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Perception of Physics Teachers about Their Pedagogical Practice in Secondary Education

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Abstract

Teaching methodologies and didactic models are a fundamental part of the teaching-learning process and have been studied worldwide. In the case of science, strategies have been developed that allow teachers to improve their teaching-learning processes. This paper investigates and evaluates physics teaching in public education in Colombia from the perspective of the teachers themselves. For this purpose, a review of the specialized literature existing in Colombia and in the world on teaching-learning methods in physics was carried out. Based on this, a survey was administered to 90 physics teachers in Colombia. The instrument consisted of specific questions regarding the organization and methodology of a lesson, teacher qualification, availability of resources, as well as their perception of the attitude, previous knowledge, and socioeconomic and cultural situation of the students. The results indicate that 84,4 % of the teachers surveyed provided accounts of their lesson organization, while 36,7 % reported using a specific methodology, mainly related to transmission-reception didactic models. A total of 24,4 % consider their academic education to be inadequate and insufficient. The primary obstacles identified include the deficiency of infrastructure and institutional resources, insufficient previous knowledge of the students and their low interest in physics. Furthermore, teachers highlighted that the socioeconomic and cultural conditions of the students significantly condition the physics teaching-learning process in Colombia. Based on the results obtained, the difficulties they have in their teaching work were identified and analyzed in the light of the constructivist didactic method.

Keywords

teaching-learning process; didactic models; educational qualification; secondary education; public education

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Percepção dos Professores de Física sobre sua Prática Pedagógica no Ensino Médio

Resumo

As metodologias de ensino e os modelos didáticos são parte fundamental dos processos de ensino-aprendizagem, razão pela qual têm sido objeto de estudo em todo o mundo. No caso das ciências, foram desenvolvidas estratégias que permitem aos professores melhorar os seus processos de ensino-aprendizagem. Este trabalho investiga e avalia o ensino da Física na Colômbia a partir da perspectiva do próprio professor. Para isso, foi realizada uma revisão da literatura especializada existente na Colômbia e no mundo sobre os métodos de ensino-aprendizagem da Física e, com base nela, foi aplicado um questionário a 90 professores de Física do ensino médio acadêmico na Colômbia. O instrumento consiste em perguntas específicas sobre a organização e metodologia de uma aula, nível de formação, disponibilidade de recursos, bem como a sua perceção sobre a atitude, conhecimentos prévios e situação socioeconómica e cultural dos alunos. 84,4 % dos professores inquiridos responderam sobre a organização das suas aulas, enquanto 36,7 % afirmaram utilizar uma metodologia específica, principalmente relacionada com modelos didáticos de transmissão-recepção. 24,4 % consideram que a sua formação académica não é adequada e suficiente. Entre as dificuldades encontradas destacam-se a deficiência de infraestruturas e recursos institucionais, conhecimentos prévios insuficientes dos alunos e o seu baixo interesse pela Física. O último fator mencionado pelos professores, que também condiciona consideravelmente os processos de ensino-aprendizagem da Física na Colômbia, está relacionado com as condições socioeconómicas e culturais dos alunos. A partir dos resultados obtidos, foram identificadas e analisadas as dificuldades que estes enfrentam no seu trabalho docente, à luz do método didático construtivista.

Palavras-chave

processo de ensino-aprendizagem; modelos didáticos; qualificação académica; ensino secundário; ensino público

Percepción de los profesores de física sobre su práctica pedagógica en educación secundaria

Resumen

Las metodologías de enseñanza y los modelos didácticos son parte fundamental de los procesos de enseñanza-aprendizaje, por lo que han sido motivo de estudio a nivel mundial. En el caso de las ciencias, se han desarrollado estrategias que permiten que los docentes mejoren sus procesos de enseñanza-aprendizaje. En este trabajo se investiga y evalúa la enseñanza de la Física en Colombia desde la perspectiva del propio docente. Para ello, se realizó una revisión de la literatura especializada existente en Colombia y en el mundo sobre los métodos de enseñanza-aprendizaje de la Física, y con base en esta se aplicó una encuesta a 90 docentes de Física de la educación media académica en Colombia. El instrumento consiste en preguntas específicas sobre la organización y metodología de una clase, nivel de formación, disponibilidad de recursos, así como su percepción sobre la actitud, conocimientos previos y situación socioeconómica y cultural de los estudiantes. El 84,4 % de los docentes encuestados respondieron sobre la organización de sus clases, mientras que el 36,7 % manifestó utilizar una metodología específica, principalmente relacionada con modelos didácticos de transmisión-recepción. El 24,4 % considera que su formación académica no es adecuada y suficiente. Entre las dificultades encontradas se destacan la deficiencia de infraestructura y recursos institucionales, insuficientes conocimientos previos de los estudiantes y su bajo interés por la Física. El último factor manifestado por los docentes, que también condiciona considerablemente los procesos de enseñanza-aprendizaje de la Física en Colombia, se relaciona con las condiciones socioeconómicas y culturales de los estudiantes. A partir de los resultados obtenidos se identificaron y analizaron las dificultades que tienen estos para su labor docente, a la luz del método didáctico constructivista.

Palabras -clave

proceso enseñanza-aprendizaje; modelos didácticos; cualificación académica; educación secundaria; enseñanza pública

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Introduction

Teaching methods have changed over the years along with transformations in society. These methods are the core basis of teaching-learning processes, since they define actions that teachers must implement to achieve the learning objectives for the students (Narváez et al., 2020). According to Carrascosa-Alís & Domínguez-Sales (2017), for more than 50 years, lines of research have been developed to generate new knowledge that provide teachers continuous improvement in the science teaching-learning processes. Thus, the problems of these processes have become a discussion topic at numerous international events, such as the XI International Congress on Research in Science Didactics in 2021 or the 30th International Meetings on Experimental Science Didactics in 2022. These gatherings have focused on discussing the strategies that would allow the adequate incorporation of disciplinary knowledge to teaching-learning, while also emphasizing the relevance of approaching science education from the perspective of problem-based situations, the foundation of the constructivist method.

In this sense, different authors have conducted studies on science education centered on the incorporation of constructivist methodologies. For instance, Santos (2021) developed a methodological proposal for teaching physics and chemistry in the 4th year of Compulsory Secondary Education (CSE) in a school from Catalonia, Spain, to raise students' interest and motivation towards these subjects. This methodology combines Problem-Based Learning (PBL) and Collaborative Learning (CL). In turn, Rodríguez-García & Arias-Gago (2022), based on an analysis of the 2019 PISA results in Spain, showed that students who participated in inquiry-based teaching contexts achieved better academic performance compared to those exposed to traditional methodologies. Similarly, Quintanal (2023) studied the impact of implementing PBL within the physics and chemistry teaching-learning process, based on the perception of students at La Inmaculada school in Granada (Spain).

In the Latin American context, research has focused on analyzing pedagogical training programs and how they influence the instructional practices of science teachers. For example, Cofré et al. (2010) conducted a systematic specialized literature review on science teaching in Chile. According to this research, deficiencies are evident in the teaching-learning processes of science, since the traditional didactic model prevails, far from the scientific inquiry that is a core basis of science. Regarding academic education of science teachers, these authors argue that, even though teacher education programs in Chile are based on disciplinary and general pedagogical knowledge, they give little importance to science didactics, research and the use of technology, all of which are critical components of effective teacher training.

On the other hand, Hernández et al. (2020) described and analyzed the primary characteristics of the physics academic pedagogy programs in different Chilean universities. These academic education programs emphasize pedagogical knowledge over disciplinary content, resulting in a weak articulation between the two. These findings align with the concerns previously raised by Gil (1991), suggesting that a lack of disciplinary knowledge constitutes an obstacle to innovation and to the teaching-learning process itself. This situation demonstrates that after 30 years, core deficiencies persist in the professional preparation of science teachers across Latin America.

Nonetheless, some research shows that constructivist methodologies are being applied in teaching-learning processes in science. Imbert (2020) studied the impact of applying the inquiry learning method in teaching-learning processes with the aim of developing scientific competencies in students at a high school in Paso de Los Toros (Uruguay). Similarly, Fonseca-Factos and Simbaña-Gallardo (2022) analyzed the implementation of the STEM approach in the physics teaching, together with the application of PBL methodologies in first-year high school students at an educational institution in Ecuador.

In the Colombian scene, various authors have analyzed the challenges arising in the teaching-learning processes across the country's educational institutions, emphasizing the importance of implementing didactic models to enhance instructional quality. For instance, Gallego et al. (2004) conducted their research with a group of teachers, coordinators, and students from different programs in academic pedagogical education faculties, aiming to analyze the relationship between scientific disciplinary subjects and pedagogical coursework. Based on the results, disciplinary knowledge prevails in the study plans of the physics and chemistry programs, concluding that subject-matter expertise alone is insufficient for effective instruction; rather, it must be integrated with Pedagogical Content Knowledge (PCK), a statement previously made by Shulman (1986). Similarly, Coronel (2016) analyzed the pedagogical model used by teachers at the Luis Alberto Badillo Educational Center (La Gloria-Cesar). From their results, 50 % of the teachers at the educational center identify themselves with the traditional model, 42 % with the cognitive model, and the remaining 8 % rely on the romantic pedagogical model.

Regarding natural sciences in Colombia and their relationship with constructivist methodologies, Lopez-Rivera (2015) highlighted that the obstacle for teaching these subjects is mainly associated with the lack of implementation of these methodologies, prevailing the application of traditional didactic models, which does not guarantee content understanding. The author further emphasizes deficiencies in curriculum design, noting a lack of alignment with the students’ context, as well as inconsistencies in disciplinary knowledge and the absence of continuous pedagogical training.

Methodology

First, a detailed review of specialized literature on the physics teaching-learning methods in Colombia and around the world was undertaken. Then, in accordance with the curricular guidelines of the Ministerio de Educación Nacional (MEN), which recommends the incorporation of the constructivist model in the teaching-learning process (Ministerio de Educación Nacional, 1998), this model was adopted for the subsequent analysis of the results obtained in this study. Next, a survey was designed, validated, and applied, to collect real information on the teaching-learning process of physics in the country's public institutions from the point of view of the physics teachers.

The survey was divided into two sections: the first collected contextual variables (personal data and academic education), while the second consisted of a questionnaire with seven open questions and three closed questions. This instrument was administered to a group of physics teachers from public institutions in different regions of Colombia. The validation was carried out by nine university professors: two with PhDs in Physics, five in Educational Sciences and two in Didactics of Experimental Sciences. They evaluated each question of the survey in terms of clarity in its expression and relevance to meet the aim, by applying a four-level Likert Scale. The results of this assessment allowed us to specify and improve the final content of the survey[1]. Subsequently, the voluntary non-probabilistic sampling survey was sent online to physics teachers using the country's Secretariats of Education via Google form.

Finally, an analysis was made of the responses obtained from the survey applied. These were organized and categorized inductively, with a subsequent descriptive analysis by calculating the percentage (%) of the responses with respect to the respondents' total number, in order to, and according to Hernández Martín (2012), make comparisons between the groups defined in Table 1 and get a clear idea of their differences. Furthermore, central measures (mean and mode), standard deviation, and chi-square test were used with statistical software (SPSS 15.00 and Microsoft Excel).

The analysis of the open-ended responses was based on a mixed methods approach, combining elements of qualitative and quantitative research (Creswell & Plano Clark, 2017). For this purpose, the study employed an exploratory sequential design. We began with a qualitative phase, using surveys to compile

[1] https://docs.google.com/document/d/1mCK2R4hhNnopABcPNHPf49VKD-kX_5YDH5Idf7SprW8/edit?usp=sharing

open-ended responses to explore recurring themes or patterns. Subsequently, through inductive (ad hoc) categorization, we conducted a descriptive quantitative analysis of these topics. In this way, the descriptive richness of the qualitative approach is complemented by the comparative capacity of the quantitative approach (Bisquerra, 2019). Regarding the closed-ended answers, a direct quantitative analysis was performed.

Results and Discussion

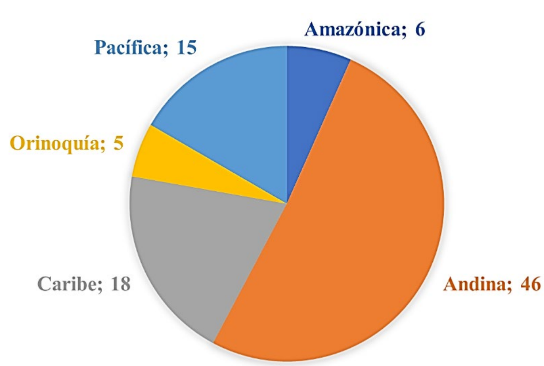
The following analysis took into account the framework of the constructivist model, organized into subsections (profile of the participants, an analysis of the teachers' academic attainment and an evaluation of the responses provided by the survey participants). About the analysis of the answers sent, this was based on the conceptual and statistical evaluation of the responses to each of the survey questions separately. The instrument was designed in such a way that it allowed for separate inquiries about diverse factors influencing the teaching-learning processes used by the surveyed teachers. This granular approach facilitated a precise characterization of the causes and consequences influencing the current state of physics education in Colombia.

Description of Surveyed Teachers

The survey was answered by 90 physics teachers who work in different public education institutions in the country (Figure 1). 36 % were women and the remaining 64 % men, both aged between 27 and 66 years old (mean 44,9 years and standard deviation 9,85 years).

Figure 1

Distribution of Surveyed Teachers by Region



Note. Own elaboration.

Table 1 shows the academic qualification of the surveyed teachers, split into four groups for further analysis.

Table 1
Definition of Groups According to Academic Qualification (N: number of members)

GROUP	ACADEMIC QUALIFICATION	N
G1 (N=59)	Bachelor's in Education - Natural Sciences	1
	Bachelor's in Education - Electricity and Electronics	1
	Bachelor's in Education - Physics	13
	Bachelor's in Education - Mathematics and Physics	4
	Specialists in Education and Pedagogy with Previous Basic Academic Education in Physics	13
	Master's in Education, Master's in Science Teaching, Master's in Pedagogy with Previous Basic Academic Education in Physics	26
	PhD in Education with Previous Basic Academic Education in Physics	1
G2 (N=13)	Physicist	1
	Master of Science in Physical Sciences	11
	Master of Science in Applied Physics	1
G3 (N=5)	Bachelor's in Education - Mathematics	3
	Mathematician	2
G4 (N=13)	Engineers	8
	Master of Science in Engineering	5

Note. Own elaboration

Analysis of the Academic Educational Level of the Surveyed Teachers

Next, the academic educational level of the surveyed teachers will be analyzed according to the graduate and postgraduate degrees shown in Table 1. Group G1 is integrated by teachers with university degrees in pedagogy/didactics and physics (four basic courses), G2 corresponds only to academic education in physics without any academic education in pedagogy and didactics, G3 to academic education in mathematics with three basic courses in physics and without any academic education in pedagogy and didactics, and bachelor in education - mathematics (without any academic education in physics), and G4 by engineers of different areas. According to the *Manual de Funciones, Requisitos y Competencias* for the positions of high school principals and teachers (MEN, 2022), the suitable professional profile to teach physics at high school is based on four components: general fundamentals, specific and disciplinary knowledge, pedagogy and educational sciences, and didactics of the disciplines, which effectively constitute the academic education of G1. As stated by Ávalos

Davidson (2004) & Barenthien et al. (2020), the teacher's competencies, besides disciplinary knowledge, must be framed in didactic knowledge and in didactic knowledge of the content. These two characteristics are only evident in this group, since all its members have an academic background in pedagogy and didactics as well as in physics, which should contribute to better teaching.

The academic education of G2 satisfies the components of general fundamentals and specific and disciplinary knowledge in physics, but lacks pedagogical and didactic academic education, so it could be assumed that they would not have the most suitable profile to teach physics. The employment relationship of this group with high school teaching is due to the lack of job opportunities in their academic education area (scientific investigation), according to Sistema Nacional de Información para la Educación Superior en Colombia (SNIES) (2022). The group G3 does not meet the minimum academic education requirements for employment as high school physics teachers, according to MEN (2022). However, high school principals assign them physics courses due to the lack of available teachers in this area. At university, mathematicians receive basic physics courses and academic scientific education in mathematics without any academic education in pedagogy and didactics (SNIES, 2022).

On the other hand, the Bachelor’s in Education – Mathematics, have pedagogical and didactic academic background but not physics disciplinary knowledge. G4, consists of engineers and master’s in engineering, is composed of individuals that have basic academic education in physics, without knowledge of pedagogy or didactics. As in G2, the members of this group entered the teaching high school career due to the lack of job opportunities in their specific area, since the academic education of the different undergraduate mathematics and physics programs in Colombia is directed towards university teaching and scientific research (SNIES, 2022).

In agreement with the above, 31 (34,5 %) of all teachers surveyed do not have sufficient specific and disciplinary academic education or didactic and pedagogical competences, which represents a deficiency in the teaching of physics, according to MEN (2022).

Analysis of Answers Sent by the Surveyed Teachers

This subsection will show the results of each of the survey questions and their respective analysis grounded in the constructivist theory. This framework emphasizes meaningful learning, as well as the development of critical thinking and problem-solving skills among students. The analysis does not seek to classify responses as correct or incorrect, but to establish whether the strategies used in the classroom are suitable to promote active participation of students and, in this way, to ease more meaningful learning. In other words, it is about determining whether the strategies used by teachers in the classroom are in accordance with the recommendations from the didactics of science.

1) Question 1: Briefly explain the planning and methodology used by you during the development of a physics lesson.

The first part of this question (planning a lesson) will be analyzed based on a lesson structure, which consists of three phases: Initial, Intermediate, and Final (Morales & Mejía, 2020). In Serrano & Pons (2011) on constructivism, it is stated that knowledge is obtained from the interaction between the environment and the human mind, which interprets and reinterprets it, and it is not the result of the simple description of existing reality. This process implies that the mind explains reality in a progressive way with models that range from the basic to the most complex. From this point of view, in the Initial phase of a lesson the teacher should start with a motivation or the statement of a problematic situation, carry out an inquiry into prior knowledge, define the goals and relevance of learning, and establish evaluation criteria. In the Intermediate or developmental phase, didactic strategies based on knowledge feedback about the problem situation are applied to achieve the learning objective. In the Final or closing phase, the learning process is evaluated to determine the extent to which the expected outcomes were achieved.

Analyzing the results obtained about the planning of a lesson, it was found that only 84,4 % (76) of the total number of teachers surveyed answered the question, giving at the same time a detailed description. This means that the remaining 15,6 % (14) may have deficiencies in lesson planning, according to the MEN (1998) guidelines.

Table 2 shows the number of teachers per group whose responses were associated with the planning phases described above through an inductive categorization process.

Table 2
Number of Teachers Who Planned their Lessons by Phases (N) and the Respective Percentage (%). Total Teachers Surveyed: 90).

Phase	G1		G2		G3		G4		Total	
	N	%	N	%	N	%	N	%	N	%
Initial	35	38,9	8	8,9	4	4,4	9	10,0	56	62,2
Intermediate	49	54,4	9	10,0	4	4,4	12	13,3	74	82,2
Final	33	36,7	7	7,8	3	3,3	8	8,9	51	56,6

Note. Own elaboration.

Table 2 highlights that teachers give more importance to the Intermediate phase (82,2 %), followed by the Initial phase (62,2 %) and finally to the Final phase (56,6 %). One possible explanation for the greater choice of the

Intermediate phase could be because these teachers develop the strategies of the Initial phase during the Intermediate phase, as reported by Morales & Mejía (2020). The lower choice of the Final phase in the four groups analyzed could mean a limitation in the monitoring and metacognition of learning, an aspect also pointed out by Sancho (2017). Likewise, it is observed that the G1 group does not lead the Initial and Final phases, even though a better performance during the educational process would be expected, due to their academic background. This could be associated with deficiencies in their academic education, which may be one of the causes of the low institutional results in the Saber Pro tests (El Observatorio de la Universidad Colombiana, 2022), applied at the end of the academic education cycle in the country's higher education institutions.

As a complement to the above, an analysis of the answers given by 84,4 % (76) of the 90 teachers who responded on the planning of a lesson, enabled quantifying the number of teachers who plan a lesson, according to the number of phases mentioned in the planning of a class: 17,1 % described only one of the phases as a form of planning the lesson (G1=10,5 %, G2=2,6 %, G3=1,3 %, G4=2,6 %), 27,6 % report two phases (G1=18,4 %, G2=2,6 %, G3=2,6 %, G4=3,9 %), and 55,3 % stated that they organize their lesson based on the three phases (G1=35,5 %, G2=7,9 %, G3=2,6 %, G4=9,2 %). Consequently, 44,7 % of the teachers who responded (76) do not develop the three phases.

Analyzing this information by groups, it would be expected that the members of G1 would define the three phases, since they have an adequate disciplinary and pedagogical background for the teaching-learning process. However, only 30 % of this group answered about it. The other three groups, as expected due to their specific academic background, lack enough knowledge to be able to develop the three phases during a lesson. According to the LEE (Laboratory of Educational Economics from Javeriana University, 2020), the existing deficiencies in the academic education of teachers is one of the main problems of the Colombian university educational system, as also stated by Cabeza et al. (2018).

As a complement and as validation of the previous results, a relationship was established between teacher academic education and the planning of a lesson (three phases). In this regard, the Chi-square test was applied, through the elaboration of a contingency table relating the academic qualification per group (Table 1) with the number of phases used by teachers in the planning of a lesson (data obtained from the complementary analysis of the survey and expounded in the preceding paragraph). Based on the null hypothesis "the academic education level of teachers does not influence the use of the three phases", a value of 0,8976 (5 % statistical significance) is obtained. This value is less than the critical Chi-square value of 12,5916, meaning that no relationship can be established between academic qualification and the application of the three phases (Förster, 1979). The validity of this result is proven, since 46,7 % of the 90 teachers surveyed defined the three phases, while 55,3 % did not.

Based on this previous analysis (percentages and Chi-square), teachers possibly show deficiencies in the planification of teaching-learning processes, since more than 50 % of the total surveyed were not able to define the structure (3 phases) that the development of a lesson should follow (Morales & Mejía, 2020).

Following the second part from Question 1, related to the methodology used during the planning of a physics lesson, Table 3 shows the didactic models inferred from the answers of 36,7 % of the total surveyed about the use of some didactic methodology. In this one, the Mixed model was inferred based on the answers given by the teachers on the use of both transmission-reception and constructivist methods during a lesson, which could be interpreted as progression from the use of the transmission-reception method only.

Table 3

Number (N) and Percentage (%) of Teachers Who Answered per Group About the Methodology Used for Teaching a Physics Lesson and the Respective Inferred Didactic Model (Total Teachers Surveyed: 90).

Classification of Responses on Methodology Used	G1		G2		G3		G4		Total		Associated Didactic Model
	N	%	N	%	N	%	N	%	N	%	
Learning guides Assertive logic method Deductive method Traditional method	17	18,9	4	4,4	0	0,0	2	2,2	23	25,6	Transmission-Reception
Meaningful learning Conceptual change Active methodology Problem situation Bloom's Taxon Teamwork	5	5,6	2	2,2	1	1,1	0	0,0	8	8,9	Constructivist
Learning guides – Bloom's Taxonomy Learning guides – Teamwork	2	2,2	0	0,0	0	0,0	0	0,0	2	2,2	Mixed

Note. Own elaboration

Table 3 (only 33 teachers answered out of the total number surveyed), indicates a predominance of repetitive and rote-learning methods, as 25,6 % of the total number of teachers surveyed could be identified with methodologies associated with the transmission-reception model, very few with constructivism (8,9 %), and only 2,2 % with the Mixed method. It is of concern that 63,3 % of the total number of teachers surveyed did not answer, a result that might suggest that many of them do not have conceptual clarity regarding the didactic methodologies they apply. Furthermore, it may indicate a lack of critical analysis concerning their pedagogical practices, or insufficient academic preparation. Ultimately, these factors likely contribute to a lower quality of the physics teaching-learning processes in the classrooms, as shown in Furlani (2020) and Hernández et al. (2020).

By number of members of each group (Table 1), it is observed that of the 59 teachers in G1, only 24 (40,7 %) answered about the methodology (Table 3), which would suggest that the rest of the teachers in this group may be lacking preparation in their didactic and pedagogical academic background. In G2 (physicists), 6 (46,1 %) out of 13 teachers answered, a result that exceeds G1, despite their lack of didactic and pedagogical knowledge. This situation is more accentuated in G3 (mathematicians and bachelor's in education-mathematics): 1 (20 %) out of 5 teachers in total, and G4 (engineers): 2 (15,4 %) out of 13. This critical scenario, which has been extensively analyzed in a lot of studies (i.e. Cardona et al., 2019; Furlani, 2020; Hernández et al., 2020; Salica, 2022; Hoyos et al., 2023), is one of the main challenges that must be solved at a national level to improve physics teaching in Colombia. The fact that only 33 teachers (36,7 % of the total surveyed) answered about the methodology used, and that of these, 23 (69,7 %) apply traditional methodologies, points to a lack of theoretical knowledge about more innovative didactic methodologies.

As a validation of the previous analysis, the Chi-square test was applied to the relationship between the teachers' level of academic education (Table 1) and the use of methodologies related to constructivism (Table 3). From the null hypothesis "the level of academic education of teachers does not influence the use of constructivist methodology in a classroom", a value of 2 720 is obtained when applying the Chi-square test (5 % significance), lower than the critical Chi-square of 7 815. Therefore, it is not possible to establish a relationship between academic education and the use of the constructivist method in a lesson.

According to the previous results (percentages and Chi-square), it can be point out that a large number of teachers lack sufficient didactic and pedagogical foundations, since 63,3 % of the total number of teachers did not answer about the methodology, while 69,7 % of the sample who did, do not use active methodologies, conceiving knowledge as a repetitive process. This situation limits the development of science competencies in students, which could be explained as a structural deficiency in the academic preparation required by a high school teacher (Hernández et al., 2020).

2) Question 2: According to your daily experience, select from among the following difficulties, those that you consider affect the quality with which a physics lesson is developed.

In this question, teachers were asked to choose from a limited set of predefined non-exclusive answers and were given the alternative of an open response in case the given options did not meet their perceptions. All answers were organized into three factors related to the difficulties raised by teachers (teacher, student, and resources), as shown in Table 4.

Table 4

Teachers' Answers to Difficulties Affecting the Quality of Physics Teaching (Total Teachers Surveyed: 90)

Factor	Difficulty	G1	G2	G3	G4	Total
Teacher	Insufficient or irrelevant capacitation Undergraduate and postgraduate academic education	14	2	1	5	22
Student	Previous conceptual bases of the students Student disabilities Excessive number of students in the classroom Student interest Educational needs of students	50	11	4	12	77
Resources	Inconvenient schedule Infrastructure Laboratories Teaching resources Public services Virtuality	53	11	3	11	78

Note. Own elaboration.

For the analysis of Table 4, it should be noted that each teacher was able to choose more than one difficulty for each factor. Out of the total of teachers surveyed, 86,7 % consider that lack of teaching resources is one of the main hardships affecting quality, 85,6 % believe that students are another important factor, while 24,4 % related it to deficiencies in academic education and training. Consequently, the main difficulties affecting quality of physics teaching are found in the resources-based and students-related factors. The most frequently reported difficulties include the lack of teaching resources, conceptual deficiencies of students, excessive number of students in the classroom, the educational needs of the students as well as the lack and deficiency in infrastructure.

Analyzing in detail the teachers-based factor (Table 4), most teachers from all groups say they have no difficulties. This result contradicts the previous analysis of the deficiencies found in the academic education of teachers (Tables 2 and 3). It seems that most teachers do not recognize this challenge, which could be mainly due to deficiencies in their didactic, pedagogical, and disciplinary foundations. Furthermore, this lack of recognition may stem from a refusal to acknowledge professional errors, potentially functioning as defense mechanisms (Freud, 1954) to protect their professional identity.

3) Question 3: List the didactic resources, their condition and quality, that you currently have in the educational institution for the development of a physics lesson.

This question was answered by 90 % of the teachers surveyed and their answers were organized according to the didactic resources in Table 5. In addition, each teacher was able to give their opinion on more than one didactic resource.

Table 5

Institutional Didactic Resources (N: Number of Responses. %: Percentage). Total Teachers Surveyed: 90

Educational resource	N	%
Laboratory	22	24,4
Computer Rooms	4	4,4
Laboratory elements	32	35,6
Cell Phone	3	3,3
Internet	5	5,6
Audio visual material	28	31,1
Virtual Platforms	16	17,8
Digital wall boards	4	4,4
Electronic Tablets and/or computers	14	15,6
Drawing and writing supplies	27	30,0
Printed Material	27	30,0
None	9	10,0

Note. Own Elaboration

According to Table 5 only 24,4 % of the institutions have a laboratory, the remaining 75,6 % do not have areas for on-site laboratory practices, an absence that, as Quezada (2019) points out, hinders science learning. About “computer rooms”, only 4,4 % count on them, a result that also demonstrates the deficiencies in the infrastructure of the educational institutions represented. Regarding the “laboratory elements” —used to determine if facilities are adequately equipped— revealed that only 35,6 % of the institutions have measuring instruments. The results of the ICT resources —specifically mobile devices, internet connectivity, and digital whiteboards— show that the educational institutions represented are digitally isolated from the virtual environment (3,3 %, 5,6 % and 4,4 %, respectively).

As for the “audio-visual material” category, 31,1 % have access to this resource, 17,8 % to “virtual platforms” and 15,6 % to “electronic tablets or computers”. These low percentages again show the limitations of the surveyed teachers to access these resources, currently very helpful and useful in teaching-learning processes (Suárez-Ramos, 2017). In the categories “drawing and writing supplies" and "printed material", the percentages show the insufficient support of the institution to teachers' academic work, by not providing the required materials. Finally, the category "none" shows the absence of resources in some rural and urban public educational institutions from municipalities with low socioeconomic development.

Despite the fact that the use of teaching resources facilitates the teaching-learning process (Vargas, 2017), the results obtained are worrying, since they show that most teachers do not have the necessary teaching tools for the proper development of their lessons, resources that are essential for students to internalize and consolidate knowledge through meaningful learning.

4) Question 4: Do you use your own teaching resources to develop your physics lessons? If your answer is affirmative, please mention them.

In this question, 84,4 % of the surveyed teachers reported utilizing their personal resources to facilitate physics instruction. Their greatest contribution is in laboratory instruments (classroom demonstrations), as well as computers for simulation of experiments and teaching guides as work and complementary support material. These results confirm the deficiency of the didactic resources described in Question 3, forcing teachers to use their own resources to guarantee a minimum of students learning.

5) Question 5: Does your educational institution have a science laboratory?

53,3 % of teachers surveyed answered that the educational institutions where they work have a science laboratory, while the remaining 46,7 % reported not having one. Out of those who have a laboratory, only 45,8 % use it for their experimental practices (Table 5), which is also an indicator of the deficiencies of educational institutions in facilities and equipment.

6) Question 6: If you carry out laboratory practices for teaching physics, briefly explain the frequency, aim and organization of these practices.

Out of the total number surveyed, 71 teachers answered this question. 78,9 % reported that they carry out laboratory practices, out of which 24,4 % belong to those who have a laboratory for their practices (Question 5). It should be noted that in the answers it is not possible to differentiate between laboratory practices and demonstrations, the latter being also used in the teaching-learning process (Cuaical & Cuesta, 2017). Out of the total number of teachers who implemented laboratory practices and demonstration, it is assumed that 69 % develop them in the classroom with their own resources, which has already been reported by Castro & Gutiérrez (2017). On the other hand, 70,4 % reported on the frequency of performing laboratory practices or demonstrations in the classroom, out of which only 26,8 % do more than 10 practices/demonstrations during the school year. This result is very worrying, since according to Londoño (2007), physics teachers often fail to recognize the fundamental importance of laboratory practices, which are indispensable for the comprehensive understanding of the physics concepts taught.

In relation to the goal of laboratory practices and demonstrations, 23,9 % accurately identified their purpose as relating theory to practice, while the remaining 76,1 % did not answer. This corroborates what was described in the preceding paragraph regarding the undervalued role of experimental work. None of the 71 teachers who answered this question described the way in which they organize laboratory practices, this being also another deficiency derived from lack of planning and a lack of structured protocols for experimental development

The findings presented suggest that laboratory practices are not utilized as didactic strategies from the point of view of the constructivist approach. This is evidenced by the fact that over 88 % of the total sample lacked clarity regarding the objectives of experimental work, while 100 % of respondents failed to provide details on instructional planning. This systemic gap limits students' ability to acquire and appropriate scientific knowledge effectively (Rodríguez et al., 2022).

7) Question 7: According to your perception, what is the level of interest that students have in learning physics?

32,2 % of the teachers surveyed consider that the interest level of students is low, 57,8 % medium and 10 % high. 90 % of teachers (sum of low and medium levels) believe that the motivation of students to learn physics is not enough, which makes the teaching-learning process difficult, since their academic performance is directly related to this interest (Ricoy & Couto, 2018).

8) Question 8: Describe on what you base your answer to the previous question.

All 90 teachers responded to this question, with their answers classified into two factors: teachers (5 categories) and students (11 categories) found in Table 6 (https://docs.google.com/document/d/1_BbZAHhDt5sMgw1sKT_RfL02OBSaLwL3/edit?usp=sharing&ouid=101753883311617108285&rtpof=true&sd=true). The teacher-related factor accounted for 17,8 % of the responses. Within this group, the primary reasons cited for low students' interest in physics were mainly related to the teacher motivation category (10 %), and lack of teaching resources (5,6 %), while only 5,5 % of teachers were classified in the remaining three categories (Complexity of concepts, Teaching attitude, Observation of the students). About the student factor, the answers are related to the categories "interest and predisposition for the subject" with 72,2 %, and "mathematical deficiencies" with 12,2 %, while the remaining nine categories were classified as 23,3 %. According to the perception of the teachers surveyed, the low interest that students have in learning physics is not mainly due to factors associated with teachers but with students. This perception does not reflect the results and analysis of Question 2, in which teachers did not recognize deficiencies in teaching physics. It is possible that the difficulties and disinterest experienced by students reflect also the lack of didactic strategies and inadequate teaching practices, which was also reported by Useche & Vargas (2019).

9) Question 9: Briefly describe which teaching and motivational strategies could improve interest of students in learning physics.

All teachers answered this question, and their answers were classified into 20 categories, found in Table 7 (https://docs.google.com/document/d/1_BbZAHhDt5sMgw1sKT_RfL02OBSaLwL3/edit?usp=sharing&ouid=101753883311617108285&rtpof=true&sd=true).

44,4 % of the teachers surveyed think that laboratory practices improve students' interest in physics. This result reaffirms what was analyzed in Question 6 and what was stated by López & Tamayo (2012), on the great relevance of laboratory practices in the teaching-learning process of physics. 28,9 % of teachers believe that applying ICT improves students' interest, since it allows, through virtual experimentation, the manipulation of physical variables involved in a phenomenon (Bohórquez Guevara, 2024). Similarly, 27,8 % believe that the strategy of applying physics to the environment also improves interest in learning. In addition, 25,6 % stated that having adequate facilities would increase student engagement, since according to the results from Question 3, 75,6 % lack functional laboratories and computer rooms. The other strategies (16) were mentioned with significantly lower frequency and were thus deemed less statistically relevant.

10) Question 10: What external factors to the educational institution do you identify that can influence student learning?

The answers of all surveyed teachers were classified into two factors: family (six categories) and environment (six categories), found in Table 8 (https://docs.google.com/document/d/1_BbZAHhDt5sMgw1sKT_RfL02OBSaLwL3/edit?usp=sharing&ouid=101753883311617108285&rtpof=true&sd=true). In the family-related factor, the categories that were primarily identified are the economic component with 33,3 % of teachers, as well as lack of support by the family with 28,9 %. The categories such as connectivity in homes/technologies, dysfunctional family, educational level of parents or attendants, and family core show less relevance. These results show that the economic situation of the students' families is a factor that impacts their performance, as reported by Jama-Zambrano & Cornejo-Zambrano (2016). This economic instability, compounded by limited parental educational attainment (Delgado, 2019), serves as a major constraint on the academic support systems available to students at home, further hindering the learning process.

Within the environment-based factor, the social (20 %) and cultural (15,6 %) categories stand out. Other categories—including state support, access to higher education, university internships, and geographic location—yielded low percentages, suggesting that teachers perceive these as having a minimal impact on student. In any case, the social and cultural conditions in which students are immersed are factors that strongly influence the way they perceive their environment and their interaction with it, which also affects how they approach learning (García et al., 2023).

Conclusions

The findings of this study lead to the conclusion that in public institutions of Colombia there are deficiencies in the teaching of physics at high school level. Significant gaps in the teaching-learning process were observed, particularly regarding planning and methodological definition of a lesson: 46,7 % of the total of the teachers surveyed reported planning their lessons using the three phases (Initial, Intermediate and Final), and only 36,7 % described the methodology applied. The fact that 53,3 % failed to describe a lesson structure and 63,3 % provided no explanation of their methodology suggests a profound deficiency in didactic and pedagogical foundations of the teachers.

This is confirmed by the fact that, according to the analysis of the academic and pedagogical background of the surveyed teachers (Table 1), 34,4 % of them do not have enough disciplinary knowledge and a minimum of didactic and pedagogical competencies and vice versa. This situation poses an important limitation in the teaching of physics, within the framework of the guidelines established by MEN.

Although the members of group G2 (physicists) lack didactic and pedagogical academic education, the percentage results of this group, both in planning (46,2 %) and in defining the methodology of a lesson (46,2 %), exceed those of G1 with academic background in didactic/pedagogy and physics (45,8 % and 40,7 %, respectively). This result is worrisome, since it is assumed that the members of G1 should have appropriate academic background, both in disciplinary and didactic and pedagogical aspects, which would ensure the most suitable profile for teaching physics at high school level in Colombia. The results of G3 (mathematicians) and G4 (engineers) clearly show the deficiencies of the members of these two groups, due to their lack of didactic and pedagogical background. The other members of G3 (bachelor's in education-mathematics) lack academic education both in disciplines and in didactics and pedagogy.

Regarding the methodology used to teach a lesson, it could be inferred that there is a structural deficiency in their academic education. Of the 36,7 % of teachers who answered about their methodology, 25,6 % use passive methodologies that limit the development of science competencies in students, and only 8,9 % identify themselves with constructivist models. These deficiencies hinder teachers' ability to recognize the relevance of laboratory work as a didactic strategy from the constructivist point of view. This lack of pedagogical intentionality is evidenced by the fact that 81,1 % of the surveyed teachers failed to articulate the underlying objectives of these experimental activities. On the other hand, teachers do not have sufficient tools and resources to support the teaching-learning processes, so that students can reinforce their knowledge through meaningful learning. The insufficiency of these resources forces teachers to use their own to ensure a minimum of learning in students.

According to this panorama, it seems that teachers are not fully aware that they have deficiencies in their didactic and pedagogical preparation, as mentioned in the previous paragraph. This result could suggest that one of the causes of the difficulties and lack of interest shown by students towards physics may be related to failures and inconsistencies of teachers in the development of their teaching-learning processes. On the other hand, the teachers surveyed expressed that academic education and teacher education are not factors that could have a determining effect on the quality of teaching a physics class. In this sense, teachers assign greater importance to the lack of teaching resources (86,7 % of the total) and to students (84,4 % of the total). Also, 62,2 % of the total believe that the economic component and the lack of support by the family are among the main external factors that influence student learning.

The results of this research study show that the deficiencies found in the physics teaching-learning process stem from a dual crisis. First, many teachers lack the specialized pedagogical content knowledge and technical skills required to teach the subject effectively at the secondary level. Second, the systemic lack of institutional resources serves as a structural barrier, depriving teachers of the necessary tools to facilitate high-quality educational processes. It should be pointed out that the socioeconomic situation and the insufficient family support of the students are also important factors that influence their teaching-learning process, as reported by the teachers surveyed. According to the above, this study can be considered as a contribution to the diagnosis and analysis of the current state of physics teaching in public education institutions of Colombia, from which strategies can be further developed to advance in the solution of the difficulties that arise in the teaching-learning process of this area of knowledge at the intermediate academic level.

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