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Inquiry-based learning. Beliefs of trainee teachers in a physics course

C A Pabón-Galán¹, C A Hernández-Suarez¹, and L S Paz-Montes²

¹ Facultad de Educación, Artes y Humanidades, Universidad Francisco de Paula Santander, San José de Cúcuta, Colombia

² Facultad de Ciencias Empresariales, Universidad Francisco de Paula Santander, San José de Cúcuta, Colombia

E-mail: cesaraugusto@ufps.edu.co

Abstract. The teaching of physics should be supported by practical or laboratory activities that seek to develop the scientific competencies of the students who study physics, so it is necessary to propose innovative strategies, such as research-based learning, in which students answer research questions through the analysis of data, which increases the interaction between the student and the physical concepts under investigation. Therefore, the objective of the study was to analyze the beliefs of teachers in natural science training at a public university in Colombia who take the subject of physics on research-based learning, to provide information on how to guide the use of innovative strategies. The study responds to a type of quantitative research with a descriptive approach and was based on a field design. On the other hand, the results reflect slightly positive beliefs of students in initial teacher training who study physics about research-based learning as an innovative strategy, although it is recommended to expand the sample to generalize. Finally, the analysis reveals as a conclusion that the implementation of innovative methodologies such as inquiry-based learning for science teaching, especially physics, should be promoted and supported more effectively to foster motivation, skills development, and conceptual understanding. of the scientific contents.

1. Introduction

The capacity to investigate and innovate depends to a large extent on people who are motivated to study science, especially those of an exact and natural nature, such as mathematics and physics; and this motivation must start at school. Studies indicate that there is a significant reduction in scientific interest and vocation for scientific studies, with a significant decrease in the number of students who decide to study academic programs in mathematics and sciences such as physics, which poses a great threat to the future of society. The demotivation of students to study scientific programs is not limited to a single cause but is a complex problem involving many variables [1-4].

Among the main factors to consider, related to the way of teaching science, among others, are the contents, methodologies, and resources. In this sense, even though natural sciences appear in the curriculum as a fundamental area of school knowledge, there is little contextualization, more focused on the cultural and social than on the scientific and technological [5,6]. Teachers' pedagogical practice influences students' attitudes towards learning science and mathematics [7,8]. This is due, among other things, to the insufficient scientific preparation of teachers at these educational levels [9,10].



Moreover, teachers' epistemological and didactic beliefs about aspects such as content and the teaching and learning process largely determine their pedagogical practice; likewise, their classroom performance can be influenced by the training they have received [11].

The teacher, in addition to knowledge about the content, must have knowledge about how to teach their discipline in the best possible way, which is called “didactic content knowledge” [12], which is the most used translation in Spanish literature of “pedagogical content knowledge” [13]. the pedagogical knowledge of content is a structure between the academic knowledge of the person and the context (static component) and the knowledge, beliefs, and attitudes about practice (dynamic component). Therefore, in the field of teaching, these components are in different stages of development, according to their professional experience [14,15].

On the other hand, research-based learning, also known as Inquiry Based Learning, is a strategy that promotes learning to construct one's own knowledge through the use and development of research tools involving scientific methods [16], ideal for improving the teaching of science and mathematics [17,18]. However, despite its benefits in student motivation, the development of competences and the understanding of concepts, its use is scarce in the pedagogical practice of science teachers. Inquiry-based strategies incorporate questioning and engagement for student learning. Therefore, there is a need to reorient teaching with the aim of achieving meaningful learning and conceptual understanding of scientific ideas rather than fragmented teaching and learning of knowledge [19].

Scientific enquiry contributes to students developing key science concepts and understanding events and phenomena of relevance to their current and future lives, so they should develop an understanding of how scientific ideas and knowledge are obtained, as well as the skills and attitudes involved in seeking and using evidence. Accordingly, the aim of the study was to analyse the beliefs of trainee teachers of a physics course about inquiry-based learning to provide information on how to guide the use of innovative strategies in teacher education.

2. Method

The study is a quantitative research study with a descriptive approach that seeks to analyse the beliefs of students in an initial teacher training program in the natural sciences about inquiry-based learning. The study was based on a field design, in which students were approached and information on the different indicators of research-based learning was collected through a questionnaire.

2.1. Study population

The population under study was made up of an academic course of 47 students, who are teachers in training, enrolled in the bachelor of natural sciences and environmental education of the Universidad Francisco de Paula Santander, San José de Cúcuta, Colombia, who are taking the subject of basic physics, where they participated voluntarily (38.3% corresponding to 18 women and 61.7% corresponding to 29 men); by age range, 72% of the participants fluctuate between 18 and 22 years (34 students), 23% between 23 and 27 years (12 students) and 4% are older than 28 years (2 students).

2.2. Instrument

As a data collection tool, an instrument was designed that includes firstly the socio-demographic data of the trainee teachers and secondly an adaptation of the Likert-type scale of Bernal [20] with four response options, from totally disagree (score 1) to totally agree (score 4). The questionnaire is divided into 6 dimensions; (1) willingness to inquire as a way of learning; (2) scientific inquiry-based learning; (3) students' skills towards inquiry-based learning; (4) role of the teacher in inquiry-based learning; (5) role of the learner in inquiry-based learning; and (6) teaching strategies that contribute to developing inquiry-based learning, each with 3 items for a total of 18 items.

The design of the instrument was subjected to a validation process through expert judgement until the final version was obtained; to consolidate the convenience and relevance of the questionnaire, a pilot test was carried out and applied to 10 students, obtaining a Cronbach's coefficient of 0.789. The value

obtained indicates a high reliability of the instrument; this satisfactory result in terms of the reliability of the test, together with the observations collected during validation, optimized the questionnaire.

2.3. Data analysis

For the questionnaire, the answers to each question per dimension were expressed according to the score given by the Likert Scale. The results from the data processing allowed obtaining tables and graphs to carry out the analysis and interpretation of the information.

3. Results

The analysis and interpretation of the results by category of students' beliefs about inquiry-based learning in physics is presented below (see Table 1). For each of the items, in the different dimensions, the students chose between 1 and 4; to obtain the total score of the scale, the arithmetic mean was used as a statistical parameter, adding up all the scores of each of the students (X_i , $i = 1 \dots 47$) divided by the total number of students ($N = 47$). For this purpose, the Equation (1).

$$\bar{x} = \frac{\sum_{i=1}^N X_i}{N}, \quad (1)$$

where (X_1, X_2, \dots, X_{47}) are the scores obtained by each of the 47 students. The arithmetic mean was chosen as it is a characteristic value that considers all the data. To interpret each of the scores obtained, the methodological guidelines of Hernández, *et al.* [21] were followed, in which scores below 2.0 indicate a negative perception and above 2.0 a positive perception of inquiry-based learning in the subject of physics.

According to Table 1, with respect to the dimension of willingness to enquiry as a way of learning, most of the students search for information on the subject, but there is a need to encourage more information management. In addition, there is a slight willingness to engage in inquiry-based learning, but there is a very low tendency to search for information mainly in physical books, as most of them search on the Internet; in accordance with the above, it is necessary to strengthen inquiry-based learning.

For the dimension scientific inquiry-based learning, although the trend is not very marked, it seems that students are motivated towards research in science. In addition, more than half of the students consider that group work contributes to the development of research skills. Finally, a dispersion of opinions is observed when referring to the motivation to use the scientific method in physics.

Likewise, for the dimension students' skills towards inquiry-based learning, due to the dispersion of the results, it could be said that there is no clear understanding of what is meant by the formulation of research projects, as well as the use of the research method in the work and consultations. Similarly, no use is made of the university's databases for consultation and research. Similarly, for the dimension role of the teacher in inquiry-based learning, the perception of research, especially teachers' projects, as part of the teaching-learning process is very low, so it is necessary to include it to understand the current state of knowledge in the field of physics.

On the other hand, in the dimension role of the learner in inquiry-based learning, students value scientific research as part of their training and the development of scientific research especially using technology. Finally, for the dimension teaching strategies that contribute to the development of inquiry-based learning, it can be stated that students still do not clearly identify the inclusion of the scientific research process as part of the physics teaching and learning process, but the perception is slightly favorable in terms of the competences that the teacher should possess as well as the disciplinary competences in physics that are best aligned with scientific research but need to be further increased.

Although different precedents have had as their main objective the approach of methodologies like inquiry-based learning [22-24], however, this strategy is not widely applied by teachers in general, especially natural science teachers [25]. Students starting initial teacher training in Natural Sciences do not have adequate knowledge of the scientific method, but students who have practice in inquiry-based

learning have greater motivation and potential to do research, guided by the teacher [26]. Furthermore, the fact that knowledge of this method should be acquired from the first courses is highlighted.

The handling of information, especially scientific information, is a competence in students that is related to learning towards research, but it must be acquired for the student to acquire knowledge. Internet sources can be accessed, but not all information is reliable, which is why teacher guidance is important. In addition, digital bibliographic resources such as the university's databases are not taken advantage of, hence the need to develop the necessary competences in the use of scientific information [27].

With research-based learning as a didactic strategy, the aim is for the trainee teacher in natural sciences, at the end of their academic program, to have managed to go through the entire methodological process of identifying and posing problems, establishing the state-of-the-art, posing hypotheses, carrying out tests, collecting and analyzing data, obtaining conclusions, and proposing solutions [28].

Table 1. Results by category on students' beliefs about inquiry-based learning.

No. Items	Dimensions and items	Mean
Willingness to inquire as a way of learning		
1	I look for information when I am interested in a topic	3.0
2	I carry out a search when the teacher asks me to research a topic	2.6
3	I like to know more than what I receive in a classroom, so I look for information in books or on the Internet	2.2
Average dimension		2.6
Scientific inquiry-based learning		
4	I learn more if I use the scientific method to do the work that requires it	3.5
5	Teamwork contributes to the development of skills towards scientific research	3.2
6	The physics course motivated me to use the method of scientific research	2.6
Average dimension		3.1
Students' skills towards inquiry-based learning		
7	I have experience in formulating a research project	2.5
8	The teacher requires me to use the research method when he/she asks me to carry out a consultation and research	2.9
9	I use the university's databases for consultation and research	2.3
Average dimension		2.6
Role of the teacher in inquiry-based learning		
10	The teacher shows students the key elements of an investigation following the scientific method	2.6
11	The teacher includes investigations in the development of the physics course	2.7
12	The teacher shows research in the field of physics in his classes	2.4
Average dimension		2.6
Role of the learner in inquiry-based learning		
13	It is important for a student studying physics to carry out scientific research	3.5
14	I read about scientific research to understand its importance and to familiarize myself with the methodology	2.5
15	The use of technology is essential for conducting research	3.2
Average dimension		3.1
Teaching strategies that contribute to the development of inquiry-based learning		
16	In the subject of physics, the process of scientific investigation is taught or applied	2.5
17	The teacher is trained to carry out scientific research	3.0
18	The teacher knows the disciplinary competences in physics that are best aligned with scientific research	3.1
Average dimension		2.9
Average total dimensions		2.8

The results obtained indicate that research-based learning should be part of the curricular design of science subjects, especially physics, through research activities applying the scientific method that enable the development of scientific competences [29,30]. This requires a teacher who plans, so that he or she can guide the student in scientific research of a formative nature, which contributes to the formation of a critical, analytical, and autonomous student [22].

Finally, research-based learning could be combined with other participatory methodologies better known by students who study physics, such as cooperative learning, whose effectiveness has been widely proven in contexts other than the object of study [31], but which future can be investigated in that context.

4. Conclusions

The effectiveness of initial teacher education programs is key to the implementation of innovative methodologies for improving the teaching of natural sciences. It is claimed that the success of a training program must be based on the positive beliefs of the trainee teacher. Moreover, the beliefs that trainee teachers have about inquiry-based learning suggest that in the future they would take them to their classrooms; therefore, using these methodologies effectively fosters motivation, competence development and conceptual understanding of scientific content.

The research process in the natural sciences teacher training program, in courses other than research seminars, is not explicit in the micro-curricula, since the teachers who guide the different disciplinary subjects are not trained and do not carry out research, therefore that it is virtually impossible for them to use inquiry-based learning in pedagogical practice with their students.

Finally, although this experience shows the results reflect the slightly positive beliefs of students in initial teacher training who study physics about research-based learning as an innovative strategy and serves as an empirical background, in future studies it will be necessary to expand the sample, perform analyzes qualitative through interviews and observations in the classroom, as well as making a contrast with the beliefs of teacher trainers or teachers in service; likewise, carry out a study on the questionnaire with the intention of generalizing.

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