WHAT ARE THE ATTITUDES AND BELIEFS ABOUT SCIENCE OF THE PHYSICS TEACHERS AND FUTURE PHYSICS TEACHERS IN URUGUAY?

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Abstract:

We investigate the epistemological conceptions of the uruguayan Physics teachers and future Physics teachers through the application of the CLASS test (Colorado Learning Attitudes about Science Survey), one of the most accepted instruments in the research community in Physics education. The results obtained allow us to compare the attitudes and beliefs about science of both groups and quantitatively evaluate the agreement or not with the conceptions of experts in the field. First, we present a general screenshot of the responses and then we identify categories in which there are significant similarities or differences between the two groups studied and in turn with the reference of the experts. The categories that show significant positive or negative variations between the opinions of future teachers and teachers indicate the areas where training is favorable or unfavorable. On the other hand, the areas where the differences with the opinions of the experts are globally notorious suggest that they should be strengthened. To get a more global perspective, we also compare our results with those published in the literature. Finally, we raise several questions that we think may favor further inquiries.

Keywords: Epistemology, attitudes and beliefs, physics teachers, teaching formation.

1. Introduction

In 1964, the renowned American psychologist B. F. Skinner noted that “education is what survives when a man has forgotten all he has been taught”. This phrase illustrates that the specific contents we teach are only a small part of the

transformation that takes place as students make their way through the educational system. Indeed, students are not “empty boxes” in which teachers dump knowledge. On the contrary, each student comes with a whole baggage of knowledge of the subject, his or her own personal history, a particular way of interacting with peers and teachers, an approach to learning and a set of varied expectations, among other things. These aspects —often underestimated in relation to the curricular ones— play an important role in the transformation we expect students to undergo.

The set of ideas, assumptions and previous conceptions about Science, especially its evolution, its methods, its validation or refutation, are encompassed in the concept of *epistemological beliefs*. These beliefs, which are generally not explicit, have a strong impact on the way we teach and learn (Redish, Saul, & Steinberg, 1998). To mention a few aspects, do we consider science as a body of knowledge set in stone or as a system in constant evolution? Is the role of experimentation simply a requirement to verify theories or rather a substantial part of understanding nature, refuting theories or delimiting the range of their validity? There is no neutral stance towards these questions. If we consider previous knowledge as immovable, there is no need to foster a critical attitude or take an interest in new developments. Likewise, if we think that “anything goes” or that experimental evidence is not relevant, we fall into the field of pseudoscientific beliefs, or positions such as those held by terraplanists or antivaccinationists.

As teachers, we are directly or indirectly influencing the attitudes and beliefs of our students in the learning and teaching of Physics with every action or omission we make in class. Let us consider, for example, a hypothetical situation in a class on kinematics where we solve a problem on the whiteboard. Imagine that, as part of the solving procedure, we write down the equations describing an MRUV and tell students that, in order to find the answer, they must “find the equation that has all the data except the requested variable and simply solve it”. In a hypothetical situation such as the one described, we would be unintentionally giving the student an erroneous image of the way in which physics problems should be solved. In that sense, we are (unwillingly) projecting an incorrect image of science and how to learn physics.

The aspects that frame the specific scientific knowledge of physics within society deserve to be discussed, analyzed and made explicit in science classes. While it is true that philosophy as a subject is present in most curricula, several aspects of its relationship with physics should be discussed alongside its more specific contents. Is it possible to talk about electromagnetic induction without mentioning the role of motors and generators in our daily life? Can we present quantum mechanics as an abstract theory while holding in our hands a smartphone with millions of transistors that are governed precisely by the laws of quantum mechanics? Is it reasonable to study the details of uranium fission without mentioning the social and ethical implications of the atomic bomb? These examples show how closely the contents we study and the set of beliefs and attitudes towards science are linked.

There are other more subtle, less conspicuous aspects of the attitudes toward science that are discussed even less in our classes. Some of these involve attitudes towards minorities or genders, especially towards the role of women in relation to the “hard sciences”. Why is the percentage of women choosing these disciplines lower? Is the teaching we provide “neutral” towards these aspects? At what point in training does this apparent lack of interest originate? Does it occur in the early

years or in more advanced stages? Is it due to the prevalent working conditions? Is it influenced by way scientists as typically portrayed in our society? Is it a matter of a “No Girls Allowed” style discrimination? All of these questions are becoming increasingly more important today. In order to move towards a convincing answer, it is only natural to delve into the epistemological attitudes and beliefs of students and teachers.

Attitudes and beliefs have multiple dimensions. One of them is transversal and weaves across the different collectives, from the attitudes of society, science students, future physics teachers and current ones to those of researchers working in this discipline. In this paper, we focus on evaluating and discussing the attitudes and beliefs of high school physics teachers and physics-teacher-training students in Uruguay. In the next section, we present a set of tools developed in recent years to analyze these aspects, which constitute our theoretical framework, and we provide the most relevant results obtained from their application in different contexts. Regarding the attitudes and beliefs of Uruguayan teachers at the core of this study, in section we present the methodology used and in section 4, the main results. Finally, the discussion and final considerations are presented in section 5.

2. Tools for the analysis of epistemological beliefs and their main results.

2.1 Standardized Questionnaires in Physics Education Research

Since nearly half a century ago, it has been observed that students in different fields of physics frequently learn to solve problems and pass their courses, but, when faced with simple conceptual problems, they often lack a thorough understanding of the studied phenomena (Viennot, 1979; Trowbridge, & McDermott, 1980; Halloun, & Hestenes, 1985; Hake, 1996; Docktor, & Mestre, 2014). Based on these observations, a demand for changes rose from the core of physics. Studies on this topic consolidated over time and a new field with its own identity emerged: Physics Education Research (PER) (McDermott, 1999), which aims to generate knowledge based on widely accepted scientific methods and especially on quantitative results with solid statistical support (Docktor, & Mestre, 2014).

One of the pillars of PER is the systematic evaluation of knowledge. Within this framework, several questionnaires were devised for the evaluation of knowledge, including the Force Concept Inventory (Hestenes, Wells, & Swackhamer, 1992). This questionnaire, applied to thousands of students in hundreds of universities, aims to evaluate the transition from an Aristotelian to a Newtonian conception of mechanics. The main conclusion derived from the analysis of the results is that active teaching methods, in which students are actively involved, result in better learning compared to traditional methods, mainly consisting of lectures where students have a passive attitude. This greater “gain” in learning is a statistically robust result that does not depend on the student, the teacher or the context in which the learning occurs (Hake, 1998).

In the years that followed, several other questionnaires were proposed, such as the *Conceptual Survey of Electricity and Magnetism* (CSEM) (Maloney et al., 2001) or the *Brief Electricity and Magnetism Assessment* (BEMA) (Chabay, & Sherwood, 2006), which focus on other fields of physics. While in the early stages these questionnaires were relatively

handcrafted, over time a series of steps, statistical requirements and stages that each proposal should fulfill to be accepted in the community were defined (Heron, & Meltzer, 2005). Several collaborative sites (notably <http://www.physport.org>) publish the questionnaires, generally with open access, and complementary information including links to the articles such, translations into many languages, spreadsheets and other tools to facilitate their implementation. On the other hand, when those requirements are met, it is possible to share information, both by uploading our own results and by accessing those of other institutions.

2.2 Analysis of epistemological attitudes and beliefs.

The field of epistemological attitudes and beliefs does not escape the researchers' aspiration to obtain quantitative information. In that sense, a series of questionnaires or standardized tests have been developed in the last twenty-five years to assess students' attitudes and epistemological beliefs about physics, its teaching and learning. Unlike specific knowledge tests, which are mostly based on multiple choice questions, attitudes and beliefs tests usually ask students to indicate the degree to which they agree or disagree (known as a Likert scale) with statements that reflect (or not) the opinion of "experts" in the discipline (i.e., professional physicists, researchers). Each statement has an expected value assigned during the design and validation process of the instrument, based on repeated interactions with experts. The differences between the students' answers and the experts' answers constitute the raw material for analyzing the epistemological status of the group of students. In general, it is of interest to analyze the impact that particular courses and teaching approaches have on students' attitudes and beliefs. To this end, the test is applied at least twice, the first time at the beginning of the course (pretest) and the second time at the end of the course (posttest). The difference between the two tests allows us to measure changes in the attitudes and beliefs as a function of demographics, methodologies and teaching strategies.

Within the set of standardized tests, three of them are of particular relevance: MPEX (Maryland Physics Expectations Survey) (Redish, et al., 1998), which, as its name indicates, aims to survey students' expectations in relation to physics, CLASS (Colorado Learning Attitudes about Science Survey) (Adams, et al., 2006), which aims to assess students' beliefs about physics and their learning, and E-CLASS (Colorado Learning Attitudes about Science Survey for Experimental Physics) (Wilcox, & Lewandowski, 2016), with the same guiding principles as CLASS but focused on the experimental aspects of physics.

2.3. Teaching methods and epistemological attitudes

Numerous papers have been published about PER, exploring the relationship between teaching methods and outcomes and the epistemological attitudes of students (Madsen, McKagan, & Sayre, 2015). In particular, it has been shown that certain "negative" epistemological attitudes of students are definitely an obstacle to the development of quality science education, as they affect the way students learn and approach science courses (Perkins, et al., 2005; Milner-Bolotin, Antimirova, Noack, & Petrov, 2011). For example, the way in which a student believes he/she

should learn physics, his/her metacognitive practices, as well as the image he/she has of physics as a science, are some of the aspects of the hidden curriculum that should affect the way he/she learns. A student who believes that physics consists mainly of disconnected facts and formulas will study differently from one who sees it as a network of interconnected concepts. Those who view physics knowledge as a coherent network of ideas have more reason to engage in metacognitive practices to monitor their learning (Redish, Saul, & Steinberg, 1998). Regarding academic performance, several studies have shown the existence of a positive correlation with CLASS and MPEX scores (Perkins, et al., 2005; Cahill, et al., 2018). In recent years, there have been multiple quantitative investigations on the changes that occur in students' attitudes and beliefs as a result of their previous training, types of courses and teaching strategies used, as well as the relationship between pretest and academic performance, among other variables (Madsen, McKagan, & Sayre, 2015).

Among all the research done on the subject, we would particularly like to highlight the studies that focus on the changes in epistemological attitudes as a result of teaching methods, as well as those that analyze the relationship between these attitudes and conceptual understanding. Based on a meta-analysis consisting of the study of 24 published research papers, Madsen, McKagan and Sayre (2015) classified teaching strategies in physics courses into three categories based on changes in the epistemological attitudes of students:

- A) Courses where there is a decline in students' attitudes and beliefs (the average posttest score on attitudes and beliefs is lower than the average pretest score). This category includes courses with traditional teaching methodologies, as well as those developed with some of the more widespread active-teaching methodologies, such as "Peer Instruction" and "Introductory Physics Tutorials" (Adams et al, 2006; Madsen, et al., 2015). While the notion of traditional courses not promoting the right attitudes and beliefs could be reasonably surmised, it is striking at first glance that students also underperform on CLASS and MPEX after taking courses based on active teaching strategies.
- B) Courses where no significant difference is detected in students' attitudes and beliefs before and after the course. This group consists of courses where some epistemological aspects are taken into account in their implementation (Kohl, & Vincent Kuo, 2012; Madsen, et al., 2015). These courses implement teaching strategies that promote the development of reasoning skills, inference-making from observation, and reflections on why we trust scientific ideas, among others.
- C) Courses where a significant improvement in students' attitudes and beliefs is detected. There are two types of courses in this group: those that are radically restructured, based on model building (Brewer, et al., 2013), and those with a strong emphasis on epistemological aspects (Elby, 2001; Redish, & Hammer, 2009). In courses based on model building, students work in small groups, perform experiments and analyze the results in order to develop models of different phenomena. A central aspect of this type of strategy is the sharing of each team's conclusions and the promotion of peer discussion to allow students to validate and refine the models they build. On the other hand, courses with a defined epistemological approach develop activities that promote metacognition, for example, working with tutorials that emphasize the integration of intuitive ideas and formal scientific thought.

Therefore, as supported by the literature, the attitudes and beliefs of students generally decay as a collateral effect of physics courses, except in courses specifically designed to promote an improvement in those attitudes and beliefs. Surprisingly, at the end of many physics courses, more students believe, for example, that physics is less connected to the real world and less coherent, that reasoning is less important, and that rote learning is useful. These results, as shocking as they may be, pose the question about the unintentional promotion of attitudes and beliefs contrary to those that we would expect to develop naturally by simply taking the courses. The close relationship between epistemological attitudes and the results of the educational process justifies to a great extent the need to understand and act on the attitudes and beliefs of students throughout the whole educational system.

3. Methodology

In the research presented in this paper we chose to use CLASS, the science learning attitudes survey developed by the PER group at the University of Colorado Boulder, in the United States (Adams, et al., 2006). This questionnaire is widely accepted as it has undergone an exhaustive validation process. It was developed based on tools such as MPEX, and then reviewed based on interviews with students and experts (16 physicists with extensive teaching experience who agreed with most of the answers). CLASS categories were created by means of a reduced-basis factor analysis in which raw statistical categories and researcher-determined categories were iteratively combined. Finally, it was applied to thousands of students and we verified that the beliefs of those with more experience in physics closer to those of the experts. The results of their application in different geographical and social contexts, or in groups where different teaching strategies are applied, are available for analysis and comparison (Milner-Bolotin, Antimirova, Noack, & Petrov, 2011; Ding, 2013; Suwonjandee, Mahachok, & Asavapibhop, 2018; Balta, Cessna, & Kaliyeva, 2020; Kontro, & Buschhüter, 2020; Nissen et al., 2021). This instrument assesses students' attitudes towards learning physics, how they think physics relates to their daily lives, and what they think about physics. It is comprised of 42 statements, each with a five-level Likert scale, from Completely disagree (1) to Completely agree (5). We note some questions as examples:

- “I think about the physics involved in my everyday life.”
- “Knowledge in physics consists of many disconnected topics.”
- “After I study a physics topic and feel I understand it, I have difficulty solving problems on the same topic.”
- “When solving a physics problem, I look for an equation that uses the variables given in the problem and I substitute the values.”

The statements can be organized, according to the authors of CLASS, into eight non-exclusive categories, as shown in Table 1. When processing a survey taken by a student, each of his or her answers will receive a value (-1 or +1), depending on the degree of disagreement (-1) or agreement (+1) between the answer given by the student and the typical answer of the experts. This criterion only applies to the 36 questions on which there is real consensus among experts (only 27 of the 36 are categorized). On the contrary, it does not apply to the six questions on which experts do not agree (see the last row of Table 1). Based on these values, the levels

of agreement (“favorable” and “unfavorable”) are determined for each of the eight categories defined by the authors, as well as for the survey as a whole. After applying this process to all the individuals in the surveyed group, we calculated the averages for each statement, category and survey total.

Table 1. Identification of categories and the statements included in each category (Adams et al, 2006, translated by the authors).

Category	Statements	ID
Real world connection	28, 30, 35, 37	RWC
Personal interest	3, 11, 14, 25, 28, 30	PI
Sense making / Effort	11, 23, 24, 32, 36, 39, 42	SM/E
Conceptual comprehension	1, 5, 6, 13, 21, 32	CC
Applied conceptual understanding	1, 5, 6, 8, 21, 22, 40	ACU
Problem solving, General	13, 15, 16, 25, 26, 34, 40, 42	PSG
Problem solving, Confidence	15, 16, 34, 40	PSC
Problem solving, Sophistication	5, 21, 22, 25, 34, 40	PSS
No agreement among experts	4, 7, 9, 31, 33, 41	

The test was implemented electronically through a form sent to active physics teachers working in secondary education and first year students of the physics teacher-training program of the CFE (Uruguayan Council for Training in Education). The survey was open to every collective, teachers and students throughout Uruguay for one month during the first half of 2020.

We received 143 responses from teachers. The gender stated by the respondents was as follows: Female (46% of the total), Male (52%), 2% did not state their gender. Fifty-two percent of the respondents stated that they carry out their teaching activities in Montevideo (the country’s capital), while the remaining 48% are distributed in other departments of the country. As for the age of the respondents, 31% stated to be between 31 and 40 years old, 22% stated to be in the subsequent age ranges (18-30 and 41-50), while 25% stated to be over 51¹.

A total of 138 students from almost all the centers where physics is taught answered the survey. As for gender, 62% of respondents stated that they were female, 38% stated that they were male, and no respondents chose the other available options. In terms of the institute where they are based, most of them (56%) study in a blended-learning model², while the rest study on-site at different centers in the country.

The results of each of the surveys were analyzed based on the categories defined and validated by the authors of the instrument. With this as our starting point, we used an electronic spreadsheet taken from the Physport portal and adapted by the authors of this work to quantify the results. The following section shows the main results.

1 The results of the teacher and student survey are available at bit.ly/CLASS-profes-UY2020 and bit.ly/CLASS-formacion-UY2020.

2 Blended learning consists of a model of teacher training available since 2003 at Teacher Training Centers throughout Uruguay, for which specific subjects are not available in some specialties, one of them being physics.

4. Analysis of results

4.1 Teachers and teacher-training students in Uruguay

In a first analysis of the results, we examine all the categorized responses of teacher. The histogram in Figure 1 represents the frequencies (number of teachers) whose answers are in agreement with the experts, in intervals of 10 percentage points wide. For example, a total of 56 teachers gave “favorable” responses that are between 80% and 90%. The typical way to characterize this distribution is by the average, which in this case is 80%, the standard deviation (13%) and the standard deviation of the average (1%).

Figure 1. Overall results of the responses to the questions categorized in the CLASS test by 143 physics teachers in Uruguay. Source: self made.

In Figure 2 we show the results by categories in the teacher survey, for favorable, neutral and unfavorable responses (according to the ID in Table 1); the first two columns represent the percentages corresponding to all responses (All) and total categorized responses (All C.), respectively.

Figure 2. Performance of physics teachers surveyed with the CLASS test broken down by category. Source: self made.

The graph in Figure 3 shows the results of favorable responses of physics teachers and teacher-training students broken down by CLASS categories (the same comments regarding the identification of categories made on the graph in Figure 2 apply here). For each category and in both groups, the standard error of the average is shown. The percentage axis is defined between 45% and 95%, in order to better visualize the area of interest.

Figure 3. Performance of 138 physics teacher-training students and 143 active physics teachers on the CLASS test broken down by category. Source: self made

One aspect that stands out in the graph is the difference in the averages of teacher and student responses. The average of categorized responses is 80% for teachers and 67% for students. If we consider the range defined by the averages of all categories, we observe that it is approximately 30 percentage points in the case of students, whereas in the case of teachers it is approximately 15 points. In the case of teachers, the responses to the categories are less dispersed than in the subsets categorized for students.

The categories that show the most agreement with the experts are the same for students and teachers. In some categories, the agreement of students and teachers with experts is very similar, for example, in *Sense making/ Effort* and *Confidence in problem solving*. On the other hand, the greatest differences are observed in the categories *Applied conceptual understanding* and *Sophistication in problem solving*. Assuming that it is possible to consider the two groups of surveyed individuals as part of a pseudo-longitudinal approach, these differences could be hypothetically explained by the systematic training processes and those mediated by the teachers' daily practice.

We proposed the survey to 79 students pursuing a Bachelor's Degrees in Physics and Mathematics at the Faculty of Sciences (University of the Republic) and to 105 students enrolled at the Faculty of Engineering of the same university. We found no significant differences between the responses of the undergraduate students and the physics teacher-training students surveyed. The same survey was presented to local researchers in the area of Physical Science. Again, we found no significant differences when comparing the results of the latter with those recorded among physics teachers. The analysis results of the responses of these groups will be analyzed as part of a subsequent study.

4.2 Comparison with international results

It is interesting to compare the overall results of physics teacher-training students in Uruguay with university students from other parts of the world. Using data from the meta-analysis by Madsen, McKagan and Sayre (2015) and Bates, Galloway, Loptson and Slaughter (2011), we took the average values of the implementation of the CLASS test among students from thirteen universities in Canada, the United States and the United Kingdom, considering the fact that those students take calculus-based physics courses as part of their curricula. This point is significant, since students who pursue majors with a strong emphasis on physics and mathematics perform better on CLASS according to the literature (Madsen, McKagan, & Sayre, 2015).

While the average of the CLASS test among teacher-training students for the 36 questions where there is agreement among experts was 63.5%, the average for the thirteen surveyed groups is 64.1% with a standard deviation of 6.0%. These results show that physics teacher-training students in Uruguay obtain results similar to those of the populations used for comparison. Although they do not explain anything about education systems, these results suggest that there may be a trend in the average CLASS test scores for students with science and engineering profiles, regardless of their country of origin.

On the other hand, regarding the attitudes and beliefs of physics teachers, a comparison with a study conducted in Thailand, a country with very different demographic, social, economic and cultural characteristics than Uruguay, may be constructive. Said study, conducted by Suwonjandee, Mahachok, and Asavapibhop (2018), analyzes the responses of 196 physics teachers and 211 high school students. Despite the aforementioned contextual differences, the responses were very similar in most CLASS questions and categories. Only two of the 42 test questions show significant differences between teachers from Thailand and Uruguay (questions 8 and 22). These are two of the six questions in the *Applied conceptual understanding* category.

In the aforementioned questions, teachers in Uruguay showed a higher degree of agreement with the experts than teachers in Thailand, something very similar to what happens with physics teacher-training students in Uruguay, who also show great differences with the experts precisely in those same two questions. In fact, it may be relevant to note that these questions are the ones in our research that present the highest degree of discrepancy between the responses of physics teachers and teacher-training students:

- Question 8: *“When solving a physics problem, I look for an equation that uses the variables given in the problem and I substitute the values.”* The degree of agreement with the experts was 60% and 24% for Uruguayan teachers and teacher-training students, respectively, and 9% for teachers from Thailand.
- Question 22: *“If I want to apply a method used in one physics problem to a different one, these problems must involve very similar situations.”* The degree of agreement with the experts was 67% and 27% for Uruguayan teachers and teacher-training students, respectively, and 38% for teachers from Thailand.

These two questions seem to point out that the attitude towards physics problems is a key aspect in the training of physics teachers and seem to be a relative strength of Uruguayan teachers. The low degree of agreement shown by Uruguayan teacher-training students in question 8 seems to suggest that they approach physics problems by plugging in equations, solving them with the available data, without thinking too much about the conceptual aspects. Question 22 seems to reinforce

this idea, implying that teacher-training students fail to fully grasp the conceptual aspects and basic principles of physics and instead learn physics by memorizing equations, which would prevent them from approaching new situations with enough confidence to solve them.

5. Final comments

The epistemological attitudes and beliefs of teachers and students play a fundamental role in the classroom, involving many different aspects. In that sense, it is essential to be aware of its importance and recognize the impact that our actions within the classroom can have on the image of science that we promote, the choice of future careers or the academic achievements of our students.

Students' "epistemological" beliefs (their views on the nature of knowledge and learning) are an obstacle to the development of quality science education, affecting the way students learn and approach science courses. For example, those who consider that learning consists mainly of absorbing information will have a different attitude towards knowledge than those who consider that it is based on understanding (Elby, 2001). Therefore, one of the keys to improving our students' learning is to promote appropriate epistemological attitudes. For example, helping students understand the importance of the consistency and coherence of knowledge, as well as the difference between rote learning and deeper understanding, is certainly a teaching objective in itself, as part of the development of quality science education. As teachers, recognizing the images of science that we transmit, the relationship of science with technology and society, how to evolve towards notions that foster learning among our students, their ways of working and gender perspectives, are fundamental aspects that we must take into account and explicitly address in our classes.

In this paper we report the results obtained from the implementation of the CLASS test among an significant group of high school physics teachers and future teachers in Uruguay. The overall test scores show that the teachers' scores are higher and with less dispersion between categories than those of future teachers who have a lower mean value as well as higher dispersion. Another important finding is that the categories that have the highest agreement with the experts' opinion are the same for both groups, particularly the categories *Sense making/Effort*, *Connection with the real world* and *Personal interest*. On the other hand, we found the greatest differences in the categories of *Applied conceptual understanding* and *Sophistication in problem solving*. These observations suggest that the latter are acquired during professional training and practice. At the opposite end is the category *Confidence in problem solving*, for which we found no significant difference between the responses of teachers and teacher-training students (71% and 67%, respectively). These percentages are among the lowest (in the case of teachers it is indeed the lowest of all categories) for both groups, in relation to the respective average.

We also observed that the group of teacher-training students and the group of students who pursue careers with emphasis in Physics and Mathematics present similar scores. Although the results of these groups of students are generally good, they are clearly below those presented by professors and researchers. Thus, it seems clear that in secondary education there is a need to focus on working on issues related to the epistemological attitudes and beliefs of our students.

Finally, our work leaves several open questions to be addressed in future research. At what stage do teacher-training students transform their epistemological beliefs to approach that of experts? How do these beliefs impact teacher-training? How can teacher-training and high school courses be rethought to positively impact the epistemological attitudes of students? Are there differences between the beliefs of physics teacher-training students and those of other specialization areas? If we are to have a higher-quality science education, these and other relevant questions must be addressed.

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