The Presence of Physics Education Research in the Curriculum of an Initial Teacher Education Programme

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Abstract. The objective of this study is to understand how a curriculum of an initial physics teacher education programme introduces elements of research in physics education for future teachers. This study is justified by the need to reduce the gap between what educational research outcomes says and what is practiced in the classroom, taking the initial teacher training as a possible way to bridge this gap. We present analysis of curricular documents of an initial teacher education programme in Brazil, mainly the Pedagogical Project and Teaching Plans of the subjects Methodology and Practice of Physics Teaching, and we based on Discourse Analysis as a theoretical-methodological framework. Analysis of the curricular documents of the programme indicates that there are several topics that are being studied by the researchers in physics education such as alternative conceptions, CTS relations and didactic laboratories, present in the curriculum. However, the various possible interpretations for teaching issues can provide different meanings between research outcomes, teacher training and physics teaching.

1. Introduction

Several authors, from Brazil and other countries, have been expressing concerns about the gap between research findings in science education and the practice of teaching in elementary and secondary schools [1-5]. Some studies also point to science teachers’ rejection and even disqualification of the academic knowledge [18]. Therefore, there is a need to better understand this rejection and propose strategies for change it. We agree with Cachapuz et al. [2] that a greater link between primary and secondary teachers’ practice and educational research can contribute to the improvement of teaching practice and for the development of Pedagogy of Sciences as an area of knowledge. The authors point out the need to produce more research around what they call "impact of research on science teaching" and that these may contribute to the definition and validation of evaluation criteria for this impact.

Various factors may interfere in the relation between the productions of knowledge and the teachers’ practices at the schools. Like the way how initial and continued training of teachers is designed, the teaching profession conditions, the access to research results, the conceptions of teachers about the educational research, the relationship between universities and schools, and the content of researches and political aspects [5, 9, 17].

This study examines the extent to which an initial physics teacher-training programme addresses the importance of investigating the relationship between research and practice. It focuses on an initial physics teacher training programme, because we understand that the importance of investigating the relationship between research and practice in a broad way is evident in the context of initial teacher training. That is important in view of the need to train professionals in harmony with the contemporary
production of teaching research allowing the access and reflections around a variety of topics and theoretical references, as well as the enrichment of the teaching work.

The objective of this study is to understand how the curriculum of an initial physics teacher-training programme is designed to introduce results of research in physics education for future teachers. We assume that if research topics are studied in initial teacher education, future teachers may use them in their teaching practices.

2. Theoretical considerations about teacher education

Initial teacher education programmes should provide a base for building pedagogical knowledge, to encourage reflective processes about education and the social reality through different experiences during its occurrence. Initial teacher education programmes should enable students to develop "knowledge and skills, attitudes and values that will enable them to permanently build their teaching know-how, based on the needs and challenges that the teaching, as a social practice, puts in their daily lives" [6].

The paradigms above cited, adopted in the programmes of initial teacher training on curricular organization, the objectives and practices that guide the formation of professionals interfere in the way in which the readings and discussions of the various texts are proposed and carried out within the programme disciplines. In this sense, we consider relevant the study of teacher training models [7,8], as explained below, and the relationship between theory and practice formulated in each model [9].

Technical Model: the professional activity consists in the instrumental solution of a problem made by the application of a scientific theory or a technique. It is guided by a positivist approach and obeys the rules of cause and effect. There is a separation between educational theory and practice and the educational environment is a field for the application of scientific theories elaborated by the researchers.

Practical Model: it is characterized by the valorisation of the practice and the notion of reflection on the teaching work. In this model, the teachers are the protagonists, since they have experience and knowledge from it, which allows them to deliberate and act on what they consider most appropriate for each case. There is a greater appreciation of the practical dimension, being this criterion for the choice of theory.

Critical Model: teaching, in this perspective, besides fulfilling its function of cultural transmission, also aims at the social and political formation of the student, aiding the development of his/her capacities to learn and to be inserted in a critical and participatory way in the society [10]. In this model, the relationship between theory and practice is contradictory, since they are articulated and autonomous instances.

We understand that the critical model allows us to oppose a utilitarian conception of the research results, which understands them as products or "recipes" to be applied in the classes by teachers who are consumers of these researches. We understand that it is up to the teachers to select the academic productions that interest them, so that they can read and, based on their interpretations, identify contributions to their teaching practices and teaching work, depending on the context in which it is inserted. In the words of Duarte and Silva [9]: "the theory is linked to society, conditioned by the real conditions of existence, but not subordinated to it, not bound to that reality, not in the service of practice, but, on the contrary, theory is independent of this reality, of this social practice. And only for this reason is theory capable of thinking, reflecting and transforming this reality" (p.142).

An important factor for the practice of reading educational research is the contact of teachers with the knowledge produced by researchers since initial teacher education, either through the disciplines that make up the curricular structure or other activities, such as extension, teaching initiation and scientific initiation. However, the knowledge that forms the basis for teaching corresponds very little to the theoretical knowledge that is studied at the university by the teachers, including those produced by the researches in the area of Education [11]. This situation reinforces the need to carry out investigations related to teachers' knowledge and their relationship with their teaching practices.
3. Methodology
Take into consideration that, the main objective of the research was to understand how a curriculum of an initial physics teacher education programme introduces elements of research in physics education for future teachers. The study, carried out in a public university in the São Paulo State, was composed of two main stages:

I. Initially, we analyzed curriculum documents from an initial physics teacher-training programme looking for clues of references to topics and issues of researches in physics education. The documents analyzed were: (a) the pedagogical project of the programme (PPP) in which are defined collectively the educational activities and the characteristics necessary to achieve the objectives; (b) and the teaching plans of the disciplines called "Methodology and Practice of Physics Teaching" (MPPT) - which compose the teaching pedagogical approach and include knowledge of the didactic transpositions of the specific contents. We chose MPPT disciplines because they addressed integrative knowledge, contents and pedagogical approaches, which are those that focus on the study of knowledge related to the teaching of content in a specific area - in our case, physics teaching [12]; such knowledge is also called “pedagogical content knowledge” [13].

II. In a second moment, we analysed the discourse of eight students of the last year of the programme. They had already completed most of the integrative disciplines proposed by the curriculum. We followed these undergraduate students in the context of the Supervised Curricular Internship, in which the main activity was the planning and teaching of classes for high school students. These students begin high school after 9 years of basic schooling and are between 16 and 18 years of age. We consider as source of information of this stage of the study the plans of classes that the undergraduate students have elaborated, individually or in pairs.

We sought to analyse in the discourses behind the documents and students’ indications of references to researches in physics education. For this, we will be based on notions of Discourse Analysis (AD), in the perspective of Michel Pêcheux, according to the studies of Eni Orlandi [15].

In this paper, we will present analyses of the results referring to stage I, focusing on the curricular documents of an initial teacher training programme.

4. Discourse Analysis Considerations
The theoretical reflections of this section and the analysis device were based mainly on Orlandi’s studies [15,16]. This author joins a French branch of AD, with Michel Pêcheux as the main reference.

For AD, there is not a single sense, hidden by the text, waiting to be found; due to the misunderstanding of language, there is always the possibility of interpretation that occurs from the tension between the reproduction of the same (paraphrase) and the production of other senses (polysemy). These two processes work together in a tension between the same and the different. The paraphrase is said matrix of the language, because it is sustained in the possible of being said, in the repetition. Polysemy is the source of language; is the very movement of discourses, for without such multiplicity of meanings there would be no need to say.

In the discursive perspective, the text must be related to its conditions of production. The conditions of production can be considered in their strict sense, reflecting on the immediate context in which a certain enunciation occurred, or also in its broad sense, referring to the social, historical and ideological context.

The “Discourse Analysis considers that the language is not transparent. In this way, it does not seek to cross the text to find a meaning on the other side. The question is: how does this text mean?” (15), concerned with the language production process and not just with its products.

The way in which the interpretation is approached in AD is different from the content format with which it is traditionally approached in the human and social sciences. In this approach, it is considered only the information that the discourse brings, imaginary formations are not problematized and the focus is on knowing what a certain text means. We do not deny the importance of transmitting information, but for the AD an analysis that disregards the nature and functioning of language is seen as reductionist.
The theoretical methodological reference of AD contributes in this investigation to the identification and analysis of how references to the research in physics teaching are present in the curricular documents of the initial teacher training and what its possible effects for the education of future physics teachers.

5. The Results of the Study

5.1 Analysis of the Pedagogical Project of the Programme

In a first moment of this document analysis, we highlight the Pedagogical Project of the Programme (PPP), which can be understood as a collectively constructed document, which aims to organize the pedagogical work of an educational institution and to define the actions and characteristics necessary for the attainment of the purposes and intended intentions. The evaluation of the effectiveness of the PPP began in 2006, after a curricular restructuring in the course, which aimed to comply with the determinations of the Brazilian educational legislation of the time in the search for the consolidation of specific projects for teacher education. In this project, pedagogical modules have been offered since the first semester of the course and the module "Methodology and Practice of Physics Teaching" (MPPT) ran across five semesters, in parallel to other five modules of General Physics. Thus, in the module “Physics I” offered in the first semester of the course, it was studied contents of Mechanics; in MPPT I, it was studied contents referring to the teaching of physics with a focus on Mechanics. The same was proposed for the disciplines of MPPT II and Physics II (Waves and Thermology), MPPT III and Physics III (Electromagnetism), MPPT IV and Physics IV (Optics), MPPT V and Physics V (Modern Physics).

The lecturers of MPPT (a permanent teacher and others temporarily contracted) gathered to organize the disciplines and decided that for each of the five pedagogical disciplines of the content of physics (MPPT) there should be, at least one subject of research in education that would prevail over each semester [17]. For example, in MPPT I besides specific articles on teaching mechanics, future teachers should also study publications of spontaneous conceptions and learning models; in MPPT II the focus would be on the relations of Science Technology and Society. Other topics proposed to be studied in the pedagogical disciplines of physics teaching were history and philosophy of science, laboratory activities, ICT and multi-media, scientific divulgation etc. (Table 1)

| Subjects                        | MPPT I                  | MPPT II                  | MPPT III                 | MPPT IV                  | MPPT V                  |
|--------------------------------|-------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Physics Focus                  | Mechanics               | Waves and Thermology     | Electromagnetism         | Optics                   | Modern Physics           |
| Diverse Topics in Research in Science/Physics Teaching | Spontaneous conceptions and learning models; Science, Technology and Society, History and Philosophy of Science, laboratory activities, ICT and multi-media, scientific divulgation.

From the reading of the PPP, we highlight some points that bring evidence of a concern of its authors that the research in physics teaching is present, somehow, during the course.

At one point, it is suggested in the PPP that the research be considered as "tools for understanding the process of learning in Physics". We highlight the polysemy aspect of the term "tools" that can lead to an instrumental interpretation of teaching research, which understand an "application" of satisfactory research results, without taking into account the theoretical bases that underlie the research and the context to be applied. This interpretation is more frequent in the technical model of teacher education. Another possible reading is the idea of considering research results as a theoretical tool in which the knowledge acquired is considered as a subsidy for the "understanding of the learning
process in physics", but without disregarding the specific characteristics of each teaching context - this interpretation is more coherent as the critical model teacher education.

A second mention of research in physics teaching in the PPP is as follows: "From the importance that has been given to scientific education, the research in Science Education (and Physics) of the last decades has considerable production, and it is not possible to conceive a Physics teacher whose competence resides only in the transmission of contents". In our reading, this statement refers to the trajectory of the research area in Science/Physics Education in the last decades and to the increase of its production to justify that there is no more space for admitting a teaching guided "only in the transmission of content". The term in focus, the word "only" may be a qualification stating that the lecturing-style teaching, the “chalk and talk” style should not be banned from classrooms. Even because it consists of a coherent and widespread model throughout the history of school education, but it has limitations, and proposals for viable alternatives are necessary [12] - and it is in this sense that research in physics education can contribute.

The document also points out that one of the experiences of the undergraduates’ students should be the realization of "bibliographic research, knowing how to identify and locate relevant sources of information". This experience can be made feasible by any course subject, but considering those of pedagogical knowledge of the content, as the MPPT, and that initial teacher training should prepare the students for the construction of new knowledge throughout their professional life. That seems to be consistent with an idea of a critical model education, which defends the autonomy of teachers and, in this case, teachers can seek, through the reading of academic productions in physics teaching, subsidies to develop their teaching work. Considering the volume of research published in events, periodicals, theses and dissertations, books, it would be important that the disciplines enable the experience of knowing and considering these sources already in the initial education.

Other points that we identify in the Pedagogical Project of the Programme, which refer to educational research, are related to the supervised internship. The document indicates two possible relationships between internship and research. The first of these is the idea of taking advantage of the internship space to also develop some research activity in teaching. The stage in the form of research projects has been proposed, analysed and disseminated in several researches and can be a theoretical methodological path that contributes both to the training of future teachers and to the creation of possibilities for improvement of schools. The second relation between research in teaching and internship that we locate in the PPP proposes the "elaboration and development of interventions and interdisciplinary projects incorporating results of the production of the research of Physics and Sciences". It is the elaboration and development of teaching skills by the future teachers and the suggestion for them to look for research results to take them as references for their classes.

One last observation to be taken about the PPP and the relations that it establishes with researches in physics education, is the quotation, in the bibliographical references of three academic researches (dissertations of masters) produced in the Graduate Programme in Science Education that exist in the same institutional unit in which the initial physics teacher education programme is offered. According to the document, these three researches "also supported the present curriculum restructuring". It is not evident in the PPP what the specific contributions that these master's researches have added to the preparation of this document. In consultation with these researches, we noticed that all of them took as focus aspects of the faculty and students of the initial physics teacher education programme offered at the unit.

5.2 Analysis of Teaching Plans
In this subtopic, we try to verify if the teaching plans of the five disciplines of "Methodology and Practice of Physics Teaching" (MPPT), having 2012 as academic year base year, contemplate subjects referring to researches in physics education and how this occurs. The disciplines considered were all taught by educators, effective or substitutes, with training in the area of physics education.

Teaching plans should not be taken as rigid and absolute documents, but as guidelines for the teacher's work in the classroom, subject to the concrete situations that in turn are always in motion.
The teaching plans were elaborated according to a normalization that includes the following sections: Identification, Objectives, Content, Methodology, Bibliography, Evaluation Criteria of the Learning and Discipline Syllabus.

It was possible to identify a presence of the following topics that are also objects of investigation of research in science/physics education: alternative conceptions; methods, materials and strategies; educational laboratory; History of Science; CTS; legislation and curricular programmes. These topics give us an overview of the discussions that might have been addressed in the MPPT disciplines, but it is not possible to indicate to what extent each one was studied.

The following is an analysis of the teaching plans for the sessions Discipline Syllabus, Objectives and Contents. It is worth explaining that the module presents the general ideas that will be approached throughout a discipline in a synthetic way [17].

Each MPPT discipline takes certain contents of physics as the guiding thread (Mechanics, Waves and Thermology, Electromagnetism, Optics and Modern Physics). Then, for each semester, the theoretical reflections and the research results used are oriented according to this guideline and the defined teaching themes. At the end of each MPPT module, students prepare a brief teaching plan based on the discussions in the disciplines, including those from research in physics education.

About the Discipline Syllabus: we consider first the syllabus of the disciplines, because we understand that they are starting points for the elaboration of the plans. In three of them, we find the following sentence: "The future teacher must perceive and recognize the reality of physics teaching in middle school in its difficulties and problems and analyse it under the focus of theoretical reflections and research results on the practices, materials and elements that characterize it". This section mentions "research results", specifically the research "about the practices, materials and elements" that characterize the "reality of physics teaching in the middle school". That is, the school physics teaching can be analysed from various elements (teaching practices of teachers, materials used, ways of evaluating learning, curricula that follow etc.), but this analysis should be based on theoretical reflections, including those made possible by the researches of science education.

Again we call attention to the term "research results" that can be interpreted as the taking of the research products, from which the study of the theoretical references adopted is excluded and only emphasizes its methods and conclusions, to direct the teaching work - mainly by agents outside the school; thus contributing to a technical model of teacher education. However, the term "results" may also refer to scientific productions as a whole, disseminated through theses and dissertations, chapters of books, articles published in periodicals or events, etc.

About the Objectives: we identified two direct references to research and scientific production in the objectives of the MPPT disciplines:

1. Analyse and evaluate researches in physics and sciences education, in an attempt to apply them in teaching situations;

2. To stimulate the future teacher to become a researcher in physics education through the contact with the diverse methodologies of the research in Physics/Sciences education and with the reality of the teaching in the classroom.

The first presents indications of an instrumental sense of the research, understanding it as a tool produced by specialists to be "applied" by teachers in the classroom.

We offer two interpretations, among others possible, for the second mention that aims as the objective of the discipline "to stimulate the future teacher to become a researcher in physics education". This researcher to be trained can be understood as both a professor-researcher of higher education, with post-graduate training; or as a teacher of basic education who researches his own teaching practice - the contact with methodologies of research in teaching and with the reality of the classroom can favor both directions. However, the first case of a teacher-researcher of higher education may oppose the discourse that the priority of initial teacher education is to prepare elementary school teachers (rather than physicists), because it emphasizes the need to encourage researchers education.

About the Content: we find the following direct references to research of physics education:
1. Origins and evolution of research in physics and in physics education in Brazil.
2. The Teaching Practice and its relations with the research, some methodological approaches in the research of physics education.
3. Research about the insertion of Modern and or Contemporary Physics in basic education.

The citation 1 is in the plan of the discipline MPPT I, offered in the first semester of the first year of course; a general study of what research in teaching is needed, its origins and its thematic lines. This can be the first contact of the future teachers with this type of material, that could appear in other times and disciplines of the course.

In citation 2, it is not explicit what the "methodological approaches" studied are, but it seems to point to a focus on the research methodologies and their possible relations with the teaching practice.

In citation 3 is in the plan of MPPT V that has as a guideline the teaching of Modern and Contemporary Physics, justifying the study of researches in teaching that approach this subject.

6. Conclusions
We can conclude that there are several indications that show the presence of the discourse about the research physics education in curricular documents of the initial teacher training programme that we consider in this study. From the very way in which the disciplines of Methodology and Practice of Physics Teaching were organized in the curriculum, parallel to the General Physics disciplines, and that emphasize the importance of the pedagogical knowledge of the contents, or integrating knowledge of the teaching of physics - which are work objects of research in physics education [12]. Even the insertion of specific research topics to be read, studied and discussed in the MPPT disciplines - as the analysis of teaching plans showed us.

This presence, however, does not happen without divergences of interpretations that represent, even, divergent theoretical-ideological visions, for example in the use of the terms "research as a tool", "application of research" or "research results" different relationships between research physics education, initial teacher education and teaching, depending on the reading done.

Answering our main research question, we can affirm that the way in which the curriculum of this initial teacher-training programme was organized, considering contributions of education research and including them throughout the disciplines, was only possible due to several factors in the production conditions of this document. One of the factors are the new educational legislation in Brazil, which requested a specificity in the curricular projects of teacher education and the participation of researchers in physics education in the elaboration of the document. Although there is only one effective teacher trained in the area of science education, the unit counts on a Graduate Programme in Science Education by providing new meaning effects to the question of to investigate science/physics education and its teaching.

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