Beliefs of students around the study of physics in basic secondary and technical education

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Beliefs of students around the study of physics in basic secondary and technical education

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Abstract. This research is part of a line of research in education that aims to determine the degree of influence that affects have on the study of basic sciences that usually generate high rates of academic loss or repetition in school environments. The aim of this research was to analyze the system of beliefs that a group of students had about themselves as physics students, about physics as a discipline, about the physics teacher and his or her teaching practices, and about the importance of this area of knowledge in their social environment. To achieve this objective, a private educational institution is intentionally selected, with a home in San José de Cúcuta, Colombia, characterized by good results in the Saber 11 state tests. The informants were all students enrolled in 2019 in grades nine and eleven. A questionnaire was designed consisting of 36 items evaluated by means of a Likert scale with five levels of response. The results attested to the internal consistency and validity of the questionnaire. Subsequently, a complete characterization of the informants was carried out, allowing us to discover that the women in the sample have a better attitude and abilities in the study of physics. Finally, a factorial analysis was carried out in order to verify whether the opinions of the respondents fit into the four categories of beliefs considered by the researchers. Six factors were identified that explain 80% of the common variance, highlighting within them the beliefs that the student has about himself and his relationship with the teacher as the main factor explaining 41% of the variance.

1. Introduction

Much of the effort in Education has been focused on identifying the learning difficulties that students have around the various skills linked to the education system, regardless of the cultural context or the educational level at which they are analyzed [1-9]. Several of these studies consider only cognitive aspects as the object of research determining school success or failure. However, over the last forty years a new approach to analysis has emerged in which the affective or emotional is recognized and linked as a factor influencing the expected success of the educational process [10,11].

In this sense, the research work developed by [12-15], among many others, should be recognized. They report in their findings that it is impossible to think that the process of learning knowledge (in the particular case of mathematics) is limited only to the cognitive sphere of the student, ignoring the positive or negative effect that the beliefs, attitudes or emotions that the student experiences in class can have. Some of these expressions of affection are derived from the experience that the student has had in previous years with this disciplinary knowledge; but in other cases, many of them are brought about by the characteristics associated with the teacher and the development of his or her pedagogical practice [11]. When the affective component and its influence on the learning process is analyzed, beliefs, attitudes and emotions emerge as basic descriptors [12] and [16]. According to [17], beliefs "form part of the knowledge belonging to the cognitive domain and the feelings that are held about the discipline,

its teaching and learning that are generated by the person from his or her experience" (p. 67). As a background, beliefs about mathematics have been a widely researched topic, highlighting the classification of beliefs stated by [18]: beliefs about the knowledge and learning of the discipline, beliefs about oneself as a learner, beliefs about teaching and beliefs associated with the social context in which the student develops. A similar proposal with fewer categories is presented [19] by those who claim that there are beliefs related to disciplinary knowledge, beliefs about oneself and one's performance in disciplinary knowledge, and beliefs associated with the teacher and the environment promoted in the classroom.

Based on what has been mentioned so far, it can be stated that beliefs are personal positions, which manifest themselves from experience and the training process carried out, generating positive or negative beliefs that influence various specific behaviors and actions as recognized in [20]. Few studies have focused on determining the influence of effect on the study of physics, so it was considered important to carry out this research in the educational context in which the data was collected, since it is an educational institution characterized by obtaining scores above the departmental average in Saber 11 tests and approximately three out of every five graduates enter their professional development in engineering training programs, where the concepts of physics are fundamental to their academic process. This research is expected to generate a background on the influence of effect on the teaching-learning process in physics.

2. Methodology

This research adopts a quantitative approach at a cross-sectional descriptive level since the data were treated statistically in order to improve the process of characterizing the situation under study [21]. The research is cross-sectional since the data was collected in the last week of November 2019, since at that time the contents projected for the school year had been developed.

The population was made up of all the students of the educational institution, which totaled 188 students between the sixth and eleventh grades. For the selection of the members of the sample, it was adopted as a selection criterion that by the year 2019 they be enrolled in one of the grades from ninth to eleventh (87 students), since it is in these grades where the development of the concepts of physics is concentrated with greater intensity. Then, it is concluded that a two-stage sampling was applied: (a) initially, non-probabilistic sampling was applied under the convenience sampling technique; (b) already in the second stage, a census was applied, since the instrument was filled out by all of the students in each grade.

As for the instrument used, a questionnaire was designed with 80 items all with closed multiple choice and single response, which were distributed as follows: (a) 36 associated with the beliefs that students have towards physics measured on a Likert scale with five levels of agreement, an adjusted version of the questionnaire suggested by [15]; (b) 24 associated with the attitudes and emotions that students experience towards physics measured on a Likert scale with five levels of frequency; (c) 20 items corresponding to the physical competences that should be promoted in the classroom work. This article reports the results associated with the first section of the questionnaire evaluated.

3. Results and discussion

After obtaining the data, they are processed in SPSS v23 and then presented in four sections: a report on the demographic profile of the informants, since it is important to know their characteristics, then the validation report of the instrument used in the research is reported, then the detailed analysis of the belief system towards physics is recorded and ends with the factorial analysis which aims to verify whether the groupings of beliefs in the informants can be verified as recorded in the consulted records.

3.1. Demographic profile

Table 1 identifies the demographic characteristics of the informants, where they stand out as predominant features that 37% are from the ninth grade, concentrating 78% of the cases in ages between 15 and 16 years, with a predominance of the female gender coming from households mostly between

strata 3 and 5, which allows them to access services such as internet and to have technological resources such as a computer at home or a smartphone facilitating their access to various sources of information. Finally, 58% of the informants say that they like the concepts seen in physics class. This information is important since, as mentioned in [13,14], emotions are directly linked to a person's experiences and the social environment in which they develop.

Table 1. Demographic profile of informants.

Characteristic	Dimensions	Frequencies (#)	Percentage (%)
Grade	Nineth	32	36.8
	Tenth	29	33.3
	Eleventh	26	29.9
	Total	87	100.0
Age	14 years	11	12.6
	15 years	49	56.3
	16 years	19	21.8
	17 years	8	9.2
	Total	87	100.0
Gender	Female	57	65.5
	Male	30	34.5
	Total	87	100.0
Socioeconomic	Two	8	9.2
	Three	27	31.0
	Four	26	29.9
	Five	23	26.3
	Six	3	3.4
	Total	87	100.0
Do you like physics classes?	Yes	50	57.5
	No	37	42.5
	Total	87	100.0

3.2. Reliability report

The evaluation of the reliability of a measurement instrument with a Likert scale, which is an additive scale, allows the calculation of the total score of each informant from the sum of all the answers provided in the questionnaire. For this reason, all the items on the scale must aim to measure the same concept and it is here that the internal consistency of the instrument is discussed, referring then to the degree of relationship between the items that make up the scale.

To evaluate the reliability, through the internal consistency of the questions, the Cronbach's Alpha coefficient can be used, which can take values between 0 and 1. The reliability of the scale considered to measure the beliefs around the study of physics, offers a value of 0.956 that is considered excellent [22,23] from the 36 items of the questionnaire. In a complementary way, the relevance of each of the items included in the questionnaire is evaluated, so it is concluded that by deleting one of them, a better value of the Cronbach's Alpha statistic is not obtained, so it is concluded that the instrument is adequate as proposed.

3.3. Analysis of the belief system towards physics

Given the Likert scale used to determine the influence of each of the stated beliefs, Equation (1) is used to calculate the average score obtained by each student at the general level for the belief system.

$$\text{Belief}_{\text{Average}} = \frac{\sum_{1=1}^{36} C_i}{36} \quad (1)$$

This new variable obtained is analyzed from its descriptive characteristics obtaining an average of 2.91 and a median of 3.03, which allows us to intuit that the distribution is asymmetric, a condition that can be corroborated by determining that the asymmetry coefficient is -1.06 (tail to the left) with a high concentration of scores between 2.80 and 4.00.

When investigating if there are significant differences between the confidence intervals around the average score for the characteristics of gender, taste for physics and degree of schooling currently studied, it was possible to verify that there are no significant differences between the different levels of response to each characteristic. But what is significant is the variability of its data, for example:

- With regard to the grade studied by the informants, it was identified that grade 10 has the highest dispersion while grade 9 is more stable in its values despite having two values outside the lower limit.
- In relation to gender, men have very different opinions regarding the belief system they hold about physics with a tendency to values below 3.00, while women exhibit more compact behaviour above 3.00.
- With regard to the liking of physics, it was determined that students who like the subject, present more stable grades with an average score that exceeds that found in those who do not like it (see Figure 1 showing the box and mustache diagram), despite having more outliers.

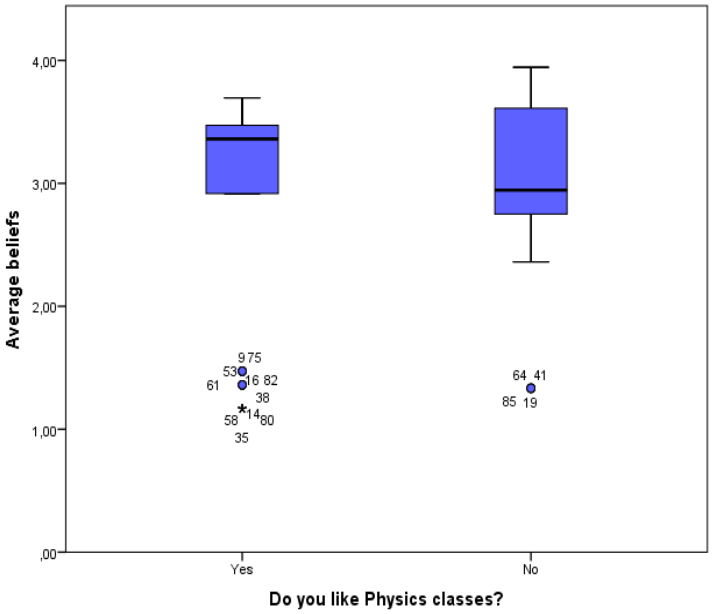

Figure 1. Comparative diagram of the average of the Beliefs disaggregated by the student's like in physics.

Subsequently, a new qualitative variable was generally used to determine the level of perception of each student's belief system according to the following scale: (a) low for average scores between 0.00 and 2.90; (b) medium for average scores between 3.00 and 3.90; (c) high for averages greater than or equal to 4.00.

Based on this new classification of the average belief system, it was determined that 44% of students are at the low perception level, while the remaining percentage is at the medium perception level. When breaking down these perception levels according to the three variables analyzed, one has to:

- The average level of perception decreases as the degree of schooling increases, then it could be thought that as the complexity of physical concepts increases, grade by grade, the percentage of students with low scores increases.
- Male students are distributed equally across the two performance levels, while females have a higher percentage of average performance. It should also be noted that, at this educational institution, women have higher grades in physics than men.

- As for the students who like the subject, they exceed the percentage of students with a low perception level by 200% in the medium level of perception (see Figure 2). The opposite is true for those who say they do not like physics, as here the percentage with low perception is higher than that of the medium level.

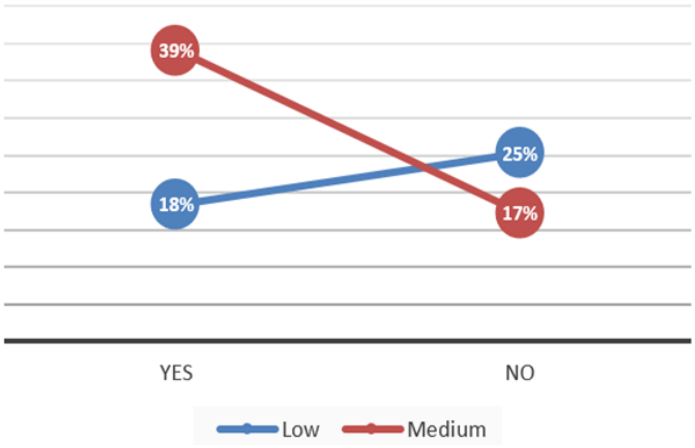

Figure 2. Comparative diagram of the average perception level of the beliefs disaggregated by the student's taste in physics.

3.4. Analysis factorial of the belief system towards physics

In this final section of data analysis, the focus is on the application of factor analysis to explore how the 36 items in the questionnaire are associated in order to validate whether the belief system fits into the categories suggested by [18] in their research; but before conducting factor analysis, its feasibility must be analyzed, *i.e.* its conditions must be verified. For this reason, the Bartlett Kaiser-Meyer-Olkin (KMO) and sphericity tests are applied, obtaining a value of 0.83 for the KMO, which, being greater than 0.70, is a good measure, which, added to a significance level of 0.001 in Bartlett's sphericity test, concludes that with the data obtained there is goodness of fit. From these results, the communality of each of the items in the questionnaire is analyzed, verifying that their values oscillate between 0.65 and 0.90, then all the values are higher than the value of 0.50 which, according to the literature, defines it as a desirable value. From the factorial analysis, six factors are obtained with a self-value higher than 1 and that together explain 80.07% of the total common variance, after the application of the principal components' method, achieving the convergence of the rotation after 10 iterations. All the items of the questionnaire can be consulted at online questionnaire: (https://forms.gle/KXVi9oUM8rW47Z3B7). A summary of the item clustering process and the latent variables obtained is shown in Table 2.

The factors generated differ from the categories of the belief system proposed in [18] in terms of the number of categories proposed, and therefore offer a better breakdown of them, for example: for the informants in this research the most important factor in terms of the generation of their beliefs towards physics is derived from their relationship with the teacher, recognising in this relationship the interaction from the human side and not from the teacher-student relationship, which corresponds to the third factor found. There is a coincidence in the factor that recognises the beliefs that are held about disciplinary knowledge and its benefits in academic training for the understanding of the world around them. Finally, the recognition of the importance of mathematical concepts for the development of physics subjects and their strong relationship with the resolution of daily problems is highlighted as a positive element.

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Table 2. Principal component analysis summary.

Factors	Variance explained	Grouped items
Beliefs as a student and relationship with the teacher	41.1%	16, 15, 17, 25, 22, 23, 18
Belief in discipline and its benefits	15.5%	29, 32, 36, 31, 19, 12,34, 35, 14
Beliefs about the pedagogical practice of physics teachers	8.0%	9, 24, 8, 1, 10, 21, 20, 26
Beliefs about learning physics	6.3%	3, 28, 2, 7
Beliefs about problem-solving strategies	4.8%	6, 4, 30, 13
Beliefs about the influence of mathematics on physics	4.4%	11, 27, 5, 33

4. Conclusions

In this research a questionnaire was used that was initially proposed to measure the belief system that students exhibited towards the study of mathematics; given the strong relationship between these two areas of knowledge, it was decided to adjust the questionnaire, which was corroborated by the Cronbach alpha reliability value obtained, which endorsed the inclusion of the 36 items in the questionnaire, leaving a record of the internal consistency of each of them. Given that a Likert scale was used to evaluate the relevance of each item, based on its additive property it was proposed to determine for each student the average grade; from which it was possible to determine a greater dispersion in the grades of male students in tenth grade who claimed not to like physics.

From this average, general qualitative performance levels of perception of the belief system were generated. From this process, it stands out that no student was at the lowest or lowest level of perception, which allows us to conclude that in the whole group of informants there is a positive position regarding the study of physics. Finally, from the analysis of main components, six factors are obtained that concentrate a good percentage of the total variance, highlighting as the main factor the good relations between the teacher and his students that transcends the academic environment, which gives an important weight to the emotional part in the learning process.

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