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Beliefs and attitudes toward physics and their relationship to academic performance

Creencias y actitudes hacia la física y su relación con el rendimiento académico

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Abstract

Attitudes and beliefs toward physics are influenced by individual, educational, and social factors that directly affect academic performance. The present study aimed to analyze the relationship between beliefs and attitudes toward physics and academic performance in General Unified Baccalaureate (BGU) students. A quantitative approach was used with a non-experimental, cross-sectional, correlational design in a sample of 301 students. The instrument was validated by seven experts in physics teaching, a pilot test was conducted, and its reliability was evaluated using Cronbach's alpha coefficient. For the analysis of the variables, Spearman's correlation coefficient was calculated between the dimensions evaluated and academic performance, and Student's t-tests were applied to compare differences in means. The results revealed positive and statistically significant correlations between academic performance in physics and dimensions such as interest in the subject, self-efficacy, attitude toward learning physics, perception of the teacher, and educational context. Likewise, it was observed that female students obtained, on average, higher academic performance than male students, and that the gender variable showed a significant association with performance only in the female group. In conclusion, the study confirms that maintaining positive beliefs and attitudes toward physics is associated with better academic performance in this subject, highlighting the importance of strengthening pedagogical strategies aimed at developing favorable perceptions of science in the school context.

Keywords: attitude toward physics, beliefs about physics, academic performance.

Resumen

Las actitudes y creencias hacia la física están influenciadas por factores individuales, educativos y sociales que inciden directamente en el rendimiento académico. El presente estudio tuvo como objetivo analizar la relación entre las creencias y actitudes hacia la física y el rendimiento académico en estudiantes de Bachillerato General Unificado (BGU). Se empleó un enfoque cuantitativo con un diseño no experimental, de tipo transversal y alcance correlacional, en una muestra de 301 estudiantes. El instrumento fue validado por siete expertos en enseñanza de la física, se aplicó una prueba piloto y se evaluó su fiabilidad mediante el coeficiente alfa de Cronbach. Para el análisis de las variables, se calculó el coeficiente de correlación de Spearman entre las dimensiones evaluadas y el rendimiento académico, además de aplicar pruebas t de Student para contrastar diferencias de medias. Los resultados revelaron correlaciones positivas y estadísticamente significativas entre el rendimiento académico en física y dimensiones como el interés por la materia, la autoeficacia, la actitud hacia el aprendizaje de la física, la percepción del docente y el contexto educativo. Asimismo, se observó que las estudiantes mujeres obtuvieron, en promedio, un rendimiento académico superior al de los hombres, y que la variable sexo mostró una asociación significativa con el rendimiento únicamente en el grupo femenino. En conclusión, el estudio confirma que mantener creencias y actitudes positivas hacia la física se asocia con un mejor rendimiento académico en esta asignatura, lo que resalta la importancia de fortalecer estrategias pedagógicas orientadas al desarrollo de percepciones favorables hacia la ciencia en el contexto escolar.

Palabras clave: actitud hacia la física, creencias hacia la física, rendimiento académico.

Introduction

Physics is a fundamental discipline due to its contribution to the development of logical, critical, and scientific thinking among students (Jamil et al., 2024). However, its teaching and learning present various challenges that affect the academic performance of students in the Unified General Baccalaureate (BGU). In this regard, previous research has demonstrated that students with positive attitudes toward physics tend to exhibit better academic performance (Aprilia et al., 2023; Chala, 2020; Malespina et al., 2023; Figueiredo et al., 2024; Appiah-Twumasi, 2024). Furthermore, it has been documented that favorable beliefs about physics motivate students to specialize in this science (Adams et al., 2006; Bates et al., 2011).

In Ecuador, the National Institute for Educational Evaluation (INEVAL, 2023) reported an average score of 694 out of 1000 points in the Ser Estudiante exams from 2020 to 2023, equivalent to a 69.4% success rate. In contrast, in 2019, physics topics achieved an average success rate of 51.4% (INEVAL, 2020). It is noteworthy that during the 2019-2020 period, this assessment grouped physics, chemistry, and biology within the natural sciences area. Therefore, the level of physics knowledge among Ecuadorian students can be considered basic at the national level, which explains why the Secretariat of Higher Education, Science, Technology, and Innovation (SENESCYT, 2022) reports a low demand for studying university degrees related to natural sciences, mathematics, and statistics. In line with this, Villalva and Nieto (2018) point out that “fewer and fewer students from schools and universities voluntarily choose to study a physics course” (p. 10). This situation is reinforced by Kaur and Zhao (2017), who argue that a favorable attitude toward physics not only influences immediate learning but also impacts students' interest in pursuing careers in scientific fields.

For a better understanding of the study, several key concepts are defined. The term belief derives from the verb “to believe” and is understood as a mental construct influenced by personal experiences, guiding perception and behavior (Lee et al., 2025; Rokeach, 1970; Vitriol et al., 2024). The concept of attitude refers to a disposition—positive or negative—formed by the set of prior beliefs that influence an individual's responses (Fishman et al., 2021). According to Northcote (2020), the beliefs of teachers and students regarding teaching and learning are termed educational beliefs. In the context of physics education, these encompass assumptions, ideas, and prior concepts about science, its evolution, methods, and validation processes (Suarez et al., 2022). On the other hand, the set of attitudes of teachers and students towards the teaching-learning process is referred to as educational attitudes, which manifest in the willingness to learn, the value placed on the subject, perceptions of self-efficacy, and perceptions of the teacher, among other factors.

In this framework, fostering positive attitudes and beliefs toward physics is essential in the educational domain, as they directly influence academic performance (Paoloni & Bonetto, 2013; Appiah-Twumasi, 2024; Li & Singh, 2023; Mao et al., 2021). Consequently, the role of the teacher transcends mere knowledge transmission and includes the promotion of affective characteristics such as positive attitudes, beliefs, and values (Blömeke et al., 2020). This way, students can develop an appreciation for science and a greater willingness to learn.

There are also sociodemographic and social factors that impact academic performance. According to Real-Delor et al. (2024), these factors include work capacity, effort, competencies, study intensity, personality, aptitude, memory, and motivation. Additionally, demographic context (rural and urban institutions) constitutes another relevant element, as an educational gap persists related to resource scarcity in rural areas (Reyes, 2024; Salgado Oviedo, 2025). Gender also represents an important factor: the Organization for Economic Cooperation and Development (OCDE, 2025) reports that women represent only 22% of graduates in Information and Communication Technologies (ICT) and 35% in engineering, highlighting a gender gap in scientific fields.

Regarding social factors, aspects such as economic income, parents' educational level, and family issues influence performance in regions of Latin America and the Caribbean (OCDE, 2025). These factors can negatively impact academic performance, thereby increasing the likelihood of school failure (Rodríguez & Guzmán, 2019). Therefore, understanding how all these elements influence beliefs and attitudes toward physics is essential. In this regard, Suarez et al. (2022) emphasize the importance of analyzing whether the type of educational institution, teacher profile, and teaching materials affect the development of more positive beliefs and attitudes. Likewise, Adams et al. (2006) stress that teaching practices can negatively impact beliefs, underscoring the need to review the methodologies employed.

Various studies have developed instruments to assess students' perceptions of physics. For instance, Malespina et al. (2023) identified four components of student mindset, among which “my ability” and “my growth” were predictors of academic performance in physics. Similarly, Figueiredo et al. (2024) noted that students with a higher level of self-efficacy perform better than those with lower levels.

For this study, four previously validated and internationally relevant instruments were referenced: the Test of Science-Related Attitudes (TOSRA; Fraser, 1981), the Colorado Learning Attitudes about Science Survey

(CLASS; Adams et al., 2006), the Physics Attitude Scale (PAS; Kaur & Zhao, 2017), and the instrument developed by Gürler and Baykara (2020). The main characteristics of these instruments are presented in Table 1.

Table 1
Dimensions evaluated in the base instruments

Instrument	N	What It Measures
TOSRA (Fraser, 1981)	70 items	- Social implications of science - Normality of scientists - Attitude toward scientific inquiry - Adoption of scientific attitudes - Enjoyment of science classes - Scientific interest in leisure - Professional interest in science
CLASS (Adams et al., 2006)	42 items	- Connection to the real world - Sense-making/effort - Applied conceptual understanding - Problem-solving sophistication - Confidence
El *PAS* (Kaur & Zhao, 2017)	60 items	- Enthusiasm for physics - Learning physics - Physics as a process - Physics teacher - Physics as a future vocation
Gürler et al. (2020)	21 items	- Motivation - Physics anxiety - Interest in physics courses - Self-efficacy - Student interest - Anxiety about mathematical operations

In this context, there arises a need to analyze the relationship between academic performance and beliefs and attitudes toward physics among students in the Unified General Baccalaureate (BGU), considering possible differences associated with gender, type of institution, and demographic area. Based on this, the hypothesis is proposed that beliefs and attitudes toward physics are significantly related to academic performance.

Methodology

This research adopted a quantitative methodological approach with a non-experimental, cross-sectional design and correlational scope, as it analyzed the relationship between beliefs and attitudes toward physics and the academic performance of students in the Unified General Baccalaureate (BGU).

The sample consisted of 301 students, aged between 15 and 17 years, of whom 155 were female and 146 were male. The participants came from fiscomisionales and fiscal educational institutions, located in urban and rural sectors, to ensure diversity in educational contexts. A non-probabilistic convenience sampling method was employed, considering the accessibility and willingness of the institutions to participate in the study.

For the design and formulation of the items, a thorough review of the scientific literature on beliefs and attitudes toward physics was conducted, with the main references summarized in Table 1. Based on this review, items were adapted and additional items were created, incorporating two new dimensions: perceptions related to gender and beliefs about the educational and social context. The final questionnaire consisted of 38 items using a Likert scale, structured into seven analysis dimensions:

1. Interest and enjoyment in physics.
2. Perception of the utility and relevance of physics.
3. Perception of difficulty and self-efficacy.
4. Attitudes toward learning physics.
5. Perception of the physics teacher.
6. Gender-related perceptions.
7. Beliefs about the educational and social context.

To ensure the validity and reliability of the instrument, a content validation process was conducted with the participation of seven experts in physics education (Table 2). The specialists evaluated the relevance, formulation, coherence, relevance, and clarity of the items. Subsequently, a pilot test was administered to 25 BGU students with characteristics similar to the main sample to verify the comprehension and appropriateness of the items.

The internal reliability of the questionnaire was estimated using Cronbach's alpha coefficient for each dimension (Table 3), yielding values that indicated adequate consistency. The application of the instrument was conducted in person, ensuring voluntary and anonymous participation of the students.

Table 2

Expert validation (N=7)

Indicators	TD	D	N	A	TA
Pertinence				4	3
Formulation			1	3	3
Coherence				3	4
Relevance			2	3	2
Validity		1		4	2

Note. TD = Totally Disagree; D = Disagree; N = Neutral; A = Agree; TA = Totally Agree.

Additionally, the average official grades in the physics subject for the three trimesters of the academic year were collected, which were used as an indicator of academic performance. With this data, the possible correlation between students' beliefs and attitudes and their academic performance was analyzed using Spearman's correlation coefficient. Complementarily, Student's t-tests were applied to identify significant differences in academic performance based on gender, demographic area, and type of educational institution, using a significance level of $p < 0.05$.

Results

The application of the instrument demonstrated acceptable reliability indices in most of the evaluated dimensions (Table 3). Improvement opportunities were identified in the dimensions related to gender perceptions and beliefs about the educational and social context; however, both were maintained in the analysis due to their theoretical grounding and sociocultural relevance in understanding the factors influencing academic performance.

Table 3

Reliability analysis of the instrument using Cronbach's Alpha

Dimension	Pilot Test	Final Questionnaire
	N = 25	N = 301
Interest and enjoyment in physics	0,829	0,847
Perception of usefulness and relevance	0,904	0,785
Perception of difficulty and self-efficacy	0,599	0,767
Attitude towards learning physics	0,671	0,717
Perception of the physics teacher	0,862	0,884
Gender-related perception	0,527 (Female) 0,566 (Male)	0,641 (Female) 0,519 (Male)

Beliefs about the educational and social context	0,647	0,629

Note. N= number of participants.

Correlation tests

Before presenting the results, Table 4 shows the interpretation criteria for the correlation coefficients used in this study.

Table 4

Interpretation of Spearman's correlation coefficient

Value of rho (ρ)	**Meaning**
-1	Large and perfect negative correlation
-0.9 to -0.99	Very high negative correlation
-0.7 to -0.89	High negative correlation
-0.4 to -0.69	Moderate negative correlation
-0.2 to -0.39	Low negative correlation
-0.01 to -0.19	Very low negative correlation
0	No correlation
0.01 to 0.19	Very low positive correlation
0.2 to 0.39	Low positive correlation
0.4 to 0.69	Moderate positive correlation
0.7 to 0.89	High positive correlation
0.9 to 0.99	Very high positive correlation
1	Large and perfect positive correlation

Note. Taken from Martínez Rebollar & Campos Francisco (2015)

In Figure 1 and Table 5, the Spearman correlation coefficients and significance values (p-values) obtained between the dimensions of the questionnaire and academic performance are presented. The results indicate positive and statistically significant correlations in the dimensions of interest and enjoyment in physics and perception of difficulty and self-efficacy ($p < 0.001$), which present the highest association values. Additionally, the dimensions of attitudes towards learning physics ($p = 0.028$), perception of the physics teacher ($p = 0.007$), and beliefs about the educational and social context ($p = 0.003$) also showed positive and significant correlations, albeit of lesser magnitude. In contrast, the dimension of perception of usefulness and relevance of physics exhibited a nearly null correlation with academic performance ($\rho = 0.07$; $p = 0.201$). These results suggest that emotional factors associated with learning physics influence academic performance, even though the correlations are of low intensity. This behavior may be explained by the absence of a strong monotonic relationship, where the influence of interest or enjoyment could depend on other mediating variables, such as perceived self-efficacy (Figure 1).

Figure 1

Spearman correlations (ρ) between the dimensions of the questionnaire and academic performance (N = 301)



Note. D1 = Interest and Enjoyment in Physics; D2 = Perception of Usefulness and Relevance of Physics; D3 = Perception of Difficulty and Self-Efficacy; D4 = Attitude Towards Learning Physics; D5 = Perception of the Physics Teacher; D7 = Beliefs About the Educational and Social Context.

Table 5

p-values between the dimensions of the questionnaire and academic performance (N= 301)

Dimensions	p-value (p)
Interest and Enjoyment in Physics	< 0,001
Perception of Usefulness and Relevance	0,201
Perception of Difficulty and Self-Efficacy	< 0,001
Attitudes Towards Learning Physics	0,028
Perception of the Teacher	0,007
Beliefs About the Educational and Social Context	0,003

Analysis by gender

The dimension of gender-related perceptions was analyzed separately, as it included specific items for men and women. The results, presented in Table 6, show that, for women, there is a positive and significant correlation (ρ = 0.204; p = 0.011) between gender perceptions and academic performance. In contrast, no correlation or significance was found for men (ρ = –0.004; p = 0.964).

Table 6

Spearman correlation for gender-related perception

Gender-related perceptions	N	Rho (ρ)	p-value (p)
Female	155	0,204	0,011
Male	146	-0,004	0,964

t-tests for academic performance by gender, geographic area, and type of institution.

Comparative group analysis

Additionally, Student's t-tests were conducted to analyze differences in academic performance based on gender, geographic area, and type of educational institution. Table 7 presents the group comparisons: Group 1 corresponds to men from fiscomisional institutions in urban areas, while Group 2 corresponds to women from fiscal institutions in rural areas. The sample size (N) is detailed for each group. After confirming the normality of the academic performance variable using the Kolmogorov-Smirnov test (p = 0.200), a statistically significant difference was identified between men and women (p = 0.009). Women achieved a higher mean (M = 7.98; SD = 0.81) with a large effect size (d = 0.90), indicating a relevant difference both statistically and practically.

On the other hand, no significant differences were found in academic performance based on geographic area (p = 0.067) or type of institution (p = 0.208); however, both comparisons showed high effect sizes (d = 0.91), suggesting potential latent differences that warrant deeper analysis.

Table 7

t-tests related to academic performance

Comparison	Group 1 M (SD)	Group 2 M (SD)	N1	N2	p-value (p)	Cohen's d (d)
Male vs Female	7,71 (1,00)	7,98 (0,81)	146	155	0,009	0,90
Urban vs Rural	7,90 (0,87)	7,70 (1,01)	225	76	0,067	0,91
Fiscomisional vs Fiscal	7,78 (0,91)	7,92 (0,92)	153	148	0,208	0,91

Note. M = mean; SD = standard deviation; N = sample size; p = significance; d = Cohen's effect size.

Summary of results

Overall, the findings reveal positive and significant correlations in most of the evaluated dimensions. The t-tests showed significant differences by gender, with women exhibiting superior academic performance, in addition to high effect sizes across all comparisons made. A slightly higher mean was also observed in urban settings compared to rural ones (7.90 vs. 7.70).

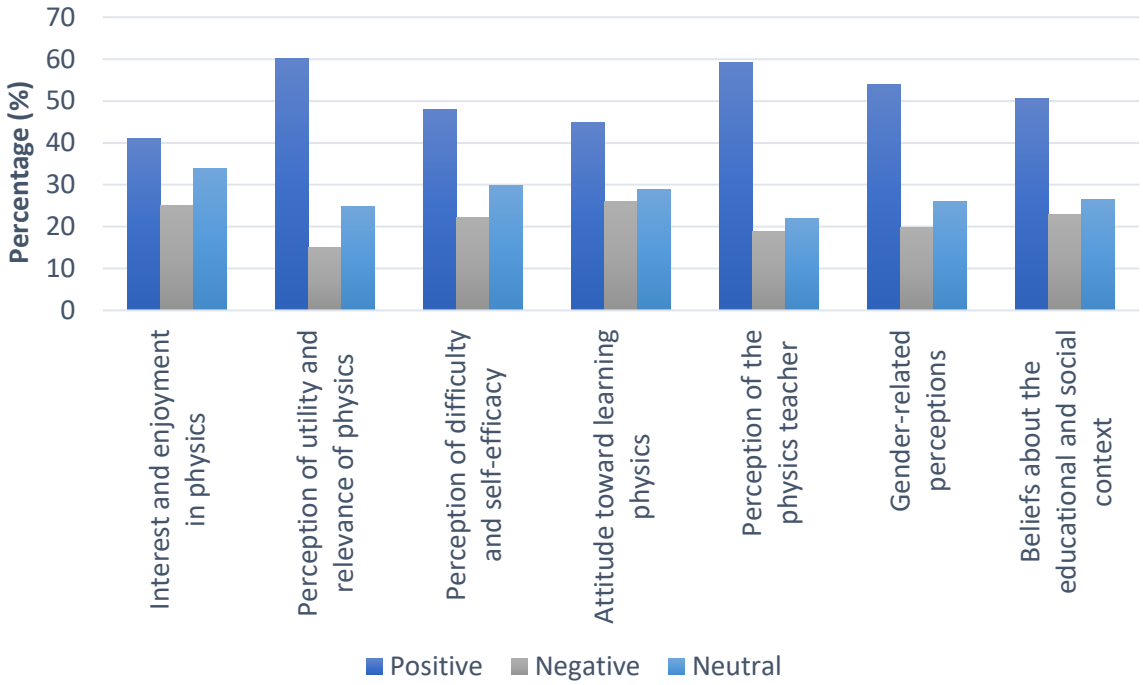
These results support the proposed hypothesis: positive attitudes and beliefs toward physics are significantly correlated with academic performance. Moreover, the complementary influence of sociocultural, demographic, and gender factors was identified, which, while not fully determining academic performance, contribute to its variability.

Response frequency analysis

Regarding the dimensions of the questionnaire, Figure 2 shows the percentage of responses obtained by category. Positive responses were considered those options "Agree" and "Totally Agree"; negative responses were "Disagree" and "Totally Disagree"; and neutral responses were represented by the option "Neutral."

The majority of responses fell into the positive category, exceeding 40% in all dimensions. Neutral opinions accounted for an average of 27%, while negative responses constituted the lowest percentage.

Figure 2
Bar graph of response distribution by dimensions



Among the notable results, the dimension of interest and enjoyment in physics exhibited proportionally fewer positive responses and a greater number of negative ones, suggesting the need to delve deeper into the factors affecting student interest in this subject. In contrast, the dimensions of perception of usefulness and relevance of physics and perception of the physics teacher showed a significant difference between positive and negative responses, with favorable responses being predominant. This indicates that, although the enjoyment of the subject is limited, students recognize its utility and positively value the teaching effort in the classroom.

Discussion

The dimensions of interest and enjoyment in physics and perception of difficulty and self-efficacy showed the highest and most significant correlations with academic performance. These findings reinforce the idea that affective and motivational factors play a decisive role in student performance (Adams et al., 2006; Chala, 2020; Mao et al., 2021; Aprilia et al., 2023; Malespina et al., 2023; Figueiredo et al., 2024; Appiah-Twumasi, 2024; Limbaga & Borlio, 2025). In the case of interest and enjoyment in physics, this dimension not only reflects the degree of emotional attraction to the subject but also acts as a catalyst for academic engagement. Previous research supports that favorable attitudes and the motivational role toward physics influence both learning and the desire to pursue studies in scientific areas (Kaur & Zhao, 2017; Adams et al., 2006). For instance, Mao et al. (2021) identified a significant correlation between attitudes toward science and academic performance ($\rho = 0.248$; $p < 0.001$), reinforcing the importance of promoting positive experiences in the classroom that strengthen motivation and learning.

Similarly, the results of the present study show that the perception of difficulty and self-efficacy highlights the influence of individual beliefs in learning capability. Prior studies agree that students with greater confidence in their abilities tend to overcome academic challenges and achieve better performance, while those lacking such confidence often experience blockages or difficulties (Figueiredo et al., 2024; Kaur & Zhao, 2017; Paoloni & Bonetto, 2013). Dehbozorgi et al. (2021) complement this assertion by stating that self-efficacy not only impacts performance but is also associated with positive attitudes toward learning.

On the other hand, although students recognize the usefulness of physics (see Figure 1), this perception does not translate into a direct impact on academic performance ($\rho = 0.074$; $p = 0.201$). This finding suggests a possible disconnect between valuing the importance of physics as a science and effective commitment to its learning.

Regarding the perception of the teacher, the results confirm that the teacher's role transcends mere content transmission. Therefore, physics teachers should pay attention to their students' attitudes and the interactions that occur in the classroom, given the positive impact these can have on academic performance (Blömeke et al., 2020; Li & Singh, 2023; Appiah-Twumasi, 2024; Danladi & Adamu, 2025).

The findings related to the dimension of gender-related perceptions are particularly revealing in terms of equity. In the case of women, this dimension showed a significant correlation with academic performance ($\rho = 0.204$; $p = 0.011$), while no relationship was found for men ($\rho = –0.004$; $p = 0.964$). This result highlights the gender tensions that still permeate school experiences in the sciences. In this study, women reported slightly higher grades than men (7.98 vs. 7.71); however, negative internal beliefs persist that may limit their participation in scientific spaces. Wang and Degol (2017) point out that many women with talent for sciences continue to be underrepresented in academic and professional environments due to gender stereotypes and sociocultural barriers that restrict their opportunities and full development. In contrast, men seem to show a disconnect between their gender beliefs and their academic performance.

The dimension of beliefs about the educational and social context also presented a significant correlation with academic performance ($\rho = 0.172$; $p = 0.003$), indicating that the environment in which the student operates influences their performance. Although no significant differences were observed based on geographic area or type of institution in the t-tests, the high effect sizes alert us to latent inequalities that could be affecting the results. Factors such as access to technological and laboratory resources, teacher training, family support, geographic location, and socioeconomic conditions have been widely documented as determinants of academic performance in Latin American contexts (OCDE, 2025; Rodríguez & Guzmán, 2019; Salgado Oviedo, 2025). Consequently, academic performance must be understood as a multi-causal construct where individual and structural factors interact continuously.

In conclusion, the findings of this research confirm that positive attitudes and beliefs toward physics are significantly and favorably correlated with academic performance. Therefore, it is recommended that in the classroom, not only the conceptual component be addressed, but also the strengthening of students' interest and self-efficacy. Additionally, it is crucial to foster an equitable learning environment that promotes equal opportunities and values individual capabilities. Together, the factors of interest, self-efficacy, teacher perception, and social context directly influence the improvement of academic performance.

Conclusions

The results demonstrate that positive attitudes toward physics, such as interest and enjoyment in the subject, perception of self-efficacy, favorable attitudes toward learning, positive perceptions of the teacher, and an adequate educational context, are significantly related to academic performance. These findings reinforce the need to implement pedagogical strategies that foster intrinsic motivation and student confidence, as these factors not only impact knowledge acquisition but also the willingness to continue studies related to the sciences.

Furthermore, the study highlights the relevance of the teacher's role as an emotional and pedagogical mediator that transcends mere content transmission. The teacher's influence manifests in their ability to create stimulating learning environments, promote active participation, and strengthen students' self-confidence.

The dimension related to the educational and social context also showed significant associations, indicating that structural inequalities—such as resource availability, family support, or geographic location—indirectly affect performance, even if they do not always reflect in statistical differences. This suggests that academic performance should be analyzed from a comprehensive perspective that considers both individual and contextual factors.

Regarding gender perceptions, it was observed that women achieved higher academic performance than men, and only in women did the perception of gender correlate significantly with that performance. In contrast, men exhibited a distinct dynamic characterized by a disconnect between their gender beliefs and academic performance.

Overall, the results confirm that performance in physics is a complex and multifactorial phenomenon influenced by cognitive, emotional, social, and contextual components. In this framework, the importance of fostering interest and self-efficacy, strengthening the teacher's role as a motivational mediator, and promoting inclusive environments that help reduce gender and contextual inequalities is emphasized, in order to improve the quality of learning in the sciences.

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