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A longitudianl study of an initial teacher training student's representations about Teaching of Physics[+*]

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Abstract

Assuming the relevance of initial teacher training courses as a central moment of constitution, consolidation and reformulation of representations that constitute the teaching professional identity, we aim to understand how aspects of the teaching professional identity develop throughout a Physics Teacher Education course, focusing on the analysis of how the undergraduate students' representations about a Physics class and about the role of Physics in the formation of Basic Education students change throughout the course. For this, supported by notions of Discourse Analysis that had Michel Pêcheux as one of the founders, we elaborated three questionnaires, which were applied at the beginning of the course of a given group in a Brazilian federal public institution, two years after the beginning of the course of that group and almost four years after the beginning of the course, thus, characterizing a longitudinal study. We took for analysis the answers given by a student who participated in the three questionnaires and who finished the course shortly after answering the last one. The analyzes show that their representations about a Physics class and about the functions of teaching Physics did not change in essence. Nevertheless, these representations have become more grounded throughout the course. Specifically in the last questionnaire, it was possible to notice in their answers movements of inscription in ideological formations associated with teaching and research in Physics Education, insertions in these discursive spaces, appropriations of what/how is said in these discursive spaces. Their participation in projects such as PIBID and Residência Pedagógica stood out as conditions for the production of

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their answers and alterations in their representations, as well as the development of a Scientific Initiation project and the contact with research in the area of Physics Education provided in mandatory curricular components attended in the second half of the course.

Keywords: *Representations; Initial Teacher Training; Physics Classes; Functions of Teaching Physics; Longitudinal Study.*

I. Introdução

Since the 1970's, teacher training research has intensified, focusing on themes such as the reflective teacher, teacher knowledge, professionalism and teacher identity, and the teacher as a researcher. Notable authors in this field include Donald Schön, António Nóvoa, Kenneth Zeichner, Maurice Tardif, Philippe Perrenoud, and Paulo Freire (Langhi; Nardi, 2011; Bozelli; Nardi, 2012). This work mainly relates to the theme of professionalism/identity of the teacher.

Since the 1980's, published research defends the so-called professionalization of teaching, conceiving the idea that teachers should have a knowledge framework whose development would be guaranteed throughout their training. In fact, we can understand such works as a consequence of studies – developed in the 1960's and 1970's – that had as their object the teacher's action in relation to student learning. From them, it was expected, among other things, to know the specific knowledge of teachers, their skills, and didactic and methodological knowledge (Bozelli; Nardi, 2012).

In Brazil, the theme of professional teacher knowledge was introduced primarily through the work of Maurice Tardif and collaborators. Tardif assumes that the notion of "knowledge" encompasses knowledge, skills, and competencies. He distinguishes four sources of teacher knowledge: professional training knowledge, originating from teacher training institutions and from the representations of teaching practice; knowledge of subjects, related to the objects of study of each scientific/artistic field; curricular knowledge, associated with the selection, categorization, and presentation of knowledge to be taught; and experiential knowledge, developed in everyday practice, emerging and validated by experience (Bozelli; Nardi, 2012; Toti; Pierson, 2012; Vieira; Melo; Bernardo, 2014).

According to Lee Shulman (1987), another prominent author in this field, teachers must possess content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of the students and their attributes, knowledge of educational contexts (classroom, school management, etc.), and knowledge of the purposes, goals, and values of education. These types of knowledge enable a teacher to teach a certain content through didactic strategies pertinent to specific students in a given context (Shulman, 1987; Bozelli; Nardi, 2012; Toti; Pierson, 2012; Vieira; Melo; Bernardo, 2014).

Despite the brevity of initial training – usually a Bachelor's degree program focused on teaching – compared to the complexity of teaching practice (Langhi; Nardi, 2012), we understand this formative stage as the primordial one (Quadros et al., 2005). It is a moment

when future teachers can intensify their contact with the knowledge of the discipline they will teach, the pedagogical knowledge, and the experiential knowledge – all considered interrelated here. It is also during initial training that future teachers begin (or should begin, in our view) contact with research in the field of Teaching/Education, which can become sources that enhance their ongoing formation (Marandino, 2003). Thus, while incapable of producing ready and finished teachers (Langhi; Nardi, 2011) – a stage, in fact, that is unattainable in any profession or field of knowledge –, initial teacher training courses are responsible for providing access to the bases that will dialogue with the representations (images) that undergraduates had before the course and with the experiences they will have when practicing as teachers.

For Physics/Science teachers, based on Shulman's (1987) characterization of professional teacher knowledge, we can highlight in the scope of pedagogical content knowledge the understanding of various teaching resources and strategies proposed and investigated by researchers in the field, such as: the use of History, Philosophy, and Sociology of Science; Science, Technology, Society, and Environment approach; reading of scientific divulgation texts; experimental activities with low-cost materials; inquiry-based teaching; among many others.

Still within the scope of pedagogical content knowledge, it seems pertinent that Physics/Science teachers know and reflect on the so-called alternative conceptions movement – characterized as ideas divergent from the current scientific knowledge on a given subject (Gravina; Buchweitz, 1994). Originating in the 1970's, this movement signaled the need to recognize that students come to classes with alternative conceptions. It also brought to light a new issue that has been debated, and continues to be: how to deal with students' alternative conceptions? Since the pioneering work by Posner *et al.* (1982), several researches have advocated that Science Teaching should promote conceptual change, that is, the replacement of students' alternative conceptions with scientific conceptions. Conversely, other authors, since Mortimer (1995), argue that it is more pertinent to foster a change in the conceptual profile of students, allowing the construction of scientific conceptions without necessarily eliminating alternative conceptions. In this perspective, it would be essential for the subject to understand the validity limits of each conception that forms their conceptual profile regarding a given concept.

Historically, Physics has been taught in Basic Education disconnected from the world, ignoring the fact that students have prior conceptions (many of them alternative conceptions) and emphasizing mnemonic exercise solving involving the use of Mathematics. Additionally, many institutions have taken student preparation for entrance exams as the main objective. In contrast, currently, at least among Physics Education researchers, there seems to be a consensus that Science Education, in general, should aim as one of its main goals what various authors call scientific literacy:

> *[...] in the sense of understanding basic principles of everyday phenomena up to the ability to make decisions on issues related to science and technology [...], whether personal or public interest decisions. Thus, a person functionally literate in science*

> *and technology would know, for example, how to properly prepare dilutions of household products; satisfactorily understand the specifications of a medicine leaflet; adopt prophylaxis to avoid basic diseases affecting public health; demand that goods meet legal commercialization requirements, such as specifying their expiration date, technical handling precautions, indicating active components; operate electronic products, etc. Moreover, this person would know how to position themselves, for example, in a community assembly to take steps with public agencies on problems affecting their community in terms of science and technology* (SANTOS, 2007, p. 480).

In this context, we can affirm that among the possible barriers to the formation of new Physics teachers aiming to develop students' scientific literacy is the so-called "mirror effect." This refers to the reproduction of the form/content through which the teacher was trained during their basic and/or higher education. In other words: teachers often mirror those who were their professors at the University and/or their teachers in Basic Education, working on content and adopting approaches similar to those used by them, especially because they consider these contents/methods appropriate and effective – since they consider them to have worked for themselves (Zimmerman; Bertani, 2003; Quadros *et al*., 2005; Borges, 2006; Langhi; Nardi, 2012).

We start from the premise that in the initial training of Physics teachers, it is necessary to work with the undergraduates' representations – concept to be detailed in the next section – about, among other things, the teaching profession, the functions of a teacher, the objectives of teaching Physics in Basic Education, the teaching content, and didactic resources and strategies (Quadros *et al.*, 2005). Simultaneously, we understand as fundamental to provide Physics undergraduates with experiences that counteract the ways Physics and its teaching and learning processes have historically been viewed in schools – as if the teacher was the transmitter and students, the receivers of knowledge, as if learning occurred through simple memorization and repetition of equations and exercises, as if school contents only made sense within the school, having no relation to society or general culture, among other aspects. Alternative experiences and attitudes to these ideas, in addition to fostering the reformulation of representations already formed by undergraduates, can become other sources of mirroring for future teachers (Freitas; Villani, 2002; Zimmermann; Bertani, 2003).

We can think of representations related to the teaching profession and teachers' actions based on the concept of teachers' professional identity. Although it is an ambiguous concept in the educational literature, it can be considered as the perception which the teachers or undergraduates have about themselves as teachers or future teachers (Lamote; Engels, 2010). Teachers' professional identity encompasses not only the perceptions about who they are as teachers, but also the perceptions about what type of teachers they want to become. Therefore, the teacher's professional identity is not stable or unitary, but a complex, dynamic and multidimensional system of representations used to justify and attribute meaning to itself and to its contexts of action (Coldron; Smith, 1999). Aspects of teachers' professional identity influence how teachers act, their professional development and their actions towards proposals

for changes in the educational field. Consequently, the understanding of how the undergraduates see teaching, learning and themselves as future teachers may, among other things, favor the improvement of the structure and the planning of initial teachers training courses (Coldron; Smith, 1999; Lamote; Engels, 2010).

In view of these considerations, we aim to understand how the development of aspects of teachers' professional identity of Physics undergraduates occurs throughout an initial teacher training course. Specifically, we seek to outline answers to two questions: How do the representations of Physics undergraduates about a Physics class change throughout the course? And how do Physics undergraduates' representations of about the role of Physics along the training of Basic Education students change throughout the course?

II. Theoretical-Methodological Basis

As for the theoretical, methodological, and analytical support of this study, we draw upon some concepts from Discourse Analysis in the tradition initiated by the French thinker Michel Pêcheux. We will refer to this strand of Discourse Analysis simply as DA.

In DA, the meanings of a speech, text, or image are not predetermined by the materiality of these manifestations; the meanings are not attached to the words, phrases, or images. It is the relationship between language and its external elements that allows meanings to be constituted. This externality – both immediate and socio-historical – comprises the conditions of production of discourse (Orlandi, 1987). Consequently, discourse – as a theoretical object that can be understood from the analysis of its linguistic materiality (text, speech, image) – is understood as the effect of meaning produced between interlocutors in a given context (Orlandi, 1992). Understanding the process of discourse production implies understanding "the set of formal mechanisms that produce a given type of discourse in given 'circumstances'" (Pêcheux, 2014, p. 73).

According to DA, our words are inscribed in a pre-existing dynamic discursive space called discursive memory or interdiscourse. This space supports the possibility of saying: "For my words to make sense, they must already make sense" (Orlandi, 2005, p. 34). Discursive memory has fluid, heterogeneous, and interrelated regions, known as discursive formations. The inscription of saying in one or another discursive formation will determine the meanings produced in a given situation of speech, conversation, writing, or reading (Orlandi, 2005). The alteration of aspects of the production conditions (externality) can result in changes in the inscription process of sayings in the discursive formations and, consequently, in the changes in the meanings produced: "The same words can mean differently because they are inscribed in different discursive formations" (Orlandi, 2005, p. 44). For example, the word "work" will recall different meanings already existing in discursive memory depending on the context and the interlocutors in question. In a Physics class, "work" tends to indicate a concept, a physical quantity. In a Sociology class or everyday conversation, since it is inscribed in other discursive formations, the same word tends to recall other meanings.

Regarding the interlocutors, the subjects involved in the process of producing meaning, it is not their empirical-social-objective positions that act in the process, but rather the imagetic (imaginary) projections that they make of themselves, of others and of the positions they occupy in a given social formation (Pêcheux, 2014). The same goes for the referent (the content of speech): it is an "imaginary object (namely, the subject's point of view) and not of physical reality" (Pêcheux, 2014, p. 83). It is, therefore, through the imaginary that the subject relates to reality and produces images in the discursive field, that is, representations of this reality. It is these projected images (representations) that act in the discursive processes (Orlandi, 2005). According to Brasil (2011, p. 174): "The subject of the discourse brings to the debate a group of individual representations regarding themselves, the interlocutor and the subject addressed." Therefore, throughout this work, when we use the term "representations", we do so based on DA, intentionally emphasizing that it is something that goes beyond individual and immediate conceptions or perceptions about something/someone. Representations are directly related to immediate and socio-historical conditions of production, have a social character and act in the discursive sphere, that is, in the process of producing meanings.

Although language is opaque, we have the illusions of its transparency and of us being the source of meanings. Such illusions, besides being considered necessary for DA, are understood as a consequence of subjects' interpellation by ideology, the imaginary (unconscious) that mediates the subject's access to reality. Ideology, by hiding the way meanings are produced, enables the relationship between thought, language, and the world. It is the act of forgetting that we are not the source of meanings, that we are merely the support for socially constructed representations, that allows us to constitute ourselves as authors of "our" sayings (Orlandi, 2005; Brandão, 1999, Pêcheux, 2014). In this sense:

> *The great difference between speech and discourse is Pêcheux's non-subjectivist perspective [...]. In this perspective, the subject is not the creator, source, or origin of their speech [...], but a support for representations received from the interdiscourse. What is presupposed in the concept of speech (freedom of the speaker, creation, subjectivity, idealism, etc.) is incompatible with the perspective adopted by Pêcheux* (Narzetti, 2017, p. 1096).

Similarly to sayings – which are inscribed in discursive formations to acquire certain meanings in given contexts – subjects, considering their imaginary positions in a given context, are inscribed in ideological formations, which, in turn, encompass one or more interconnected discursive formations (Orlandi, 1987, 2005). Orlandi (2005, pp. 42-43) says: "Words change meaning according to the positions of those who employ them. They 'derive' their meaning from these positions, i.e., in relation to the ideological formations in which these positions are inscribed." For example, the statement that public school working conditions are poor sounds different when made by a teacher or the country's Minister of Education. Not directly because of their empirical-social-objective positions, but because of the socially constructed

representations of these positions.

We assume that adopting the notions of AD characterized in the previous paragraphs as theoretical-methodological-analytical support implies focusing on the investigation of how meanings were produced by certain subjects in a given context, situating their interpretative gestures, situating what they said, identifying which ideological formations in which they are inscribed, identifying in which discursive formations their sayings are being inscribed, and identifying which aspects of the immediate and socio-historical production conditions serve as the basis for their representations.

III. On Data Collection for the Research

We sketched out answers to the two questions proposed in this paper through the data analysis obtained from the application of three questionnaires to Physics education students at a Brazilian federal public institution. The first questionnaire was applied in person during the first week of classes for these students. The second was applied in person about two years after the first, that is, when the students who had answered the first questionnaire were beginning the second half of the course. The third was applied remotely (due to the conditions imposed by the COVID-19 pandemic) when, according to the course duration (four years), the same students were in their final semester, almost four years after the first questionnaire was applied. Since the proposal was to follow a process over time, analyzing possible changes, this work is configured as a longitudinal study (Hochman *et al.,* 2005). In the case at hand, we followed how, in relation to Physics undergraduates, the development of representations that make up their professional teaching identities occurred.

The first questionnaire (Q1) contained ten questions: 1) Did you attend high school in a public, private, or both types of schools? 2) Comment on experiences or events (school-related or not) that have marked your life so far. 3) Who were the best teachers you ever had? Why do you consider them the best? 4) When you were a student, what were your high school Physics classes like? 5) Have you ever worked as a teacher? If yes, describe the experience (what subject you taught, how you did it, who the students were, how you felt, how the interaction with the students was, etc.). If not, do you plan to work as a teacher in the future? Why? 6) In your opinion, what are the roles of teachers today? 7) In your opinion, does it make sense to have Physics classes in high school? Justify your answer. 8) What factors contributed to your enrollment in a Physics Teacher Education Course? 9) In your opinion, what characterizes a good Physics teacher? In other words, a good Physics teacher should... 10) Suppose you have just been hired to teach Physics in a public school. What would your classes be like?

The second questionnaire (Q2) had seven questions: 1) In your opinion, what are the positive and negative aspects of the course so far? 2) Comment on situations, moments or significant events experienced during the course. 3) So far of the course, have you worked as a teacher? If so, tell us about it (what subject you taught and how you did it, who the students

were, how you felt, how you interacted with the students, etc.). If not, do you want to work as a teacher in the future? Why? 4) What were the best classes you had during the course? Why do you consider them the best? 5) In your opinion, what should Physics classes be like in high school? Justify. 6) Complete the sentence: A good teacher is one who... 7) Suppose a high school student asks you: 'Why and what for do I have to study Physics at school?'. What would you answer?

The third questionnaire (Q3) contained nine questions: 1) You are almost finishing the course. In your opinion, what were the positive and negative points of the course? 2) Out of all the experiences you had during the course, which ones marked you the most? Why? 3) Have you recently worked or are you currently working as a teacher? If so, describe how it was or how it is (what subject you taught, how you did it, who the students were, how you felt, how the interaction with the students was, etc.). If not, do you plan to work as a teacher in the future? Why? 4) In your opinion, what are the characteristics of a good Physics class? 5) What do you think is necessary to know to teach a good Physics class? 6) What are or will be your characteristics as a teacher (how you will structure and conduct classes, how the relationship with students will be, etc.)? 7) As a high school Physics teacher, complete the sentence: "I teach Physics so that my students..." 8) Many roles are often attributed to teachers. However, in your opinion, which roles should not be the responsibility of teachers? 9) And what, in your opinion, should be the roles of teachers?

In the preparation of the questionnaires, we took into account the methodological strategies suggested by Silva and Almeida (2017), who indicated procedures that can maximize the quality of research information collected from humans in studies that rely on DA as theoretical-methodological support. Specifically, we sought to: i) through the explicitness of the research objectives and procedures, invest in the trust relationship with the participants, who were our students during the time of their participation in the questionnaires; ii) formulate questions with broader statements, centered on the participants' opinions/conceptions and on the report of experiences they had; iii) make it clear that the participants could and should be as authentic as possible, especially since their names would never be exposed and because participation and the content of their responses had no bearing on grades/approval/failure in course components.

It is worth mentioning that the three questionnaires were developed in the context of a broader project focused on investigating the development of aspects that make up teaching identity. Thus, in this article, we will analyze the responses obtained in only some of the questions proposed in each questionnaire – those that, in our opinion, allow us to outline answers to the two research questions explained in the last paragraph of the Introduction.

In the following section, based on the notions of DA that we described previously, we present the analyses developed and transcribe some of the responses obtained. We focus on the written productions of a graduate student who answered all three questionnaires and completed the course in the four years scheduled, that is, right after her participation in Q3. Unfortunately, this is the only case of a student in this class who participated in all three questionnaires and

completed the course in the scheduled time. Another student, although he participated in all three questionnaires, did not finish the course immediately after participating in Q3. Others only participated in two of the three questionnaires. In fact, this proved to be a difficulty for the development of a longitudinal study, which, in a way, was already expected, given the high dropout rates associated with Physics Teacher Education courses as indicated by studies such as Arruda and Ueno (2003), Lima Junior, Ostermann and Rezende (2012), Lima Junior, Silveira and Ostermann (2012), Lima and Machado (2014), Oliveira and Silva (2020) and Silva and Cabral (2022).

From now on, we will refer to the undergraduate student whose responses were analyzed by the fictitious name of Maria. In the transcriptions made, we maintained the original spelling of her responses, including possible errors in the use of the Portuguese language [original]. The bold text in her answers was used by us to highlight aspects of interest within the scope of this work.

IV. Results and Analysis

IV.1 Representations about Physics Classes

Below are Maria's written responses to questions 10 and 9 of Q1, regarding how her Physics classes would be if she were hired by a public school and what characterizes a good Physics teacher:

I would try to think of a way to present Physics in a way that everyone would be more interested in it, to change the students' perception that Physics only involves doing boring and difficult calculations, as many think.

[...] should invest in classes that move a bit away from theory and focus more on practice, thus making students more interested.

In question 4 of Q1, when asked about her Physics classes as a high school student, Maria answered as follows:

In the first two years, there were several teacher changes, which made it difficult to keep up. But in the last year I had a great teacher who made me very interested in the subject.

Taken together, the responses suggest that in the first two years of high school, Maria's classmates – and even she herself – were not very interested in Physics, especially due to the "boring and difficult calculations" and the theoretical focus. This scenario, at least for Maria, seems to have changed in the last year of high school, when she claims to have become "very interested in the subject." These experiences lived in Basic Education by the then incoming undergraduate student seem to shape her representations of what her classes would be like if she were hired as a teacher at that time. Specifically, the mirror effect is evident here: projecting

herself as a teacher, Maria indicated that her Physics classes would aim to interest students in the subject, just as she was in her last year of high school. Her representations mirror the "great teacher" she considered to have had. The responses also provide clues about her representations at that time regarding how high school Physics classes should be: with practical activities and not just focused on the theories and calculations involved. In Q2, applied halfway through the Physics Teacher Education course, about two years after Q1, Maria expressed the following when asked how high school Physics classes should be:

They should be adapted according to the students' abilities. Other teaching methods should be explored, besides the traditional methods.

Compared to the answers given in Q1, it is interesting to note that the then-student maintains in Q2 the defense that Physics classes should involve the use of different approaches. Indeed, although it is not clear what she understood by "teaching methods", it seems that the idea continues to be that Physics classes should not be limited to what she considers "traditional methods", based on the presentation of theories and solving exercises involving calculations.

Also in Q2, Maria wrote the following when asked about the positive aspects of the course so far (question 1):

[...] most teachers care about the students and are always willing to help, besides always approaching different ways of applying the content.

The different approaches brought by the professors to work with Physics content converge with one of the aspects that the then-student considered fundamental for high school Physics classes: the multiplicity of methods. Thus, it seems evident to us why her representations of the Physics Teacher Education course in which she was enrolled included this aspect as something positive.

In the final questionnaire (Q3), answered by the then-student in her last weeks of the course, when asked, "In your opinion, what are the characteristics of a good Physics class?", she answered:

A good Physics class contextualizes the content addressed with the students' daily lives. Besides considering their alternative conceptions to try to modify them. A good Physics class also contextualizes the content historically in addition to bringing ways for students to visualize phenomena, such as through experiments, videos or simulations.

Once again, there is a defense of the multiplicity of methods for Physics classes. However, in this response, Maria better details what some alternatives to the "traditional methods" would be, in her opinion: contextualization with daily life, historical contextualization of the content, and the use of experiments, simulators and videos. Thus, her representation of what a Physics class should be like now appears to be made up of more

objective elements.

In summary, therefore, throughout the course, the representations of the then-student about a Physics class did not change in essence. However, they became more substantiated, more consistent with conceptions associated with the field of Physics Education research. The indication of the relevance of contextualizing content with the daily lives of students and using different resources and teaching strategies relate, respectively, to the concept of scientific literacy as described by Santos (2007) and to the pedagogical content knowledge as characterized by Shulman (1987).

What is new in Maria's response to the final questionnaire is the mention of the importance of taking students' alternative conceptions into account. As we discussed in the Introduction to this work, this is a view that, academically, was constructed within the scope of the so-called alternative conceptions movement and that, since then, has been widely defended by studies in the area of Science Education.

Thus, at the end of the course, we have evidence to affirm that Maria began to subscribe to ideological formations associated with teaching and research in Physics Education, inserting herself in these discursive spaces, appropriating what/how is spoken in these spaces. Consequently, her statements begin to take up meanings of discursive formations embraced by these ideological formations, specifically with regard to the defense that Physics classes involve the adoption of diversified approaches, contextualize the content and take into account students' alternative conceptions. This is no longer a somewhat vague defense – as can be inferred from her answers in Q1 and Q2 –, with statements that are part of discursive formations associated with common sense or that are based on mirroring experiences lived during Basic Education.

Regarding the conditions of production of Maria's statements, in her answer to the second question of Q3, about the remarkable experiences throughout the course, the then undergraduate student offers evidence of factors that contributed to the development of her representations about Physics classes:

> *Having participated in the Pedagogical Residency, PIBID and having undertaken Scientific Initiation were the experiences that most marked me in the course because they were the ones that made me grow the most personally and professionally.*

It is worth noting that the Scientific Initiation (SI) project that Maria refers to in her response was developed in the area of Physics Education research in her final year of Undergraduate studies.

Another factor that possibly contributed to a greater foundation in Maria's representations about what Physics classes should be like is the fact that from the fifth semester of the course (beginning of the second half) there are specific curricular components in the area of Physics Education. These components occur in the fifth, sixth, seventh and eighth (last) semesters of the course and focus on discussing issues associated with teaching the areas of Physics based on the literature in the area of Physics Education research. In this sense, their

syllabuses provide, among other things, that undergraduate students come into contact with studies on alternative conceptions in the teaching of Physics and on teaching resources and strategies – such as the History, Philosophy and Sociology of Science (HPSS) approach, the Science, Technology, Society and Environment (CTSE) approach, experimentation, the use of computer-based teaching simulations, etc. Therefore, we consider that having had contact with and experiencing these possibilities, whether within the scope of PIBID and/or the Pedagogical Residency (PR) and/or the SI and/or the curricular components of the course, served as a condition for the changes in Maria's representations about Physics classes, according to the analysis of the clues left in her answers throughout the questionnaires.

IV.2 Representations on Physics Education Functions

In question 7 of Q1, about whether or not it made sense to have Physics classes in high school, Maria answered as follows:

It makes sense because Physics involves the whole world around us, and having a basic understanding of it is very important for everyone.

The defense of the then incoming student regarding the importance of everyone having a basic knowledge of Physics, as it would be related to the world we live in, is consistent with her representations of how Physics classes should be. It should be noted that in the tenth question of Q1, Maria had stated that one of her goals as a Physics teacher was to "change the students' perception that Physics only involves doing boring and difficult calculations".

In Q2, administered midway through the course, when asked in the seventh question, "Suppose a high school student asks you: 'Why and what for do I have to study Physics in school?' What would you answer?", Maria wrote:

I would answer that Physics is not only found in books, it is everywhere and all the time even in the simplest things, so studying it is important both for new technologies and for understanding the world around you.

The answers given in Q1 and Q2 are essentially consistent: defending that learning Physics is important because of its relationship with our world. However, in Q2, Maria explains her defense better, indicating that studying Physics helps in understanding the world. Additionally, in Q2, Maria indicates that studying Physics would also be relevant for "new technologies". Within the scope of her answer, we consider that she is probably defending the idea that learning Physics also enables understanding aspects of the functioning of contemporary technological artifacts, such as cell phones, microwave ovens, computed tomography scanners, etc.

In the final questionnaire (Q3), when asked in the seventh question, "As a high school Physics teacher, complete the sentence: 'I teach Physics so that my students...'", Maria expressed herself in writing as follows:

[…] *Can understand the natural phenomena of the world in which they live and learn about science in a way that helps them develop critical thinking.*

As she positioned herself as a teacher, the then-student – who at that point was about to complete the course – continued to emphasize the understanding of Physics knowledge as necessary for comprehending the phenomena that occur in our world. Here, however, Maria's representation regarding the functions of teaching Physics expands, now encompassing the belief that scientific knowledge can assist students in developing critical thinking. Even though she did not explicitly define what she understood by students with critical thinking, we believe it is reasonable to assume that Maria is referring to individuals who can use scientific knowledge as one of the sources for evaluating and adopting certain positions in socio-scientific discussions – which aligns with the notion of scientific literacy and perspectives such as the STSE approach.

Therefore, her representations about the functions of teaching Physics, although not having changed in essence, became more substantiated throughout the course—just as her representations about Physics classes did. Her answer in Q3, highlighted previously, gives us clues about the value placed on teaching Physics as a mechanism for fostering scientific literacy among individuals. As emphasized by Santos (2007), scientific literacy involves understanding everyday phenomena, but is not restricted to it. It also implies being able to use this knowledge to take a social stance on scientific issues. Thus, we can say that by the end of the course, Maria had begun to align herself with ideological formations associated with research in Physics/Science education, appropriating the contents/forms related to these discursive spaces. Her statements, in turn, began to reflect the meanings of discursive formations embraced by these ideological formations. It is enough to note the similarity between Maria's response in Q3 and excerpts from the quote by Santos (2007, p. 480) presented in the introduction to this text. While the then-student points out the relevance of Physics education so that people "can understand the natural phenomena of the world in which they live", the aforementioned author indicates that scientific literacy involves the "understanding of basic principles of everyday phenomena". While Maria responds that she would teach Physics so that students could also "learn about science in a way that helps them develop critical thinking", Santos (2007, p. 480) asserts that a scientifically literate person would know how to take a position (a possible objective manifestation of critical thinking) "on issues that affect their community in terms of science and technology."

Again, we consider that the expansion of Maria's representation regarding the functions of teaching Physics probably had as its main production condition the experiences lived by the then undergraduate student throughout her initial training, with emphasis on PIBID, PR, SI and the specific curricular components of the area of Physics Education, which, as already mentioned, are taught from the second half of the course. It is in these components that discussions appear in a planned way (in line with their syllabuses) about, among others, scientific literacy and the CTSA approach.

V. Final considerations

The analyses we developed in the previous section support considerations presented in the literature on teacher education. Specifically, they highlight the dynamic nature of professional teacher identity as a complex system of representations, the relevance of pre-course experiences in shaping these representations, and the influence of the mirror effect on them. They also illustrate the importance of the initial teacher education course as the first formal moment in which future teachers gain access to the foundations of research in Physics education and can experience situations that will produce meanings capable of confronting, refining, or strengthening their initial representations related to teaching. In the context of this formative stage, we emphasize participation in projects (such as PIBID, PR, and SI) and the curricular components associated with the field of Physics education as significant areas for the development of what Shulman (1987) called pedagogical content knowledge – the knowledge about the possibilities for addressing specific Physics content and promoting its learning.

We observed that Maria's representations, the then-student whose answers we analyzed in this work, did not change drastically throughout the teacher education course. In fact, the changes were subtle and more noticeable in the final questionnaire, answered shortly before the end of the course. Regarding Physics classes and the role of Physics in student education, her defense of the multiplicity of methods and the perspective of teaching aimed at scientific literacy became more consolidated, deepened, and gained clearer contours. Therefore, we consider it valid to assert that the initial teacher education course enabled the then-student to engage with other ideological formations, which, in turn, allowed her statements to align with other discursive formations – those associated with teaching and the academic literature in the field of Physics/Science education.

Based on studies on professional teacher identity cited in the introduction, we consider that the representations that constitute professional identity directly influence practical teaching performance. In this sense, the tendency is that Maria's effective performance in teaching Physics will be consistent with the representations she expressed throughout our research. This is a tendency and not a certainty, as professional teacher identity is dynamic. Additionally, this consistency depends on factors such as the school's approach, the degree of autonomy of the school's teachers, the need or not to follow a textbook or workbook, etc.

Finally, we point out as future research perspectives the expansion of the focus on teachers' representations over longer periods, following them from the beginning of the initial teacher education course to the "maturity" period in their careers, and the extension of longitudinal analyses, such as the one developed here, to students from other teacher education programs, whether in Physics or other fields. Studies that analyze the possible implications for the construction of professional teaching identities of highly controversial documents – both in the political and academic spheres –, such as the National Common Curricular Base (BNCC) and the National Common Base for the training of basic education teachers (BNC-teacher training), also emerge as challenging opportunities to be faced.

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