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RESEARCH ARTICLE

Factors Influencing the Scientific Competency of High School Students: A Case Study in Northern Vietnam

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ABSTRACT

This study explores the factors influencing the scientific competency of high school students in Northern Vietnam. Using a quantitative approach, the research collected survey data from 380 students, employing exploratory factor analysis (EFA) and multivariate regression to identify and evaluate key factors. Five groups of factors were found to significantly affect scientific competency: individual factors, family factors, school factors, social factors, and personal motivation. Among these, school-related factors, including teaching quality and the learning environment, along with individual factors such as students' personal motivation and self-study skills, were identified as having the strongest impact on scientific competency. The regression analysis further confirmed that school factors exert the highest influence, with a standardized coefficient (β) of 0.708. Conversely, factors such as social influences showed lower statistical significance. This study provides empirical evidence to guide educational policy and instructional improvements in the Vietnamese context, suggesting that enhancements in teaching quality and student motivation can lead to better scientific outcomes. Additionally, the research underscores the need for targeted educational interventions aimed at improving scientific competency, with a focus on addressing the specific challenges faced by students in Northern Vietnam.

1. INTRODUCTION

1.1. Scientific competency and the interest in students' scientific competency in education in Vietnam

The concept of scientific competency is used to describe abilities related to activities such as questioning phenomena, scientifically interpreting data and evidence, and using scientific information for decision-making and action (Bybee et al., 2009; Muelle, 2020; White et al., 2023).

Scientific competency plays an important role because it allows individuals to gain a broader vision of the world, to reconcile their knowledge with real-world situations through critical, creative, and innovative thinking, which is highly effective for professionals. It promotes the application of basic competencies to understand reality and fosters the learning of science by taking into account the surrounding environment and the transition from theory to practice (Guzmán, Oliveros & Mendoza, 2017).

In the context of current global development, scientific competency in students plays a crucial role in equipping the younger generation with the necessary knowledge and skills to confront modern societal challenges. Particularly, as Vietnam strives to become a developed nation, the education system has shifted from content-based teaching to competency-based education, including scientific competency development (Ministry of Education and Training, 2018).

Focusing on scientific competency not only helps students gain a deeper understanding of natural and social phenomena but also contributes to the development of critical thinking, problem-solving skills, and decision-making based on data and evidence. In Vietnam, although the 2018 National General Education Curriculum has introduced reforms aimed at developing students' scientific competency, many challenges remain. Therefore, researching and identifying factors that affect students' scientific competency is essential, not only for improving teaching quality but also for creating educational strategies tailored to specific regions and groups of students.

1.2. The research area

Vietnam is geographically divided into three regions: North, Central, and South. Each region has its own distinct economic, cultural, and social characteristics, yet all share the common cultural identity of the Vietnamese people. In Northern Vietnam, there are areas with strong economic, cultural, and social development, particularly in cities like Hanoi and Hai Phong, which offer favorable conditions for students to develop scientific competency (General Statistics Office of Vietnam, 2023, p. 118). However, the North also includes mountainous, remote, and rural areas where economic and educational opportunities are more limited. This diversity makes it essential to study the scientific competency of students in the North to understand the unique challenges and strengths of this region, enabling the development of targeted policies and interventions that ensure equitable access to quality science education for all students.

Northern Vietnam is geographically divided into three sub-regions: the Northeast, Northwest, and Red River Delta, comprising 25 provinces. The population of Northern Vietnam is primarily rural, with an average population density of about 450 people per square kilometer. This region has a total of 993 secondary schools with 28,175 classes and 1,164,010 students, including 601,649 female students and 211,577 ethnic minority students. On average, each class has about 40.5 students, and the student-teacher ratio is 20.3 (General Statistics Office of Vietnam, 2023, p. 899).

In the 2022-2023 academic year, Northern Vietnam faced a shortage of about 58,000 teachers out of the total 445,000 teachers currently available (Tuoi Tre Newspaper, 2023). The Red River Delta region had the lowest teacher-to-class ratio at the secondary school level (Public Policy Development, 2023). In terms of infrastructure, the Northern mountainous region had the lowest rate of permanent school facilities in the country (Ministry of Education and Training, 2023). At the lower secondary level, the rate of permanent classrooms exceeded 92.44%, and at the upper secondary level, the Northern mountainous provinces had a rate of over 95% for permanent classrooms. However, the availability of essential teaching equipment was still low; in the Northern midland and mountainous region, the lower secondary level met about 97% of the teaching equipment needs, while the upper secondary level met only about 51.6% (Mai et al., 2023; Ministry of Education and Training, 2023).

1.3. Research objectives and questions

The overall objective of this study is to explore and identify the factors affecting the scientific competency of high school students in Northern Vietnam. To achieve this goal, the study focuses on determining the factors that have the greatest impact on students' scientific competency and evaluating the extent of their influence. Based on these findings, the research will provide specific recommendations aimed at improving and enhancing students' scientific competency in the local educational context, thereby contributing to the overall development of science education quality in the region.

To address these objectives, the study will answer the following research questions:

1. What factors influence the scientific competency of high school students in Northern Vietnam?
2. To what extent do these factors impact the students' scientific competency?

These questions aim to clearly identify the influencing factors, thereby laying the foundation for proposing solutions to improve the teaching and learning of science subjects for high school students in the local area.

Để đưa ra câu hỏi này cần tổng quan những NC điều tra về NLKH hơn là những nhận định ở trên vì nó ít ăn nhập với câu hỏi đưa ra.

1.4. Significance of the research

Theoretically, this research deepens understanding of the factors influencing students' scientific competency in a specific context, expanding existing science education theories. It clarifies how cultural, social, and educational conditions impact students' competency within the Vietnamese education system, laying a foundation for future research in similar contexts. Practically, the study provides valuable data for educational managers, teachers, and policymakers to improve science education quality. The findings will help schools design more effective curricula, fostering comprehensive development of students' scientific skills and supporting efforts to enhance educational outcomes and human resource development in modern society.

2. LITERATURE REVIEW

2.1. Theoretical fframework

2.1.1. Scientific competency

Scientific competency encompasses a broad range of skills and abilities that allow individuals to apply scientific knowledge to identify problems, construct new knowledge, provide explanations, and draw conclusions based on evidence. It also includes the development of reflective thinking, enabling individuals to actively participate in resolving issues related to science (Mayasari & Usmeldi, 2023). These competencies are essential for students as they foster critical thinking, creativity, and innovation, which are crucial for their personal and professional development (Conel, 2021, Mardiana & Cahyani, 2018). The Programme for International Student Assessment (PISA) provides a robust framework for understanding scientific competency. According to PISA (2006), scientific competency is defined as the ability to use scientific knowledge to identify, explain, and draw conclusions about scientific phenomena and issues. This definition emphasizes understanding science as an inquiry-based process and the role science plays in shaping the natural world (Bybee et al., 2009). In the PISA (2018) framework, scientific competency is broken down into three key components:

1. **Explaining phenomena scientifically**: This involves recognizing, offering, and evaluating explanations for a range of natural and technological phenomena.
2. **Evaluating and designing scientific inquiry**: This refers to describing and appraising scientific investigations and proposing ways of addressing scientific questions.
3. **Interpreting data and evidence scientifically**: This competency includes analyzing and evaluating data, claims, and arguments presented in various forms and drawing scientifically appropriate conclusions (Muelle, 2020).

The upcoming PISA (2025) extends these competencies to include the ability to engage in reasoned discourse on topics related to science, sustainability, and technology. A scientifically educated individual should be able to explain phenomena, construct and evaluate designs for scientific inquiry, and critically interpret scientific data and evidence. This also includes obtaining and evaluating the credibility of scientific information related to specific global, local, or personal issues and using this information to make informed decisions (Muelle, 2020; White et al., 2023).

Scientific competency also involves a range of specific skills. These include the ability to recall and apply scientific knowledge, identify and evaluate models, and recognize and formulate explanatory hypotheses related to the material world. Students must also be able to identify research questions, propose appropriate experimental designs, and evaluate whether the designs are suitable for answering specific scientific questions. Additionally, the competency involves searching for, evaluating, and communicating the merits of different sources of information relevant to making decisions on scientific issues (Bybee et al., 2009; White et al., 2023).

Attitude plays a significant role in the development of scientific competency. Engaging with science-related issues and considering them critically, using both scientific knowledge and values, is a key aspect of scientific competency. The extent to which students engage in extracurricular and out-of-school science activities also contributes to their development of scientific competency. Students' enjoyment of learning about science, both in and out of school, is a strong indicator of their overall engagement and success in developing these competencies (White et al., 2023).

2.1.2. Factors affecting scientific competency

Understanding the factors that influence scientific competency is critical for educators and policymakers in fostering better learning environments. These factors, which span individual, familial, school, and societal domains, interact to shape students' ability to acquire and apply scientific knowledge effectively. Below, we explore each factor in detail.

Individual factors

Several individual traits play a vital role in shaping scientific competency. Learning motivation is one of the primary drivers, as students with high intrinsic motivation tend to perform better academically. Studies show a positive correlation between intrinsic motivation, curiosity, and students' academic performance in science (De-Silva et al, 2018; Jayawardena et al., 2020). Additionally, students' attitudes toward science—such as their willingness to engage with scientific issues and critically assess scientific information—also contribute significantly to their competency (White et al., 2023). Lastly, self-learning skills such as reading habits and creativity have been found to strongly influence scientific literacy. Students who engage in independent learning activities develop greater scientific competency compared to those who rely solely on teacher-directed learning (Mayasari & Usmeldi, 2023).

Family factors

The role of the family in developing scientific competency cannot be understated. Parental support, both financial and emotional, has been shown to positively impact students' achievement in science. Parents who provide additional tuition, motivate their children to study, and emphasize the applications of science in daily life contribute to higher academic performance (De-Silva et al., 2018). Moreover, parents' educational background is another influential factor. Children of parents with higher educational attainment often receive more help with homework and are exposed to a broader range of learning experiences (Jayawardena et al., 2020). Lastly, the family's socio-economic status significantly impacts students' performance. Students from higher socio-economic backgrounds tend to perform better in science due to greater access to resources and a more supportive home environment (Dudaite, 2016).

School factors

School-related factors, including teaching methods, facilities, and teacher qualifications, are critical to the development of scientific competency. Inquiry-based learning strategies have been particularly effective in promoting scientific reasoning and critical thinking skills (Krell et al., 2020). Schools that provide well-equipped laboratories and access to technology create environments that support the development of students' scientific skills (De-Silva et al., 2018). Moreover, the quality of teachers—especially their understanding of scientific literacy and the ability to teach inquiry-based methods—has been identified as a major determinant of students' scientific competency (Prinsloo & Harvey, 2018).

Social factors

Social influences, including peer groups and the broader community, also shape scientific competency. Peer learning environments, where students can discuss and explain scientific concepts to one another, foster deeper understanding and retention of scientific knowledge (Altun, 2015). Additionally, the community environment, particularly whether students live in urban or rural areas, impacts their access to scientific resources and opportunities. Students in urban settings generally have greater access to educational resources, leading to better academic outcomes in science (Dudaite, 2016).

In conclusion, scientific competency is shaped by a complex interplay of individual, familial, school, and social factors. Among these, school-related factors, such as teaching quality and resources, and individual factors, including motivation and self-learning skills, appear to exert the greatest influence. Recognizing and addressing these factors in educational policies and practices is essential for fostering the development of scientific literacy in students, ensuring they are well-equipped for future scientific challenges.

2.2. Research model

The research model in this study aims to examine the factors influencing the scientific competency of high school students. The dependent variable is defined as the students' scientific competency, measured through their average academic performance in science subjects, including Mathematics, Physics, Chemistry, Biology, Technology, and Technology. Given the structure of Vietnam's education system, where students are required to study Mathematics but have the option to select other science subjects based on their study combination, the research uses the average scores from four selected science subjects per the students' chosen study combination.

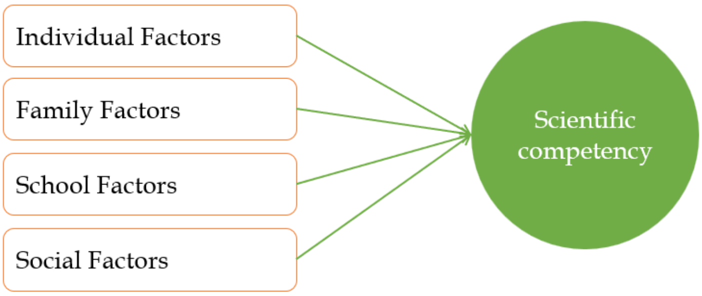

Figure 1: Research model

The independent variables in this study include individual, family, school, and social factors, all hypothesized to directly impact students' scientific competency. Individual factors cover learning motivation, attitudes, perceptions, and self-learning skills, which drive students' engagement and independent study. Family factors, such as parental involvement, educational background, and socio-economic status, are crucial to academic success. School factors involve the quality of teaching methods, teacher qualifications, and access to resources like laboratories, all essential for fostering scientific skills. Social factors include peer influence, community educational policies, and societal attitudes toward science, which shape students' competency.

The proposed research model illustrates the relationships between these independent variables and the dependent variable, scientific competency. To test these hypotheses, the study employs Exploratory Factor Analysis (EFA) to identify the underlying structure of the influencing factors and Regression Analysis to measure the impact of the independent variables on students' scientific competency. This model not only identifies the most significant factors but also provides a foundation for practical recommendations aimed at improving science education within the local context.

3. METHODOLOGY

3.1. Research design

This study adopts a quantitative research design aimed at measuring the factors that influence scientific competency among high school students in Northern Vietnam. A survey method was chosen to collect data due to its efficiency in gathering large amounts of information across multiple respondents in a relatively short time, and its ability to generalize the findings across the population. The research process consists of three main stages.

First, developing measurement instruments. A survey questionnaire was created based on the theoretical framework and prior studies to ensure that all questions align with the research objectives and accurately measure the identified variables. This questionnaire was piloted with a small sample to test its reliability and validity. Afterward, adjustments were made to ensure that the instrument could effectively capture the variables under study.

Second, sampling and data collection. A stratified random sampling method was used to ensure high representativeness and reduce sampling error. The sample included students from various types of high schools and different geographical areas across Northern Vietnam. This approach ensures that the findings can be generalized across the region. Data were collected through online surveys, a method chosen for its accessibility and ease of use, particularly after the Covid-19 pandemic, where students became more accustomed to digital platforms.

Finally, data analysis. After data collection, the responses were processed and analyzed using appropriate statistical techniques, including Exploratory Factor Analysis (EFA) to identify the underlying structure of the influencing factors and Regression Analysis to measure the impact of independent variables on the dependent variable — scientific competency. EFA helps reveal latent factors, while regression analysis quantifies the effect of each independent variable on students' scientific competency, offering valuable insights for both theoretical and practical applications.

This systematic research design ensures that the procedures are conducted scientifically, with rigorous attention to reliability and validity. The study is expected to yield reliable and actionable insights into the factors that shape high school students' scientific competency in Northern Vietnam.

3.2. Population and sample

The population of this study comprises high school students (grades 10, 11, and 12) from Northern Vietnam. This region provides a diverse economic, cultural, and educational landscape, making it ideal for exploring the factors influencing students' scientific competency. Northern Vietnam includes different economic and social conditions, offering a rich context for understanding how various factors impact students' science learning outcomes.

To ensure representativeness, a stratified random sampling method was used. The sample is drawn from three sub-regions of Northern Vietnam, with one province selected to represent each sub-region. Within each province, two high schools were chosen—one specialized high school and one general high school—allowing the study to capture diverse educational settings.

In each selected school, students from grades 10, 11, and 12 were randomly selected for the survey. Each grade is represented, ensuring that the sample reflects all stages of the high school learning experience. The estimated sample size is 380 students, a number large enough to ensure the reliability and generalizability of the research findings.

Northern Vietnam, which is divided into three sub-regions (Northeast, Northwest, and Red River Delta), consists of 25 provinces. From each sub-region, one representative province was selected. For example, Cao Bang in the Northeast sub-region was chosen, and surveys were conducted at two high schools in that province: one specialized school and one general high school. The same approach was applied in the other selected provinces, ensuring that the sample adequately represents the varying educational conditions across the region. This method ensures that the sample is both scientifically valid and representative of the region's educational diversity (Table 1).

By following this sampling strategy, the study guarantees transparency, scientific rigor, and minimizes selection bias, enabling the research to offer valuable insights applicable to the wider context of Northern Vietnam's high school education system.

Table 1: Information about the survey sample

Subregion	Province	Selected School	Selected Class	Number of Students	Number of Collected Surveys
Northern Highlands	Cao Bang	Cao Bang Specialized High School	10 Physics	35	80
			11 Physics	35	
			12 Physics	35	
		Quang Trung - Trung Khanh High School	10 A	35	62
			11 A	33	
			12 B	28	
Hong River Delta	Vinh Phuc	Vinh Phuc Specialized High School	10 Physics	35	90
			11 Physics	35	
			12 Physics	35	
		Tam Duong II High School	10 A	45	44
			11 A	42	
			12 A	42	
Northwest Highlands	Hoa Binh	Hoa Binh Specialized High School	10 Physics	35	71
			11 Physics	35	
			12 Physics	35	
			10 A1	46	33

		Cong Nghiep High School - Hoa Binh City	11 A2	45	
			12 A1	46	
Total					380

3.3. Measurement instruments

The primary tool used in this study is a survey questionnaire, designed based on the factors identified in the theoretical framework and the research model. The questionnaire is divided into several parts: personal information, and questions relating to individual, family, school, and social factors. These sections aim to measure the influence of each factor on students' scientific competency.

The questions are structured using a 5-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree." This scale allows for an assessment of students' perceptions and attitudes toward the different factors influencing their scientific competency. The design of the questionnaire was informed by previous studies and tailored to meet the objectives of this research.

To ensure the reliability and validity of the instrument, the questionnaire underwent a pilot test with a small sample of students. The results of this pilot test helped refine the questions to improve clarity and measurement accuracy. The final version of the questionnaire ensures that it can accurately assess the variables of interest, including students' attitudes toward science, family support, teaching quality, and the influence of peers and community.

3.4. Data collection procedure

The data collection process for this study was carried out systematically to ensure objectivity, reliability, and validity. The process involved three main stages: training collaborators, approaching the study population, and managing data collection and storage.

First, to comply with ethical standards in research, permission was obtained from the principals of the schools involved before collecting any data. After receiving approval, the research team scheduled specific training sessions with collaborators from each school. Given the geographic distance between schools, the research team opted for online training sessions for the collaborators (usually the class teachers). The purpose of these sessions was to ensure that the collaborators thoroughly understood the research objectives and were able to guide and encourage students to participate in the survey.

Next, the collaborators conducted short instructional sessions to ensure that all students understood the questions in the survey. Throughout the data collection process, the collaborators were available to clarify any queries, ensuring accuracy and completeness of the data. This support helped minimize errors arising from misunderstandings or other factors that could compromise data quality.

Finally, strict measures were taken to manage and store the data securely. The research team closed the survey (no longer accepting responses) once the targeted number of responses was reached. All data collected through the Google Form platform were stored and protected to maintain confidentiality and data integrity.

3.5. Data analysis

The data analysis in this study was carried out in three main stages to ensure accuracy and reliability.

First, validity and reliability testing was conducted to assess the suitability of the data for further analysis. The Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were used to determine whether the sample size and correlations between variables were adequate for factor analysis. The results showed that the KMO value was 0.819, surpassing the recommended threshold of 0.6, indicating that the data was suitable for factor analysis (Kaiser, 1974). Bartlett's test of sphericity also yielded a significant result ($p < 0.05$), confirming that the correlations among the variables were sufficient for factor analysis.

Second, exploratory factor analysis (EFA) was performed to identify the underlying latent factors within the dataset. Only factors with an Eigenvalue greater than 1 were retained in the model. The rotated component matrix (using Varimax rotation) was employed to better clarify the factors by displaying the observed variables and their corresponding factor loadings. Five main factors were identified as contributing to students' scientific competency: personal, family, school, peer, and social factors.

Finally, regression analysis was used to measure the influence of the independent variables (identified in the EFA) on the dependent variable, students' scientific competency. A multivariate regression model was applied to quantify the relationships and determine the degree of impact each factor had on the students' competency. The standardized regression equation took the following form:

$$Y=\beta_1X_1+\beta_2X_2+\ldots+\beta_iX_i+\epsilon$$

Where:

- Y is the dependent variable (students' scientific competency),
- $\mathbf{X_1, X_2, X_i}$ are the independent variables,
- $\boldsymbol{\beta_1, \beta_2, \beta_i}$ are the standardized regression coefficients,
- ε is the error term .

This analysis provided insights into the most influential factors impacting students' scientific competency, with school quality and personal motivation emerging as the strongest predictors. The results contribute to a deeper understanding of how these factors interact within the Northern Vietnamese education system, offering a solid foundation for future educational strategies.

4. RESULTS

4.1. Introduction to data analysis results

In this study, a total of 380 valid survey responses were collected, resulting in a response rate of 56.1% (as 380/677), which is in line with the research team's initial expectations.

Table 2: Distribution of respondents by gender

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	182	47.9%	47.9%	47.9%
Female	198	52.1%	52.1%	100.0%
Total	380	100.0%	100.0%	

Preliminary analysis shows a balanced gender distribution in the research sample. Specifically, 182 male students (accounting for 47.9%) and 198 female students (accounting for 52.1%) participated in the study (Table 2). This balanced gender distribution helps minimize bias that could affect the research results. Additionally, the sample includes students from different types of schools, with 170 students from specialized schools (44.7%) and 210 students from general schools (55.3%) (Table 3). This distribution reflects the diverse learning environments experienced by the students.

Table 3: Distribution of respondents by type of school

Type of School	Frequency	Percent	Valid Percent	Cumulative Percent
Specialized	170	44.7%	44.7%	44.7%
General	210	55.3%	55.3%	100.0%
Total	380	100.0%	100.0%	

Furthermore, the data shows a diverse distribution by grade level among the participating students. There are 133 10th graders (35.0%), 114 11th graders (30.0%), and 133 12th graders (35.0%) (Table 4). This consistent distribution across grade levels ensures that the study takes into account potential variations in scientific learning across different stages of high school education. The preliminary results indicate that the collected data meets the requirements for representativeness and reliability, providing a solid foundation for further analysis in this research.

Table 4: Distribution of respondents by grade level

Grade	Frequency	Percent	Valid Percent	Cumulative Percent
Grade 10	133	35.0%	35.0%	35.0%
Grade 11	114	30.0%	30.0%	65.0%
Grade 12	133	35.0%	35.0%	100.0%
Total	380	100.0%	100.0%	

4.2. Validity and reliability testing results

KMO and Bartlett's test

The Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity are two important methods used to assess the suitability of data for exploratory factor analysis (EFA). The KMO test is used to determine whether the data contains sufficient correlations between variables to conduct factor analysis. In this study, the KMO value was 0.819, exceeding the recommended threshold of 0.6, indicating that the sample is adequate for factor analysis (Kaiser, 1974).

Table 5: KMO and Bartlett's test

Test	Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.819
Bartlett's Test of Sphericity Approx. Chi-Square	3839.994
df	253
Sig.	0.000

Additionally, Bartlett's Test of Sphericity was used to test the hypothesis that the correlation matrix is an identity matrix. The results of Bartlett's test in Table 5 show that the Chi-square value is 3839.994, with a significance level (p-value) of 0.000 ($p < 0.05$).

Thus, the results of the KMO and Bartlett tests demonstrate that the data in this study is highly suitable for factor analysis, satisfying the requirements for simplicity and correlation between variables. This supports the exploration of latent factors in the study on the scientific competency of high school students (Hair et al., 2009; Kim & Mueller, 1978).

Cronbach's Alpha reliability testing

The reliability of the scales used in the study was evaluated using Cronbach's Alpha, a widely used method for determining the internal consistency of survey items (Hair et al., 2009). The results in Table 6 show that the Cronbach's Alpha coefficient reached 0.797, exceeding the threshold of 0.7 as suggested by Nimon and Oswald (2013) and Hair et al. (2009), indicating good reliability of the scales used in this study.

Table 6: Reliability statistics

Cronbach's Alpha	N of Items
.797	23

4.3. Exploratory factor analysis - EFA results

Identification of factors

The identification of factors in exploratory factor analysis (EFA) aims to determine how many latent factors should be retained to explain the observed variables in the data. Based on the results, the number of factors to be retained is determined by examining the Eigenvalues and the percentage of variance explained.

According to Kaiser's criterion (1974), only factors with an Eigenvalue greater than 1 should be retained in the model, as they represent a sufficient amount of information to be considered. The results show that five factors have Eigenvalues greater than 1, specifically 5.301, 2.945, 2.407, 2.166, and 1.692. These factors explain 23.048%, 12.806%, 10.466%, 9.419%, and 7.356% of the total variance, respectively, with a cumulative total of 63.094% of the variance explained by the first five factors (Table 7). This meets Hair et al.'s (2009) recommendation that the total explained variance should reach at least 60% for the model to be considered adequate in social science research.

Furthermore, principal component analysis and Varimax rotation were used to clarify the factor structures, ensuring that the observed variables were reasonably distributed across the latent factors (Kim & Mueller, 1978). This distribution ensures that each retained factor has practical and theoretical significance, providing a solid foundation for interpreting the relationships between variables in the study. Therefore, the decision to retain five factors based on these criteria is reasonable and consistent with the research objective of exploring the factors affecting the scientific competency of high school students in Northern Vietnam.

Table 7: Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.301	23.048	23.048	5.301	23.048	23.048	3.996	17.372	17.372
2	2.945	12.806	35.854	2.945	12.806	35.854	3.525	15.324	32.696
3	2.407	10.466	46.320	2.407	10.466	46.320	2.493	10.839	43.535
4	2.166	9.419	55.739	2.166	9.419	55.739	2.397	10.421	53.956
5	1.692	7.356	63.094	1.692	7.356	63.094	2.102	9.138	63.094
6	.889	3.867	66.961						
7	.777	3.378	70.339						
8	.725	3.151	73.490						
9	.683	2.971	76.460						
10	.645	2.804	79.265						
11	.575	2.499	81.764						
12	.526	2.289	84.053						
13	.524	2.276	86.329						
14	.467	2.029	88.358						
15	.411	1.786	90.144						
16	.384	1.670	91.814						
17	.346	1.505	93.320						
18	.322	1.402	94.721						
19	.293	1.275	95.996						
20	.270	1.175	97.171						
21	.246	1.069	98.240						
22	.210	.913	99.154						
23	.195	.846	100.000						

- **Rotated component matrix and factor interpretation**

The rotated component matrix and factor interpretation use the Varimax rotation method to clarify the factor structure in exploratory factor analysis (EFA). This method optimizes the allocation of observed variables to the factors, enhancing interpretability by maximizing high factor loadings on one factor while minimizing loadings on others (Hair et al., 2009).

The results show that the variables are clearly grouped into five factors, with each factor having high loadings on a specific group of variables. For example, Factor 1 focuses on variables related to "individual factors," while Factor 2 represents "family factors." This clear distribution helps to identify the underlying concepts in the data and minimizes overlap between factors, in line with the recommendations by Kim and Mueller (1978).

By using the rotated component matrix, the factors become more interpretable, aiding the study in identifying the factors influencing students' scientific competency. This method ensures simplicity and applicability of the factors in educational data analysis (Kaiser, 1974; Hair et al., 2009).

Table 8: Rotated component matrix[a]

	Component				
	1	2	3	4	5
Fa5	.842				
Sc2	.827				
Fa4	.821				
Fa3	.809				
Pe8	.667				
Fa2	.652				
Sc1	.430				
Pe5		.882			
Pe1		.840			
Pe3		.839			
Pe2		.819			
Pe4		.749			
Pe7			.902		
Fa1			.819		

Pe6			.740		
So2				.810	
So1				.788	
So4				.759	
So3				.711	
Sc3					.720
Sc4					.709
Sc5					.701
Sc6					.687
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.					
a. Rotation converged in 5 iterations.					

From Table 8, we can identify five groups of factors that influence students' scientific competency: family factors (Fa5, Sc2, Fa4, Fa3, Pe8, Fa2, Sc1), individual factors (Pe5, Pe1, Pe3, Pe2, Pe4), personal motivation factors (Pe7, Pe1, Pe6), social factors (So2, So1, So4, So3), and school factors (Sc3, Sc4, Sc5, Sc6). These groups represent the different domains affecting scientific competency, with each group comprising specific variables that contribute to understanding the key influences on students' academic performance in science.

4.4. Regression analysis results

The regression model and hypothesis testing aim to assess the extent to which independent factors influence students' scientific competency, the dependent variable in this study. A multivariate regression analysis was used to construct a linear regression model, which helps identify the relationships between the factors identified through exploratory factor analysis (EFA) and students' scientific competency.

Table 9: Anova[a]

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	59.907	5	11.981	76.256	.000[b]
	Residual	58.763	374	.157		
	Total	118.670	379			
a. Dependent Variable: NLKH						
b. Predictors: (Constant), Dl5, Dl1, Dl4, Dl2, Dl3						

In this study, the F-value was 76.256, with a statistically significant p-value of 0.000, indicating that the overall model is statistically significant and fits the data well (Table 9). This suggests that the selected independent factors in the model have a good ability to explain the variation in students' scientific competency.

Table 10: Model summary

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
1	.711[a]	.505	.498	.39638	2.102
a. Predictors: (Constant), Dl5, Dl1, Dl4, Dl2, Dl3					
b. Dependent Variable: NLKH					

The R-value of 0.711 shows a fairly strong relationship between the independent factors and students' scientific competency. The R^2 value of 0.505 means that approximately 50.5% of the variance in scientific competency is explained by the factors in the model. The adjusted R^2 value of 0.498, which is close to R^2, shows that the model is not significantly affected by random factors. The Durbin-Watson statistic of 2.102 falls within an acceptable range, indicating that there is no autocorrelation in the residuals (Table 10). These results confirm the validity of the regression model in predicting students' scientific competency based on the selected factors.

Table 11: Residuals statistics

	Minimum	**Maximum**	**Mean**	**Std. Deviation**	**N**
Predicted Value	1.9058	4.6670	3.8003	.39757	380
Residual	-2.24848	1.60557	.00000	.39376	380

Std. Predicted Value	-4.765	2.180	.000	1.000	380
Std. Residual	-5.672	4.051	.000	.993	380
a. Dependent Variable: NLKH					

The standardized residual values ranged from -5.672 to 4.051, with an average close to zero, indicating that the distribution of residuals was relatively balanced (Table 11). This suggests that most of the predictions made by the model were close to the actual values, with no significant deviations. The range of residual and predicted values demonstrates that the model has a reasonably accurate ability to predict students' scientific competency within the sample. This confirms that the selected factors in the regression model are appropriate and can significantly explain the variation in scientific competency.

The regression results presented in Table 12 show the regression coefficients (β) and the statistical significance (p-value) for each factor. Specifically, the factors "individual factors" and "school factors" have high regression coefficients and p-values less than 0.05, indicating that these factors have a significant and positive impact on students' scientific competency. In contrast, factors such as "social factors" have low regression coefficients and p-values greater than 0.05, indicating that they do not have a significant impact in this model. These results allow for hypothesis testing, determining that not all factors exert the same strong influence on students' academic outcomes.

Table 12: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.169	.252		4.632	.000
	Dl1	.014	.036	.016	.395	.693
	Dl2	.020	.025	.029	.777	.438
	Dl3	-.011	.024	-.019	-.462	.644
	Dl4	.688	.035	.708	19.422	.000
	Dl5	-.021	.037	-.021	-.564	.573

Model fit indices, such as R^2 and F-values, were also calculated to assess the model's ability to explain the dependent variable. The results show an R^2 value of 0.505, meaning that approximately 50.5% of the variance in students' scientific competency is explained by the factors in the model (Hair et al., 2009). The F-value is statistically significant ($p < 0.05$), indicating that the overall regression model is appropriate and has explanatory value. These findings support the confirmation or rejection of the initial research hypotheses and provide important insights into the impact levels of each factor in the educational context of Northern Vietnam.

After conducting the regression analysis to assess the influence of the independent factors on the dependent variable—students' scientific competency—the standardized regression equation is expressed as follows:

$$Y=0.708*X_4 + 0.016*X_1 + 0.029*X_2 - 0.019*X_3 - 0.021*X_5 + \epsilon.$$

Trong đó:

- Y is students' scientific competency,
- X_1, X_2, X_3, X_4, X_5 are the independent variables corresponding to individual factors, family factors, school factors, social factors, and personal motivation, respectively,
- βi (0.708, 0.016, 0.029, -0.019, -0.021) are the standardized regression coefficients for each factor,
- ϵ is the error term.

The analysis shows that "school factors" (X4) have the strongest impact on students' scientific competency, with a standardized regression coefficient of 0.708 and a statistically significant p-value ($p < 0.05$). Conversely, factors such as "individual factors" and "social factors" have low regression coefficients and are not statistically significant, indicating that they do not have a substantial impact in this model.

5. DISCUSSION

5.1. Interpretation of rresults

The exploratory factor analysis (EFA) identified five key factors influencing students' scientific competency: individual factors, family factors, school factors, social factors, and personal motivation. These factors were clearly categorized and demonstrated varying degrees of impact on students' scientific competency.

- **Individual factors**: This includes learning motivation, self-study skills, and interest in science subjects. As many studies have shown, students with higher motivation and interest in science tend to perform better academically (Cheung, 2017; Zhu, 2019). Particularly, self-study skills play a crucial role in helping students regulate their learning process and achieve high academic results (Asfani, Suswanto & Wibawa, 2017).
- **Family factors**: Support from the family, including both financial and emotional support, is important in enhancing students' scientific competency. Research by De-Silva, Khatibi, and Azam (2018) confirmed that a family's socio-economic status (SES) has a significant effect on students' academic performance. Furthermore, active parental involvement in their children's learning process also helps improve scientific competency (Jayawardena, van Kraayenoord, & Carroll, 2020).
- **School factors**: School-related factors, such as teaching quality, facilities, and the learning environment, have a major influence on students' scientific competency. Palines and Ortega-Dela Cruz (2021) pointed out that teachers' quality of instruction and classroom management styles can make a significant difference in student outcomes. Moreover, well-equipped laboratories and modern facilities play an essential role in supporting students' development of scientific skills (Prinsloo & Harvey, 2018).
- **Social factors**: The social environment, including peer influence, can have both positive and negative effects on students' scientific competency. Hang and Binh (2021) emphasized the importance of a positive learning environment and peer support in fostering motivation and interest in science learning.
- **Personal motivation**: Personal motivation, including students' confidence and belief in their scientific abilities, is also an important factor influencing academic performance. Bakar, Halim, and Mohamad (2023) highlighted that self-confidence and motivation help students overcome challenges in science learning.

The regression analysis identified that, among the factors, school factors and individual factors had the most significant impact on students' scientific competency. This aligns with previous research, where teaching quality and teachers' methods were found to be the most important factors in improving scientific competency (Lin et al., 2016; Thuan et al., 2019). At the same time, students' personal motivation and interest in science also play a critical role, as supported by studies from Cheung (2017) and Zhu (2019).

On the other hand, family factors and social factors, although having some influence, were not as strong as the other factors in the regression model. This may reflect that, in the specific context of students in Northern Vietnam, family and peer support alone may not be sufficient to compensate for deficiencies in school-related and individual factors.

These results not only reaffirm the importance of previously studied factors but also provide empirical evidence of the specific influences in the educational context of Vietnam, expanding our understanding of the factors that affect students' scientific competency in this setting.

5.2. Significance of results

The findings of this research contribute to and expand upon existing theories regarding the factors that influence students' scientific competency. This study reaffirms the importance of individual, family, school, and social factors, while emphasizing the critical role of the educational environment and students' personal motivation. These results are consistent with previous studies (Cheung, 2017; Zhu, 2019), and provide a more focused perspective on the educational context in Northern Vietnam, thereby adding to the theoretical models of scientific competency development.

In practical terms, the study offers valuable insights for educational administrators and teachers to improve students' scientific competency. Specifically, the results highlight the need to focus on improving teaching quality, upgrading educational facilities, and fostering students' motivation to learn science. Schools should invest in teacher training, ensuring that educators are capable of applying modern and effective teaching methods, while also creating positive and creative learning environments. Additionally, families play an important role in supporting and encouraging students, helping to provide the best conditions for students to develop their scientific abilities (Asfani, Suswanto & Wibawa, 2017; Jayawardena, van Kraayenoord & Carroll, 2020).

The results also underscore the need to increase students' motivation and interest in learning through innovative and student-centered educational approaches. This will not only improve academic outcomes but also encourage students to develop independent learning and critical thinking skills in scientific contexts (Bakar, Halim & Mohamad, 2023).

By identifying the most significant factors influencing students' scientific competency, this study offers important recommendations for improving science education in Vietnam. In doing so, it supports the development of high-quality human resources that can meet the growing demands of modern society, and contributes to the broader goal of educational reform in Vietnam.

5.3. Limitations of the study

Although this study has provided important findings on the factors affecting students' scientific competency, it still has several limitations. Firstly, the scope of the research is limited to high schools in Northern Vietnam. This restriction reduces the generalizability of the results to other regions in the country or to areas with different cultural and educational contexts worldwide.

The primary data collection method used in this study was a self-reported questionnaire, which may lead to bias due to the personal perceptions or psychological state of the students when responding. Additionally, the study did not employ other methods such as in-depth interviews or direct observations, which limits the ability to verify and enrich the collected data.

From an analytical perspective, while exploratory factor analysis (EFA) and regression analysis were used, these methods also have inherent limitations. EFA only provides a preliminary look at the underlying structure of the data and does not establish causal relationships. Meanwhile, linear regression may not fully capture the complexity and interactions between the different factors. Lastly, due to time and resource constraints, the research was unable to explore certain aspects in greater depth, which may affect the precision and depth of the analysis results.

5.4. Future research directions

In future studies, research can be expanded to other regions of Vietnam and even to other countries to test the generalizability of the results obtained. By comparing different cultural and educational contexts, researchers can identify both universal and specific factors that influence students' scientific competency.

Additionally, employing a wider range of data collection methods, such as in-depth interviews, direct observations, or case studies, would help supplement and validate the information gathered from self-reported questionnaires. This would provide a more comprehensive and detailed view of how various factors impact students' scientific competency.

Future research could also apply more advanced analytical techniques, such as Structural Equation Modeling (SEM), to examine the causal relationships between factors and scientific competency. This would clarify the complex interactions between factors and provide stronger evidence for the development of educational policies.

6. CONCLUSION AND RECOMMENDATIONS

This study has identified key factors influencing the scientific competency of high school students in Northern Vietnam, including individual factors, family factors, school factors, social factors, and personal motivation. The results show that the quality of teaching and the learning environment at school, along with students' motivation and interest in learning, have the strongest impact on the development of their scientific competency. These findings not only reinforce existing theories but also provide specific empirical evidence for the educational context in Vietnam.

Based on these results, several recommendations are proposed to enhance students' scientific competency. First, there should be a focus on improving teaching quality through teacher training and professional development to ensure that teachers can apply modern and effective teaching methods. Schools should also invest in facilities, especially in laboratories and learning materials, to create the best possible conditions for students to practice and explore science.

Family and society also play a crucial role in supporting and encouraging students. Parents should actively participate in their children's learning process, creating a positive learning environment at home and providing necessary learning resources. Finally, educational policymakers should focus on developing appropriate programs and policies to motivate and stimulate students' interest in science, helping them achieve the best academic results and fully develop their scientific competency.

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8. Appendix: Questionnaire for students

QUESTIONNAIRE FOR STUDENTS

Dear Students,

We are a research team from Thai Nguyen University of Education. We are currently conducting a study aimed at "Exploring the Factors Influencing the Scientific Abilities of High School Students." This research seeks to gain deeper insights into the factors that affect your learning and development in the field of science, with the goal of proposing solutions to improve the quality of education.

We greatly appreciate your participation and valuable contributions to this research. Your responses will help us better understand the learning experiences of high school students and identify key factors influencing scientific abilities. Please note that all information you provide will be kept confidential and used solely for research purposes.

Participating in this study presents an opportunity for you to share your thoughts and feelings about studying science subjects. We are thankful for your contributions and hope that you will take the time to complete this questionnaire.

The questionnaire consists of questions designed using a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

Thank you sincerely for your cooperation!

A. Personal Information

1. Full Name (Optional): ....
2. Gender: Male / Female / Other
3. Type of School: Specialized / Non-specialized
4. Grade Level: 10 / 11 / 12

B. Survey Questions

Personal Factors (Pe)

1. I am interested in studying science subjects.
2. I always strive to excel in science subjects to achieve high grades.
3. I feel excited when participating in scientific practical activities.
4. I set clear learning goals for my science subjects.
5. I believe that science subjects are very useful in everyday life.
6. I enjoy participating in science competitions and research activities.
7. I often engage in self-study and explore science lessons outside of regular class hours.
8. I am confident in my ability to solve scientific problems without the assistance of teachers.

Family Factors (Fa)

9. My family always cares for and supports me in studying science subjects.
10. My parents encourage me to pursue science subjects.
11. My family provides the best conditions for me to study and research science.
12. My parents have knowledge and understanding of science subjects.
13. I learn a lot from my parents' experiences and knowledge in science.

School Factors (Sc)

14. My teachers use engaging and comprehensible teaching methods for science subjects.
15. Teachers often use experiments and practical exercises to help me better understand the material.

16. The teaching methods employed by my teachers help me develop logical thinking and problem-solving skills in science.
17. My teachers possess extensive knowledge of science subjects and convey it understandably.
18. My school has adequate facilities to support the learning of science subjects.
19. My school's laboratory is well-equipped for scientific practice.

Social Factors (So)

20. My friends often study and discuss science subjects with me.
21. I feel more motivated to learn science when studying with friends.
22. Society today values the learning of science subjects.
23. I notice there are many attractive career opportunities in the field of science