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Influence of individual factors on student science performance in primary education

La influencia de los factores personales del alumnado sobre el rendimiento en ciencias en educación primaria

A influência dos fatores pessoais dos alunos no desempenho em ciências no ensino básico

在小学教育阶段，学生个人因素对科学课程学业表现的影响

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Abstract

The present paper aims to analyse the effects of individual factors on student science performance in primary education. This is an ex post facto study using the TIMSS 2019 database. The sample comprised 9512 Spanish students undertaking 4th grade primary education (51.6% boys; 48.4% girls) at 535 schools. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) of the 20 items comprising the student questionnaire on the science teaching and learning process (KMO =.93) were performed. Four factors were identified: student attitude, anxiety and self-efficacy towards the sciences and teacher attitude. Multiple regression analysis was used to predict the influence of student factors on science performance. Outcomes show that student attitudes determine their self-efficacy and that anxiety has a negative impact on performance. Teacher attitude is the most predictive factor regarding performance. The number of books at home which, in itself, is an indicator of socioeconomic status, has a substantial effect on performance. Findings suggest the need to enhance student motivation towards science during the first years of primary education, promote the application of knowledge to solve scientific problems and conduct experiments in Science classes.

Keywords: academic achievement, student attitude, teacher attitude, anxiety, self-efficacy.

Resumen

El objetivo de este trabajo es analizar la influencia de los factores personales del alumnado sobre el rendimiento en ciencias en educación primaria. Es un estudio ex-post-facto a partir de la base de datos del estudio TIMSS 2019. La muestra está formada por 9512 estudiantes españoles de 4º de Educación Primaria (51.6% niños; 48.4% niñas), procedentes de 535 centros educativos. Se ha realizado un Análisis Factorial Exploratorio (AFE) y un Análisis Factorial Confirmatorio (AFC) de los 20 ítems del cuestionario del alumnado sobre el proceso de enseñanza y aprendizaje de las ciencias (KMO=.93). Se han identificado cuatro factores: la actitud, la ansiedad y la autoeficacia del alumnado en ciencias y la actitud del profesor/a. Se realizó un análisis de regresión múltiple para predecir la influencia de los factores del alumnado sobre el rendimiento en ciencias. Los resultados muestran que la actitud del alumnado determina su autoeficacia y que la ansiedad tiene un impacto negativo sobre el rendimiento. La actitud del profesor es el factor predictivo que tiene más influencia sobre el rendimiento. El número de libros en casa, que es un indicador del nivel socioeconómico, tiene un gran efecto sobre el rendimiento. Los resultados sugieren la necesidad de reforzar la motivación del alumnado hacia las ciencias en los primeros años de la etapa de Educación Primaria, promover la aplicación de conocimientos a la resolución de problemas científicos y en la realización de experimentos en clases de ciencias.

Palabras clave: rendimiento académico, actitud del alumnado, actitud del profesorado, ansiedad, autoeficacia.

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Resumo

O objetivo deste trabalho é analisar a influência dos fatores pessoais dos alunos no desempenho em ciências no ensino básico. É um estudo ex-post-facto a partir da base de dados do estudo TIMSS 2019. A amostra é composta por 9512 estudantes espanhóis do 4.º ano do Ensino Básico (51,6% rapazes; 48,4% raparigas), provenientes de 535 escolas. Foi realizada uma Análise Fatorial Exploratória (AFE) e uma Análise Fatorial Confirmatória (AFC) dos 20 itens do questionário dos alunos sobre o processo de ensino e aprendizagem das ciências (KMO=.93). Foram identificados quatro fatores: a atitude, a ansiedade e a autoeficácia dos alunos em ciências e a atitude do professor ou da professora. Foi realizada uma análise de regressão múltipla para prever a influência dos fatores dos alunos no desempenho em ciências. Os resultados mostram que a atitude dos alunos determina a sua autoeficácia e que a ansiedade tem um impacto negativo no desempenho. A atitude do professor é o fator preditivo que mais influencia o desempenho. O número de livros em casa, que é um indicador do nível socioeconómico, tem um grande efeito no desempenho. Os resultados sugerem a necessidade de reforçar a motivação dos alunos para a ciência nos primeiros anos do ensino primário, promover a aplicação de conhecimentos na resolução de problemas científicos e na realização de experiências nas aulas de ciências.

Palavras-chave: desempenho académico, atitude dos alunos, atitude dos professores, ansiedade, autoeficácia

摘要

该研究的主要目标是分析在小学教育阶段学生的个人因素对科学课程学业表现的影响。该研究为事后回溯研究，以 2019 国际数学与科学趋势研究报告 TIMSS 2019 中的数据为研究基础。研究样本由来自 535 所学校的 9512 名西班牙小学四年级的学生组成，其中 51.6%为男生，48.4%为女生。针对科学课程教学过程学生问卷中的 20 个项目，我们进行了探索性因素分析和验证性因素分析，得到 KMO 值为 0.93，并确定出了四个影响因素：学生对科学课程的态度、焦虑度、自我效能以及教师的态度。为了预测学生的科学课程表现，我们进行了线性回归分析。分析结果显示学生的态度决定了学生的自我效能，学生的焦虑对学业表现有着负面的影响。家庭的藏书数量作为家庭社会经济水平的指标之一，对学业表现也产生了很大的作用。研究结果表明在小学教育的初期强化学生对科学课程的学习动机很有必要，除此以外，研究也建议鼓励学生使用所学知识解决科学问题，激励学生在科学课程上进行科学实验实操。

关键词: 学业表现、学生态度、教师态度、焦虑、自我效能

Introduction

Education and training are effective instruments when it comes to helping both the economy and society adapt to meet the needs of complex settings. This demands effective scientific formation (López Rupérez, 2001) and requires advances in research and innovation with regards to the didactics of science (Porlán, 2018). Scientific innovation has gained momentum in the 21st century, highlighting the demand for teaching profiles related to science, technology, engineering and mathematics (STEM) (Croak, 2018). In European Union countries, it is essential to prepare young people for jobs in these areas (Centro Europeo para el Desarrollo de la Formación Profesional, [CEDEFOP], 2016). Likewise, STEM education plays a fundamental role in the environmental, social and economic changes that the world is currently facing, such as facing climate change, as discussed in the 2030 Agenda for Sustainable Development (Alcántara-Manzanares & López -Fernández, 2021; Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura, [UNESCO], 2019).

Research has shown the influence of individual student factors on performance, such as attitude (Unfried et al., 2015; Vázquez & Manassero, 2008), anxiety (Udo et al., 2004) and self-efficacy (Bidegain and Lukas, 2020). Further, the attitude of teachers (Savelsbergh et al., 2016) regarding performance in science has been shown to be important at stages following primary education, which guide the

vocation towards careers in STEM subjects and act as a stimulus for scientific learning (López Rupérez et al., 2019, 2021).

The first factor, attitude towards science, refers to the motivation and disposition of students towards this area and influences academic performance (Osborne et al., 2003). The development of positive attitudes towards science in the primary education stage is a key factor in promoting interest in STEM careers (Potvin & Hasni, 2014; Toma & Meneses, 2019). Different studies have shown that attitude determines student self-efficacy in science which, in turn, influences performance and explains orientations towards careers in the scientific field (Uitto, 2014; Wan, 2021). Successive studies of TIMSS (Trends in International Mathematics and Science Study) have shown that a relationship exists between attitude towards science and performance (Gil-Flores, 2014; Martin et al., 2012).

The second factor, anxiety pertaining to science, is defined as the negative emotion and restlessness experienced by students during science classes or in tasks related to the scientific area (Mallow et al., 2010). Research has shown that this factor has a negative effect on student performance (Ardasheva et al., 2018; Gibbons et al., 2018; Gil-Madrona et al., 2019), although some studies indicate otherwise (Burns et al., 2021). Different studies show that the attitude of teachers towards science influences anxiety (Senler et al., 2016) and that this influences student attitudes (Ayuso et al., 2021) and self-efficacy (González et al., 2017; Henschel, 2021).

The third factor, the attitude of teachers, is understood as the way in which teachers explain a topic, resolve doubts and use different strategies to teach science (De-Juanas et al., 2016; Thibaut et al., 2018). Research has shown that the attitude of science teachers has an effect on student attitudes (Denesssen et al., 2015; van Aalderen-Smeets & Van der Molen, 2015) and self-efficacy (Aguilera & Perales-Palacios, 2020). This highlights the impact of conducting experimental activities in classes on student motivation (Mateos-Núñez et al., 2020). Consequently, this factor has a huge effect on student performance (Fauth et al., 2019; Ros & Rodríguez, 2021).

The fourth factor, self-efficacy, refers to the belief in one's own abilities to organize and carry out required actions in specific situations in order to obtain a desired outcome (Bandura, 1997). Different studies show that self-efficacy influences science performance (Grabau & Ma., 2017; Guo et al., 2018; Jansen et al., 2015).

Research has shown the impact of socioeconomic status on student performance (Coleman et al., 1966; Claro et al., 2016; Dietrichson et al., 2017) with this, in turn, being reflected in the number of books at home (Chmielewski, 2019; Engzell, 2021).

According to the 2021 Report of the State System of Education Indicators (Sistema Estatal de Indicadores de la Educación 2021) (Ministerio de Educación y Formación Profesional, 2022a, p. 83), the number of books at home influences student outcomes pertaining to scientific competence.

There is a difference of 46 between those reporting having few books (0-25 books) and those having many books (more than 100) at home in Spain, relative to 62 in the OECD (Organization for Economic Cooperation and Development) (Science score of students with 0-25 books. Spain: 490; OECD average: 496/More than 100 books. Spain: 536; OECD average: 558). Socioeconomic status is one of the variables with the greatest influence on science performance. The difference between students from economically privileged and disadvantaged households is 69 points in Spain and 83 in the OECD average (average score of privileged students. Spain: 553; OECD average: 571/disadvantaged students. Spain: 484; OECD average: 488).

It is necessary to further knowledge about the effect of these factors in primary education due to the fact that, at this stage, dips in performance tend to first emerge and, if not addressed, such dips could lead to school failure in secondary education (Martínez-Otero, 2020).

To this end, it will be useful to examine data released from the TIMSS 2019 study in Spain, which evaluates the performance of 4th grade students in science (Ministerio de Educación y Formación Profesional, 2022b). The present study establishes four performance levels (p. 32): low, between 400 and 475; intermediate, between 475 and 550; high, between 550 and 625; and advanced, 625 or more. Outcomes of the TIMSS 2019 study show that Spanish students are performing at an intermediate (511) level in Science, which is below both the OECD average (526) and the European Union average (514) (p. 52).

The specific objectives of the present research are as follows:

-Analyse the influence of student attitudes on self-efficacy, whilst also examining the influence of student anxiety on their attitudes and self-efficacy and, finally, assess the attitude of science teachers on student attitude, anxiety and self-efficacy (Figure 1).

-Predict the influence of student individual factors on science performance.

Based on these objectives, the following hypotheses are proposed:

H1. Student attitudes towards science predict student self-efficacy.

H2. Student anxiety about science determines student attitudes.

H3. Student anxiety determines student self-efficacy.

H4. The attitude of science teachers determines that of their students.

H5. Teacher attitudes determine student anxiety.

H6. Teacher attitudes determine student self-efficacy.

H7. Student attitudes influences performance.

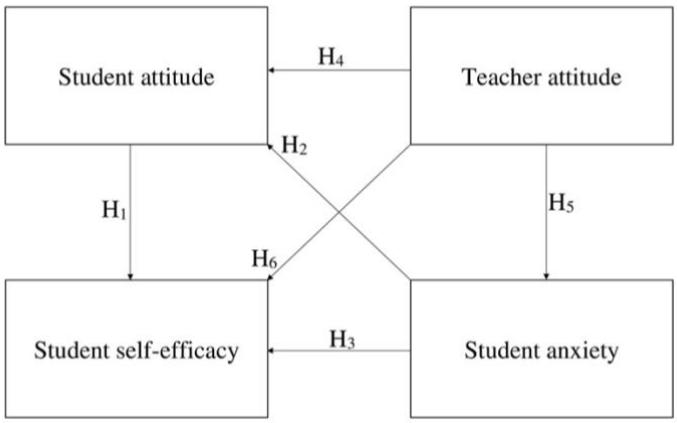
H8. Anxiety towards science influences student performance.

H9. Teacher attitudes influence student performance.

H10. Self-efficacy in science influences performance.

H11. The number of books at home influences performance.

Figure 1. Explanatory model on science performance



Method

The present study is part of a nonexperimental study, since it was not possible to randomly assign participants or manipulate the independent variables. An ex post facto design was employed, in which a phenomenon is analysed once it has occurred.

Participants

The sample consisted of 9512 Spanish 4th grade students (51.6% boys; 48.4% girls), with an average age of 9.9 years. All had previously participated in the TIMSS 2019 study (Ministerio de Educación y Formación Profesional, 2022b) and were attending one of 535 schools.

Instruments

The student questionnaire on science teaching and learning was used. This includes 20 items, which are responded to using a 4-point Likert scale, with 1 being "strongly disagree" and 4 "strongly agree" (Table 1).

Variables and analytical procedures

Analysis corresponded to four phases.

In the first phase, data distribution pertaining to all items was assessed for normality and independent estimates were made for the five plausible values available in the TIMSS database. Finally, average risk values were calculated to measure science performance (dependent variable).

In the second phase, given the ordinal nature of questionnaire items, factorization of the polychoric correlation matrix was performed, which assumes the existence of latent variables (factors) related to the observed ordinal variables (Basto & Pereira, 2012).

In the third phase, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) of the 20 items were performed based on the polychoric correlation matrix to assess the adequacy of the data for factorization. Four factors were defined with a minimum of 3 variables and saturations greater than .305.

In the fourth phase, multiple regression analysis was performed to predict science performance based on student factors and the number of books at home.

Analyses were performed with IBM SPSS Statistics 28 and the software R 4.1.

Results

Table 1 presents the 20 items of the TIMSS 2019 student questionnaire on science teaching and learning in primary education.

Table 1. Items of the student questionnaire on the science teaching-learning process

Item
I1. I enjoy learning science
I2. I wish I did not have to study science
I3. Science is boring
I4. I learn many interesting things in science
I5. I like science
I6. I look forward to learning science at school
I7. I like to do science experiments
I8. Science is one of my favourite subjects
I9. My teacher is easy to understand
I10. My teacher gives clear answers to my questions
I11. My teacher is good at explaining science
I12. My teacher does a variety of things to help us learn
I13. My teacher explains a topic again when we don´t understand
I14. I usually do well in science
I15. Science is harder for me than many of my classmates.
I16. I am just not good at science
I17. I learn things quickly in science
I18. My teacher tells me I am good at science
I19. Science is harder for me than any other subject
I20. Science makes me confused

Source: TIMSS 2019 Student Questionnaire.

Polychoric correlations matrix

Tables 2 and 3 present outcomes from the polychoric correlations between the variables that influence science performance (Sig.<.001).

Table 2. Polychoric correlation matrix I

	I1	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**I9**	**I10**
I1	1.000									
I2	-.386	1.000								
I3	-.595	.6541	1.000							
I4	.700	-.320	-.521	1.000						
I5	.849	-.437	-.650	.752	1.000					
I6	.791	-.388	-.563	.692	.840	1.000				
I7	.330	-.094	-.215	.424	.380	.358	1.000			
I8	.772	-.363	-.547	.636	.826	.781	.344	1.000		
I9	.437	-.210	-.321	.496	.467	.429	.234	.416	1.000	
I10	.432	-.237	-.336	.518	.459	.433	.300	.392	.661	1.000
I11	.478	-.248	-.381	.609	.505	.476	.328	.436	.681	.736
I12	.408	-.202	-.284	.492	.432	.432	.297	.374	.556	.671
I13	.349	-.180	-.265	.454	.368	.364	.267	.317	.546	.679
I14	.586	-.239	-.392	.488	.600	.523	.256	.572	.378	.353
I15	-.348	.434	.510	-.289	-.390	-.302	-.162	-.349	-.251	-.224
I16	-.327	.412	.513	-.294	-.375	-.281	-.155	-.332	-.209	-.193
I17	.601	-.266	-.403	.552	.635	.587	.288	.611	.479	.430
I18	.453	-.179	-.260	.391	.469	.454	.225	.471	.343	.316
I19	-.394	.428	.537	-.331	-.452	-.350	-.186	-.423	-.258	-.213
I20	-.423	.455	.576	-.365	-.472	-.389	-.186	-.424	-.321	-.271

Table 3. Polychoric correlation matrix II

	I11	**I12**	**I13**	**I14**	**I15**	**I16**	**I17**	**I18**	**I19**	**I20**
I11	1.000									
I12	.693	1.000								
I13	.683	.685	1.000							
I14	.349	.277	.260	1.000						
I15	-.239	-.179	-.184	-.429	1.000					
I16	-.213	-.133	-.161.	-.453	.636	1.000				
I17	.473	.363	.337	.648	-.377	-.348	1.000			
I18	.326	.294	.284	.583	-.275	-.256	.559	1.000		
I19	-.257	-.188	-.190	-.436	.690	.627	-.401	-.262	1.000	
I20	-.301	-.213	-.204	-.476	.651	.639	-.450	-.293	.718	1.000

Outcomes presented in Tables 2 and 3 confirm the existence of latent variables of a continuous nature on which the observable variables are constructed (questionnaire items). In this sense, strongly positively correlated latent variables illustrate direct relationships and indicate that included variables belong to the same factor (see Table 4). For example, a direct relationship was found between items 1 and 5, since both variables refer to student attitudes towards science.

Exploratory and Confirmatory Factor Analysis

A factorial reduction was used, applying oblique rotation, which assumes the most plausible factor solution according to the nature of the data and allows correlations between factors (student attitudes, anxiety and self-efficacy and teacher attitudes). An excellent Kaiser–Meyer–Olkin (KMO) index of .93 was obtained, whilst the Bartlett test of sphericity outcome was significant (.000). This reveals that the factor analysis performed was

applicable, relevant and suitable. This verifies that the following analytical process was suitable.

Table 4 presents outcomes of the oblique factor analysis pertaining to variables that influence science performance.

Table 4. Pattern matrix for the model factors and communalities

Item	Factor loadings				Commonalities
	Factor 1	Factor 2	Factor 3	Factor 4	
I6	**.892**	.104	-.030	.082	.740
I5	**.887**	.024	-.026	.095	.806
I1	**.857**	.069	-.030	.111	.726
I8	**.806**	.019	-.083	.181	.699
I4	**.645**	.113	.221	.047	.543
I3	**.523**	.460	.006	.299	.670
I7	**.305**	.099	.116	.126	.560
I15	.161	**.841**	-.025	-.129	.645
I19	.082	**.823**	.006	-.107	.649
I16	.155	**.818**	.013	-.129	.602
I20	.045	**.798**	-.015	-.120	.650
I2	-.356	**.491**	-.013	.417	.561
I13	-.086	-.016	**.798**	-.040	.575
I11	.053	-.004	**.786**	-.021	.649
I10	-.001	-.019	**.785**	.015	.629
I12	.037	.039	**.766**	-.059	.579
I9	.028	-.049	**.612**	.143	.478
I18	.156	-.054	.005	**.669**	.562
I14	.211	-.202	-.052	**.639**	.632
I17	.314	-.118	.065	**.540**	.611

The first factor is defined by variables I1, I3, I4, I5, I6, I7 and I8, which are related to student attitudes. Of the items loading on this factor, those that refer to the desire to learn science, conduct scientific experiments and consider science as a favourite subject are found.

The second factor refers to student anxiety towards science. It is composed of variables I2, I15, I16, I19 and I20, which are related to student perception of difficulty when it comes to science.

The third factor refers to the attitude of the science teacher. It is defined by variables I9, I10, I11, I12 and I13, which pertain to student opinions around the way in which the science teacher conducts lessons.

The fourth factor is defined by variables I14, I17 and I18, which are associated with student self-efficacy. Variables loading on this factor refer to the motivation of students themselves towards learning scientific concepts and progressing in science.

Factor loadings for all items were satisfactory and commonality outcomes were acceptable. This indicates that the set of items is satisfactorily represented in the obtained factorial model.

Table 5. Variance explained by each factor

Component	Initial eigenvalue			Sum of loads squared		
	Total	% variance	accumulated %	Total	% variance	Accumulated %
1	6.995	34.974	34.974	6.995	34.974	34.974
2	2.398	11.988	46.962	2.398	11.988	46.962
3	1.641	8.204	55.165	1.641	8.204	55.165
4	1.129	5.644	60.809	1.129	5.644	60.809
5	.910	4.550	65.358			
6	.721	3.606	68.965			
7	.668	3.342	72.306			
8	.569	2.846	75.152			
9	.524	2.618	77.770			
10	.513	2.564	80.334			
11	.492	2.459	82.793			
12	.469	2.345	85.138			
13	.462	2.308	87.447			
14	.458	2.290	89.736			
15	.419	2.097	91.833			
16	.412	2.058	93.891			
17	.377	1.886	95.777			
18	.329	1.645	97.421			
19	.294	1.470	98.891			
20	.222	1.109	100			

Note: Extraction method. Principal component analysis.

Table 5 presents the four factors that explain more than 60% of overall variance in performance outcomes. Student attitudes explain the highest percentage of overall variance (approximately 35%), followed by anxiety, which explains 12%, teacher attitudes, which explain 8% and, finally, self-efficacy, which explains more than 5% of overall variance.

Following oblique factor analysis, confirmatory factor analysis (CFA) was performed, as is appropriate for verifying the adequacy of the model and its four-factor structure.

Figure 2. *Confirmatory Factor Analysis*

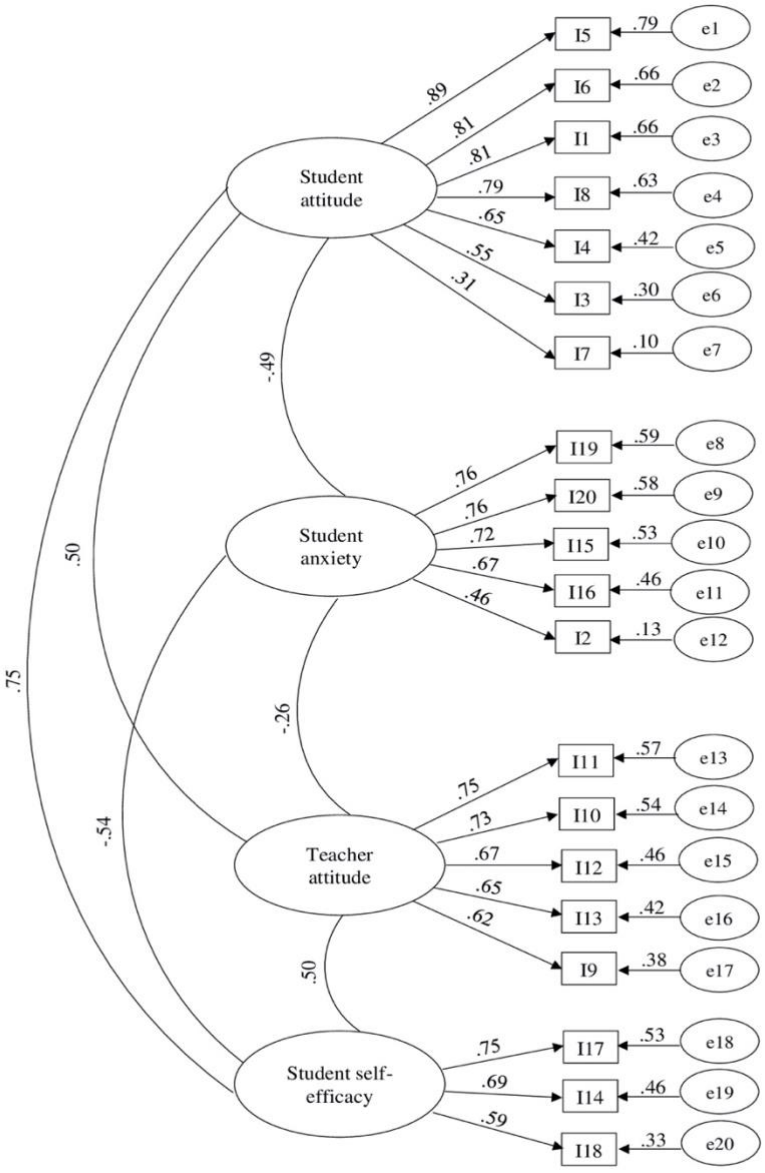


Figure 2 illustrates the way in which student attitudes determine their self-efficacy (β = .75). Specifically, the model predicts that students reporting more positive attitudes towards science will also record higher self-efficacy scores. Student anxiety determines student self-efficacy (β = -.54) and attitudes (β = -.49). In other words, the model predicts that students who report feeling more anxious will also achieve lower self-efficacy scores and report more negative attitudes. The attitude of the science teacher determines student attitudes (β = .50), self-efficacy (β = .50) and anxiety (β = -.26). In this sense, more positive teacher attitudes lead to more positive attitudes, higher self-efficacy and lower anxiety in students.

Table 6. Model fit indices

	Fit indices	Recommended values	Observed values
Absolute fit index	Chi-square/degrees of freedom	≤ 5	4.9
Comparative fit index	IFI (Incremental Fit Index)	≥.90	.924
	NFI (Normed Fit Index)	≥.90	.922
	CFI (Comparative Fit Index)	≥.90	.931
Approximation error	RMSEA (Root Mean Square Error of Approximation)	.05 ≤.08	.067

When considered alongside recommended indices, the data presented in Table 6 show that the model adequately describes the data. The Chi-square statistic is significant, suggesting that the model fits well with established parameters. Comparative fit indices confirm the proposed model.

Multiple Regression Analysis

A multiple regression analysis was performed, with science performance providing the predicted or dependent variable and individual student factors and the number of books at home (1 = None or very few [0-10] books; 2 = Enough to fill a shelf [11-25 books]; 3 = Enough to fill a bookcase [26-100 books]; 4 = Enough to fill two bookcases [101-200 books]; 5 = Enough to fill three or more bookcases [more than 200 books]) providing the predictive or independent variables.

Table 7. Model summary

Model	R	R squared	Corrected R squared	Standard error of the estimate
1	.672[a]	.451	.451	14,28409

a. Predictors: (Constant), Number of books at home, Student attitude, Self-efficacy, Anxiety, Teacher attitude.

Data presented in Table 7 provide information on the goodness of fit of the model. The R^2 or explained variance pertaining to the model is 0.451, which means that the variables included in the model explain 45.1% of the variability seen in science performance.

Data presented in Table 8 reveal a significance value of less than .05. From this it can be concluded that a relationship exists between the dependent variable and the independent variables.

Table 8. ANOVA

Model	Sum of squares	df	Quadratic mean	F	Sig.
Regression	6643205.141	5	1328641.028	486.036	.000
Residual	20988782.5	7678	2733.626		
Total	27631987.7	7678			

Table 9. Regression coefficients

Model	Non standardized coefficients		Standardized coefficients	t	Sig.
	B	Standard error			
Constant	479.489	1.627		294.632	.000
Student attitude	5.583	.597	.093	9.351	<.001
Student anxiety	-19.831	.606	-.329	-32.736	<.001
Teacher attitude	6.465	.598	.108	10.811	<.001
Student self-efficacy	1.287	.600	.021	2.144	.032
Number of books at home	14.428	.510	.286	28.262	<.001

Given that all p-values are significant, it can be observed from the coefficients presented in Table 9 that all items make a significant contribution to the model. The number of books students report having at home significantly influences science performance. Of all examined factors, teacher attitudes makes the biggest contribution to performance, followed by student attitude and self-efficacy, whilst anxiety is the only variable to have a negative impact on performance.

The multiple regression equation employed in the present research is expressed as follows (Murillo & Martínez-Garrido, 2020):

$$Y_i = \beta_0 + \beta_{1X_{1i}} + \beta_2 X_{2i} + \beta_n X_{ni} + \varepsilon_\iota$$

where Y_i is the expected value of science performance, β_0 is the value of the dependent variable or average student performance when the predictors are 0, $\beta_{1X_{1i}}$ is the effect that the increase in one of the variables X_i has on the variable Y, e_i is the error or the difference between the observed value and the estimated value in the model.

Science performance = 479.48 + 14.42 x Number of books at home + 6.46 x Teacher attitude + 5.58 x Student attitude + 1.287 x Student self-efficacy - 19.831 x Student anxiety

- The average score for student science performance was 479.48.
- For each unit increase or decrease of the variable corresponding to the number of books at home (measured along a Likert scale), performance improved or deteriorated, respectively, by 14.42.
- For each unit improvement or deterioration of the variable corresponding to teacher attitude, performance also improved or deteriorated by 6.46.
- For each unit improvement or deterioration in student attitude, performance increases or decreases by 5.58.
- For each unit increase or decrease in student self-efficacy, performance increases or decreases by 1.28.
- For each unit increase in student anxiety, performance decreases by 19.831.

Discussion and conclusions

The general aim of the present work was to determine the influence of individual factors on student science performance in primary education. To this end, two specific objectives were established, which were addressed using exploratory and confirmatory factor analysis to extract factors from variables measured in the TIMSS 2019 study. In addition, eleven hypotheses were proposed in order to further confirm the proposed model pertaining to performance.

Outcomes confirm the first hypothesis, revealing that student attitudes towards science predict self-efficacy. This finding is consistent with those reported in other studies (Osborne,

2003; Uitto, 2014; Wan, 2021), which showed student motivation towards science to reinforce beliefs about their ability to obtain desired outcomes (Bandura, 1997).

Outcomes also confirm the second hypothesis, revealing that student anxiety around science determines student attitudes. This is also consistent with other studies (Mallow et al., 2010; Ayuso et al., 2021), which show worry to have a negative influence on primary school students' experiences during science classes by reducing motivation to learn this subject. Likewise, the third hypothesis was also confirmed. Specifically, it was established that anxiety also determines self-efficacy. This is in line with a study conducted by Henschel (2021), which supported the theory that student opinions regarding their abilities mediates the negative effect of anxiety on scientific performance and explains why anxiety has a larger impact on self-efficacy than on attitudes in students (González et al., 2017).

Outcomes confirm the fourth hypothesis, revealing that the attitudes of science teachers determine student attitudes. This is also supported by findings from other studies (Denesssen et al., 2015; Van Aalderen-Smeets & Van der Molen, 2015), which have found the teaching methods employed by science teachers to influence student attitudes. The fifth hypothesis was confirmed, in the sense that the attitudes of science teachers also influenced anxiety in students (Aguilera & Perales-Palacios, 2020). In this sense, a study conducted by Mateos-Núñez et al. (2020) highlights student preferences for didactic strategies entailing practice and experimentation as opposed to traditional methodologies. Likewise, the sixth hypothesis was confirmed, revealing that teacher attitudes determined student self-efficacy in science (Aguilera & Perales-Palacios, 2020). A study conducted by De-Juanas et al. (2016) showed that approaches in which Science is taught through practical activities are more demanded from science teachers given their positive impact on student learning.

Outcomes also support the seventh hypothesis, revealing that student attitudes predict science performance, with this being the third main contributor towards variance in performance outcomes. This coincides with findings reported by other studies (Osborne et al., 2003; Potvin & Hasni, 2014; Toma & Meneses, 2019), which found positive attitudes to promote interest in STEM careers. Likewise, the eighth hypothesis can also be accepted. To this end, anxiety around science was found to negatively influence performance. This is in line with other studies (Ardasheva et al., 2018; Gibbons et al., 2018; Gil-Madrona et al., 2019; Mallow et al., 2010), which showed restlessness during Science classes to have a negative impact on performance.

Findings confirm the ninth hypothesis, such that science teacher attitudes predicted Science performance. This factor was the main contributor to variance in performance outcomes. Previously conducted research revealed similar outcomes (Fauth et al., 2019; Ros & Rodríguez, 2021), with the way in which Science teachers explain topics, resolve doubts and use different methodological strategies having an impact on performance. Likewise, the tenth hypothesis can be accepted given that self-efficacy was found to influence Science performance, in accordance with the findings of other studies (Grabau & Ma., 2017; Guo et al., 2018; Jansen et al., 2015). In this sense, findings reveal a huge impact of student attitudes on self-efficacy, with Science teacher attitudes then, in turn, reinforcing student beliefs about their ability to achieve expected outcomes (Bandura, 1997).

The eleventh hypothesis can also be accepted, with the number of books students have at home being a predictive factor of science performance. This is in line with the results of other studies (Chmielewski, 2019; Engzell, 2021), which consider this factor to be the main indicator of socioeconomic status in students (Coleman et al., 1966; Claro et al., 2016; Dietrichson et al., 2017). This finding may be partly explained by the previously discussed difference in students with very few

books (0-25) and those with many books (more than 100) in Spain (46) in comparison with OECD countries (62), alongside the average difference between students with parents who have completed compulsory education and those with tertiary education in Spain (47) relative to OECD countries (77). Indeed, the number of students with parents who have attended tertiary education is lower in Spain than in OECD countries on average. Difference in performance outcomes between students from economically privileged and disadvantaged households have also been previously recorded (Ministerio de Educación y Formación Profesional, 2022a).

In the present work, a series of conclusions can be reached.

Firstly, the attitudes of Science teachers is the factor that most contributes to variance in Science performance, via its influence on student attitudes and self-efficacy. This conclusion highlights the importance of designing personalized learning experiences that offer different approaches and are adapted to the learning methods of individual students. In this sense, teachers must receive basic training that integrates the scientific and the didactic to equip them to approach teaching with more confidence (De-Juanas et al., 2016).

Secondly, student attitudes was found to be the main determinant of student self-efficacy towards Science, followed by teacher attitudes, which promote the need to reinforce motivation towards Science in the first years of primary education.

Thirdly, anxiety towards Science is the only factor to negatively influence performance in Science, affecting self-efficacy to a greater extent than student attitudes.

Fourthly, the number of books a student has at home has a great impact on performance in Science, which suggests the need to provide more educational resources to schools that are in disadvantaged settings.

As a limitation of the study, it should be noted that the TIMSS database does not collect specific information on the socioeconomic and cultural background of families, such as that gathered by the PISA report. Instead, the number of books in the household was considered, which constitutes a reliable and valid indicator of socioeconomic status.

The present study opens new lines of research that will contribute to the improvement of performance in Science. One such line pertains to training teachers in the STEAM areas to approach Science teaching from a more competency-focused standpoint, based on the application of knowledge to the resolution of scientific problems and the running of experiments.

In conclusion, it can be stated that the present study reveals an influence of individual factors on student performance in Science in primary education. This could contribute towards reducing the significant difference seen with respect to OECD countries and the European Union as a whole.

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