fourth section focused on Parental Involvement. This section included items designed to measure the extent and nature of parental support for students' mathematics education. These items sought to capture different aspects of parental involvement, from direct academic support to broader encouragement and values, and included:

"My parents assist when I am struggling with my mathematics homework."

"My parents motivate me to strive for excellence in mathematics,"

"There is regular communication between my parents and my mathematics teacher,"

Moreover, "Education is highly regarded within my family."

The fifth section investigated the Classroom Environment. This section explored the social and physical characteristics of the mathematics learning environment. One item focused on the atmosphere, prompting students to respond, "My mathematics classroom is where I feel safe and respected." The opportunity to participate was assessed with the statement, "I am encouraged to ask questions and express my ideas in mathematics class." Interactions with peers were also considered, reflected in the statement, "My classmates treat each other with kindness and consideration in mathematics class." Finally, classroom order was evaluated, prompting students to respond, "The rules and expectations in my mathematics class are applied consistently and justly.".

Finally, a section was included to measure Student Performance in Mathematics (Self-Reported). This section asked students to rate their performance in mathematics using the same 5-point Likert scale. Items include, "I am doing well in my mathematics class," "I understand most of the concepts taught in mathematics," "I am satisfied with my grades in mathematics," and "I get good marks on math tests and quizzes."

The questionnaires were administered to students in their classrooms by trained research assistants. Instructions were provided to ensure consistent understanding, emphasizing the importance of honest and thoughtful responses. The anonymity and confidentiality of student responses were assured, and students were informed that their participation was voluntary. The questionnaires were printed on paper and distributed to students in their regular mathematics classrooms. Completed questionnaires were collected by the research assistants immediately after the students finished. Students were given approximately 20-30 minutes to complete the questionnaire during class. This duration was determined based on a pilot test to ensure sufficient time for thoughtful responses without disrupting the class schedule.

Data Analysis

Cronbach's Alpha was calculated for each section of the questionnaire to assess internal consistency reliability. An EFA was conducted to identify the underlying factor structure of the questionnaire items for the independent variables. Items with factor loadings below 0.5 were considered for removal. OLS regression examined the relationship between the independent variables and self-reported student performance. The model was checked for multicollinearity (using Variance Inflation Factors - VIFs). Statistical analyses were performed using SPSS 20.

RESULTS

Demographics Descriptive Statistics

The sample consisted of 500 students from 40 schools in Bac Giang province. Table 1 presents the demographic characteristics of the participants.

Table 1. Demographic Characteristics of the Sample

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	237	47.4
	Female	263	52.6
Grade Level	Grade 10	158	31.6

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	Grade 11	173	34.6
	Grade 12	169	33.8
School Type	Public	443	88.6
	Private	57	11.4
Parental Education (Highest Level)	Less than High School	53	10.6
	High School Diploma	197	39.4
	Bachelor's Degree	154	30.8
	Graduate Degree	96	19.2

Data source processed by the researcher (2024)

As shown in Table 1, the sample was relatively balanced in gender, with slightly more female participants (52.6%) than male participants (47.4%). The sample included students from grades 10, 11, and 12, with a relatively even distribution across the grade levels. Most students (88.6%) attended public schools, while 11.4% attended private schools. The parental education level varied, with the most common highest level being a High School Diploma (39.4%).

Reliability Analysis

To assess internal consistency reliability, Cronbach's Alpha was calculated for each scale (the five independent variables and the self-reported performance scale). The results are presented in Table 3. All scales demonstrated acceptable internal consistency, with Cronbach's Alpha values ranging from 0.759 to 0.811. This indicates that the items within each scale reliably measure the same underlying construct.

Table 2. Cronbach's Alpha Values

Scale	Cronbach's Alpha	N
Teacher Quality	0.783	4
Student Motivation	0.794	4
Learning Resources	0.811	5
Parental Involvement	0.799	4
Classroom Environment	0.795	4
Student Performance in Mathematics (Self-Reported)	0.759	4

Data source processed by the researcher (2024)

Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) was conducted on the items measuring the five independent variables. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.70, indicating that the data were suitable for factor analysis. Bartlett's test of sphericity was significant ($\chi^2 = 3909.0$, $p < 0.001$), indicating that the correlations between items were sufficiently significant for factor analysis. As hypothesized, the EFA resulted in a five-factor solution explaining 61.2% of the total variance. Table 4 presents the factor loadings after rotation. Items with factor loadings of 0.5 or greater were retained on a factor**.** The five factors were interpretable and corresponded to the hypothesized constructs: Teacher Quality, Student Motivation, Learning Resources, Parental Involvement, and Classroom Environment.

Table 3. Factor Loadings from EFA

Item	Factor 1 (Learning Resources)	Factor 2 (Parental Involvement)	Factor 3 (Student Motivation)	Factor 4 (Classroom Environment)	Factor 5 (Teacher Quality)
LR3	0.868				
LR4	0.820				
LR2	0.806				
LR1	0.622				
LR5	0.615				
PI3		0.847			
PI2		0.847			
PI1		0.758			
PI4		0.701			
SM2			0.871		
SM3			0.842		
SM1			0.776		
SM4			0.621		
CE2				0.875	
CE3				0.858	
CE1				0.745	

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CE4				0.652	
TQ2					0.859
TQ3					0.850
TQ1					0.697
TQ4					0.681

Data source processed by the researcher (2024)

OLS Regression

OLS regression examined the relationship between the five independent variables (factor scores derived from the EFA) and self-reported student performance (the dependent variable). The model was checked for multicollinearity, heteroscedasticity, and normality of residuals.

The OLS regression model was statistically significant ($F(5;494) = 194.540$, $p < 0.001$), explaining 66.3% of the variance in self-reported student performance (R-squared = 0.663, Adjusted R-squared = 0.660). Teacher Quality ($\beta = 0.526$, $p < 0.001$), Student Motivation ($\beta = 0.452$, $p < 0.001$), Learning Resources ($\beta = 0.192$, $p < 0.001$), Parental Involvement ($\beta = 0.298$, $p < 0.001$), and Classroom Environment ($\beta = 0.086$, $p = 0.001$) were all statistically significant positive predictors of self-reported student performance. Teacher Quality has the most significant standardized beta coefficient (0.526), suggesting it has the most substantial relative impact on self-reported performance in this model.

Table 4. Results of OLS Regression Analysis

Independent Variable	B	Standard Error	Standardized Coefficients Beta (β)	t-value	p-value	VIF
(Constant)	-0.132	0.126		-1.049	0.295	
Teacher Quality	0.345	0.017	0.526	19.967	< 0.001	1.018
Student Motivation	0.292	0.017	0.452	17.217	< 0.001	1.012
Learning Resources	0.134	0.018	0.192	7.336	< 0.001	1.009
Parental Involvement	0.195	0.017	0.298	11.375	< 0.001	1.008
Classroom Environment	0.055	0.017	0.086	3.274	0.001	1.002
R-squared =			0.663			
Adjusted R-squared =			0.660			
F-statistic =			194.540		p<0.001	

Data source processed by the researcher (2024)

DISCUSSION

This study investigated the key factors influencing self-reported mathematics student performance in Bac Giang province, Vietnam. It focused on teacher quality, student motivation, learning resources, parental involvement, and classroom environment. The findings provide strong empirical support for the importance of all five factors in predicting students' perceptions of their mathematics achievement.

The OLS regression model revealed that a substantial 66.3% of the variance in self-reported student performance was explained by the five predictor variables, a remarkably high proportion in educational research. This suggests that these factors, in combination, play a crucial role in shaping how students perceive their success in mathematics. All five factors – Teacher Quality, Student Motivation, Learning Resources, Parental Involvement, and Classroom Environment – emerged as statistically significant positive predictors, even when controlling for the other factors in the model. This highlights the multifaceted nature of student achievement and suggests that interventions to improve mathematics education should adopt a holistic approach.

The most striking finding was the strong influence of **Teacher Quality**, which had the most significant standardized beta coefficient ($\beta = 0.526$, $p < 0.001$). This result aligns with a substantial body of existing research emphasizing the critical role of teachers in student learning (Darling-Hammond, 2000; Hattie, 2009; Rivkin et al., 2005). The findings suggest that students in Bac Giang who perceive their teachers as knowledgeable, evident in their explanations, providing helpful feedback, and demonstrating enthusiasm for mathematics are likelier to report higher performance levels. This underscores the importance of investing in teacher training, professional development, and recruiting highly qualified mathematics teachers in the region.

Student Motivation also emerged as a powerful predictor ($\beta = 0.452$, $p < 0.001$), consistent with Self-Determination Theory (Ryan & Deci, 2000) and research highlighting the link between motivation, engagement, and achievement (Wigfield & Eccles, 2000). Students who are intrinsically interested in mathematics, believe it is important for their future, and have confidence in their abilities are likelier to perceive themselves as successful. This suggests that fostering a positive learning environment that cultivates student interest and self-efficacy in mathematics is crucial.

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Parental Involvement showed a significant positive relationship with self-reported performance ($\beta = 0.298$, $p < 0.001$), supporting previous research on the benefits of parental support for academic achievement (Fan & Chen, 2001; Jeynes, 2007). This finding suggests that strategies to encourage and facilitate parental involvement, such as regular communication between teachers and parents, workshops for parents on supporting their children's learning, and creating a home environment that values education, could benefit Bac Giang.

Learning Resources also contributed significantly to the model ($\beta = 0.192$, $p < 0.001$), aligning with research demonstrating the importance of adequate resources for effective learning (Sirin, 2005; National Research Council, 2001). This highlights the need to ensure that students in Bac Giang have access to high-quality textbooks, technology, and other learning materials at school and at home. Addressing resource disparities between schools and socioeconomic groups should be a priority.

Finally, **Classroom Environment** was a statistically significant predictor ($\beta = 0.086$, $p = 0.001$), although its effect size was smaller than the other factors. This finding is consistent with research emphasizing the importance of a positive and supportive learning environment for student engagement and well-being (Fraser, 1998; Roorda et al., 2011). While the effect was minor, it still suggests the value of fostering positive student-teacher relationships, promoting respectful peer interactions, and creating a safe and orderly classroom climate.

Limitations

It is crucial to acknowledge this study's limitations. The most significant limitation is the reliance on self-reported student performance as the dependent variable. This introduces the potential for bias, as students' perceptions of their performance may not accurately reflect their achievement. Social desirability bias, where students may overreport their performance to present themselves in a positive light, is a particular concern. Future research should incorporate objective measures of student achievement, such as standardized test scores or course grades, to provide a more valid performance assessment.

The study's cross-sectional design also limits the ability to draw causal inferences. While the findings demonstrate strong associations between the five factors and self-reported performance, they cannot establish cause-and-effect relationships. Longitudinal studies that track students over time are needed to understand better the temporal dynamics between these factors and student achievement.

Furthermore, all data were collected through a single questionnaire, raising the possibility of common method bias, which can artificially inflate the correlations between variables. Future research could employ multiple data sources, such as teacher reports and administrative data, to mitigate this concern. Finally, the findings are specific to the context of Bac Giang province and may not be generalizable to other regions or countries.

Implications and Future Research

Despite these limitations, the study provides valuable insights into the factors influencing students' perceptions of their mathematics performance in Bac Giang. The findings suggest that a multifaceted approach targeting teacher quality, student motivation, learning resources, parental involvement, and classroom environment will likely be most effective in improving mathematics education in the region.

Investing in teacher quality: A multifaceted approach to enhancing teacher quality is paramount. This should include substantial investments in ongoing professional development for mathematics teachers. Professional development programs should move beyond one-off workshops and instead offer sustained, collaborative learning opportunities that are directly linked to the curriculum and the specific needs of Bac Giang teachers. These programs should prioritize the development of pedagogical content knowledge, enabling teachers to understand mathematical concepts deeply and effectively translate that knowledge into engaging and accessible lessons for students of varying abilities. Training should also focus on effective instructional strategies, such as differentiated instruction, inquiry-based learning, and technology to enhance mathematics instruction. Furthermore, mentorship programs pairing experienced and highly effective mathematics teachers with newer teachers could provide valuable support and guidance. Finally, recruiting and retaining highly qualified mathematics teachers, potentially through incentives such as scholarships, housing assistance, or competitive salaries, should be a priority.

Fostering student motivation: Cultivating intrinsic motivation in mathematics requires creating an engaging, relevant, and supportive learning environment. Teachers should strive to make mathematics more enjoyable and relatable to students' lives by incorporating real-world applications, hands-on activities, and collaborative projects. Emphasizing the utility of mathematics for future careers and educational opportunities can also enhance its perceived value. Building students' self-efficacy, or their belief in their ability to succeed, is equally crucial. This can be achieved by providing students with opportunities for success, offering constructive feedback that focuses on effort and progress rather than just outcomes, and creating a classroom culture where mistakes are seen as learning opportunities rather than failures. Promoting a growth mindset, where students believe their mathematical abilities can be developed through effort and perseverance, is also essential.

Enhancing learning resources: Equitable access to high-quality learning resources is fundamental for all students. This requires ensuring that all schools in Bac Giang have sufficient textbooks, workbooks, and other essential learning materials aligned with the curriculum. Expanding access to technology, including computers, tablets, and reliable internet connectivity, is also critical, particularly in rural or underserved areas. This technology should be integrated thoughtfully into mathematics instruction, using interactive software, simulations, and online resources to enhance learning and provide personalized support. Furthermore, creating or expanding access to tutoring programs and after-school support can provide additional assistance to struggling students.

Promoting parental involvement: Actively engaging parents in their children's mathematics education is crucial. Schools should establish regular communication channels with parents, providing updates on student progress, sharing information about the mathematics curriculum, and offering suggestions for how parents can support learning at home. Workshops and training sessions for parents could be organized to equip them with the skills and knowledge to help their children with mathematics homework and to foster positive attitudes towards the subject. Creating a welcoming school environment that encourages parental participation in school events and activities can also strengthen the home-school connection. Furthermore, efforts should be made to address any cultural or linguistic barriers hindering parental

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involvement, ensuring that all parents feel empowered to support their children's education.

Creating positive classroom environments: Fostering a positive and supportive classroom climate is essential for student engagement and well-being. This requires implementing effective classroom management strategies that promote respect, responsibility, and a sense of belonging. Teachers should establish clear expectations for behavior, apply rules consistently and fairly, and use positive reinforcement to encourage positive interactions. Building strong student-teacher relationships characterized by trust, empathy, and open communication is also crucial. Creating collaboration and peer learning opportunities, such as group projects and peer tutoring, can enhance student engagement and provide valuable social and academic support. Addressing bullying or harassment promptly and effectively is essential for creating a safe and inclusive learning environment.

These recommendations, while ambitious, provide a roadmap for improving mathematics education in Bac Giang province. By focusing on these key areas, educators, policymakers, and parents can work together to create a more equitable and effective learning environment that empowers all students to reach their full potential in mathematics.

Future research should address this study's limitations by incorporating objective measures of student achievement, employing longitudinal designs, using multiple data sources, and exploring the potential mediating and moderating effects of other variables such as student demographics, socioeconomic status, and school characteristics. Qualitative research, such as interviews and classroom observations, could provide richer insights into the complex dynamics between these factors and student learning. Investigating the specific teaching practices that contribute to teacher quality in the Bac Giang context would also be valuable.

In conclusion, this study provides a data-driven foundation for improving mathematics education in Bac Giang province. By addressing the identified key factors, educators and policymakers can work toward creating a more equitable and effective learning environment for all students, fostering their mathematical abilities and preparing them for future success.

CONCLUSION

This study provides compelling evidence for the multifaceted nature of student achievement in mathematics, highlighting the significant influence of teacher quality, student motivation, learning resources, parental involvement, and classroom environment on self-reported student performance in Bac Giang province, Vietnam. The findings demonstrate that these five factors, acting in concert, explain a substantial proportion of the variance in how students perceive their mathematical abilities. The powerful impact of teacher quality and student motivation underscores the importance of investing in teacher development and strategies to cultivate student engagement and interest in mathematics.

While the study offers valuable insights into the context of Bac Giang, it is essential to acknowledge its limitations. The reliance on self-reported student performance as the primary outcome measure introduces the potential for bias and may not fully capture actual achievement levels. The cross-sectional design precludes causal inferences, and the findings are specific to the sampled population. Future research should address these limitations by incorporating objective measures of student performance, employing longitudinal designs to track changes over time, and utilizing multiple data sources to provide a more comprehensive and robust understanding.

Despite these limitations, this research contributes significantly to understanding mathematics education in a rapidly developing region of Vietnam. The data-driven approach provides a strong empirical foundation for evidence-based decision-making and policy recommendations. By prioritizing investments in teacher quality, fostering student motivation, ensuring equitable access to learning resources, promoting parental involvement, and creating positive classroom environments, Bac Giang province can work towards significantly improving mathematics education and empowering all students to succeed. The findings of this study serve as a call to action, urging educators, policymakers, and parents to collaborate in creating a learning ecosystem that supports the mathematical development of all students and prepares them for the challenges and opportunities of the 21st century. Further research should continue to explore these complex relationships, focusing on identifying best practices and interventions tailored to the specific needs and cultural context of Bac Giang and other similar regions. The ultimate goal is to ensure that all students have the opportunity to develop a strong foundation in mathematics, enabling them to pursue their aspirations and contribute meaningfully to society.

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