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Approaches and Methodologies for a Course on History and Epistemology of Physics: Analyzing the Experience of a Brazilian University

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Abstract This paper is an analysis of inserting history and philosophy of science (HPS) in a physics undergraduate program at a Brazilian university. It is an examination of the approaches and methodologies adopted by professors of a History and Epistemology course. The course aims to have an explicit approach to HPS. The results suggest a concern of the Physics Institute regarding inserting these questions into physics teacher training programs. The study also uncovered that the professors who taught the subject had different visions of HPS.

1 Introduction

A current debate in science education relates to the use of HPS in physics education (Langevin 1933; Lederman 1992; Matthews 1993 1994; Rutherford and Ahlgren 1995; Snow 1995; Peduzzi 1998; Ostermann 2000; Freire 2002; Paty 2002; Teixeira 2003; Massoni 2005). This article focuses on questions related to HPS in the qualification of physics teachers, through the analysis of the insertion of HPS in the physics undergraduate programme of a Brazilian university.

The relevance of this investigation emerges in a period of intense discussion on reforms in teacher's training curricula in general and particularly in physics. The Brazilian universities, influenced by current trends originated in research on science education, have tried to rethink their structures, adapting to the new legislations (Rosa 2006). Hence, new curricula, new subjects and new approaches are being created. Therefore, it has become necessary to research the effectiveness of these experiences.

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2 Explicit and Implicit Approaches

Abd-El-Khalick and Lederman (2000) have analyzed researches carried out in the past 50 years that attempted to improve the conceptions about the nature of science (CNS) of students or teachers. The authors found two approaches: in one of them, there were activities in which aspects of HPS were implicitly treated; in the other, questions of HPS were explicitly discussed. In an evaluation comparing these approaches, the explicit attempts were relatively more effective in "improving"[1] the CNS of the teachers (Abd-El-Khalick et al. 2000).

Teixeira (2003) reports positive results regarding the CNS of physics undergraduates after a contextualized course using the explicit approach. The course, Physics Foundations I, which includes classical mechanics, was taught with the purpose of teaching the "physics concepts within a contextual perspective, with the use of HPS elements" (p. 41). The author provides evidence that the course contributed to the improvement of the students' understanding of CNS.

Massoni (2005), analyzing a subject on the history and epistemology of physics for physics undergraduates, has concluded that:

> […] the perception of the nature of science when it does not happen explicitly is very subtle and the use of historical elements must be very well considered, since if in some cases it enriches and helps comprehension, in others it may seem to confirm the inductivist logic (p. 73).

These more recent results corroborate those found by Abd-El-Khalick et al. that explicit approaches are more effective for improving teachers' conceptions of the nature of science and must be prioritized as strategies in teacher training.

From the analysis conducted in this study the History and Epistemology of Physics was the only mandatory subject that explicitly included in its summary a discussion of HPS aspects. For this reason it was chosen for this study.

To investigate the work done by the teachers of this subject, semi-structured interviews were recorded. Additionally documents of the institution, such as the syllabus, course programs, summary and list of subjects were analyzed.

3 HPS in the Curriculum

The physics programs in Brazilian universities usually offer two options: Teaching Degree[2] and Bachelors Degree.[3] In this university in study, there are four courses of 60 h each related to HPS; one of these is mandatory for the teaching degree only.

It is important to note that none of these courses are required for the bachelors degree, so a student can go through this course of study without encountering any epistemological discussions. For this study the optional courses were not considered because taking them varies according to each student's personal choice. Also only courses with a summary that

[1] We have used quotes to emphasize that the word "improving" brings the idea that this conception is better than another one, it adds value, but we understand this a closer conception to the contemporary epistemologists, not absolutely better.

[2] Teaching Degree is a course that qualifies the Physicist Educator to teach high school physics and conduct basic Physics Education research.

[3] Bachelor's Degree is a course that qualifies the Researcher Physicist to conduct basic Physics research.

included an explicit approach to HPS were analyzed. To a certain extent the amount of HPS in the syllabus reflects the ideas of the academic community of the importance of HPS in teaching physics, whether it is for student's learning physics or for teacher training.

One of the alternative courses offered to the Bachelors degree program, Topics in Physics Teaching, suggests that this institution sees the study of "epistemological questions" as important by not essential. Its importance is also evident by the three optional courses that form ten percent of the total optional available subjects. On the other hand, having the History and Epistemology of Physics as mandatory for the Teaching degree indicates that for this program HPS is essential.

4 The Course: History and Epistemology of Physics

The course History and Epistemology of Physics was created, under that name, in 1998 and, possibly,[4] was previously called Physics Conceptual Evolution, but it had a different summary.

Since its creation, the course was taught by three professors, two of them graduated in Physics Education and one of them in Physics. The course summary allows different approaches, but there was more similarity between the approaches of the professors with qualification in education area, whereas the physics researcher's course had a different structure.

What follows is a description of how each conducted his/her course.

4.1 Professor 03RS

Professor 03RS works from topics, such as: radioactivity, the discovery of X-rays, or "What is the Philosophy of Science?" He divides the group into pairs and each pair has to study one of the topics during the semester and present it in a seminar. They must develop the subject from the history and philosophy of science perspective. For a physics topic such as relativity, the students should prepare a seminar showing how the idea of relativity was developed, how the concept evolved and analyze it from an epistemological perspective.

In addition the professor carried out expositive classes and discussions with the students. The papers are presented by the students at the end of the course, through a seminar and the elaboration of written material. The professor admits giving more emphasis to history of science and having some restrictions regarding philosophy.

> […]I think it is very bad that physics students do not have a good historical view. Physics students in general. Now, I think, I have huge fights regarding this question when it comes into philosophy, I have many arguments with… I agree… most of the time we agree but also disagree a lot, "Professor W" and I, about these things. I've had very serious arguments also with "Professor X" about that and the empiricism history comes up and these things. I think when Philosophy is into question… first I think we are very… I think we have a limited ability to discuss philosophy, we the physics graduates in Brazil, since I know how we are qualified.

As a history and epistemology of physics professor, he reveals a feeling of limitation to discuss epistemological questions. However, this professor publishes, besides research in

[4] According to the professor's interview, the name was "Modern Physics Conceptual Evolution" or " Quantum Theory Conceptual Evolution". A copy of the physics course curriculum before 1998 was not available.

physics, papers in the history of science area. He is very comfortable defending a subject that includes historical discussions. However he admits resistance towards philosophy, but he considers that epistemology should be present:

> There should be a heavy philosophy course, epistemology, something I don't like, but there should be, because it brings a breath of fresh air, even though I disagree with most of the things they say there, even if I think, this that I say now, that I will say now is, so to speak, "an aggression to the philosophers", now I'm placing myself in the prejudiced side, I think that is sort of confetti, it is analyzing what has been already done, it is a re-reading that not always the one who did it, did that and all, well, anyway, but I think that anyway it is a cultural, intellectual activity, and I think it adds to the person's cultural qualification.

4.2 Professor 06RS

The professor begins with a test assessing the student's understanding of CNS. From there he discusses some epistemologists of the 20th century who have influenced the physics education, such as Kuhn, Popper, Lakatos, Laudan, Toulmin and Bachelard. He considers the three first chapters of the book "What is This Thing Called Science?" by Chalmers to be an excellent beginning to discussing the empiricist view of science that he indicates he normally finds in students.

He leads the subject with more emphasis on the history of mechanics. He uses a lot of the work of Professor Luiz Peduzzi. He indicated there is a lot of material in this area. He tries to integrate history and epistemology and for that he uses history as a contribution for the epistemologists he discusses:

> […] you end up having to investigate more of the history, to try to understand the epistemology, to do something, like I said, integrated.

He considers it a challenge to do this integration with four weekly hours. Another challenge is the lack of material on history of science. He indicated there are a lot of texts about mechanics, but for the other areas it is harder.

He considers the polemic questions in epistemology particularly interesting:

> […]This is what I think is fascinating, that sometimes the students say, 'wow, but in physics if this theory has been successful, then it is the most correct, but in epistemology, how can I know what is right and what is wrong?'. The idea of polemic, right? That knowledge can be extremely polemic, I think it's very interesting, I particularly consider this fascinating.

Based on an experience with the postgraduate courses, the professor concludes that discussing epistemology can contribute to the teacher's class planning, basing this planning in an epistemology:

> […]we thought how […] a given epistemology could inspire a class planning, and then they really had to […] come up with a class planning, based on an epistemology, so I think this work was very interesting. They enjoyed it very much. It seems to me that they are more used to taking a theorist of teaching–learning as an inspiration, right? So now the idea was not, so if you want to take Thomas Kuhn, as inspiration to a strategy […].

The professor thinks he contributes to the undergraduate in another way because the students begin to question the contents of the didactic books:

> many say even if they got an Alvarenga to teach about free fall, they would talk about Galileo as it is written in the book, and that they were already able to question more. I'm not saying they'd have to be Kuhnians, I mean that at least they should have a perspective of the plurality of this response of what science is, and especially what it is not.

In addition he believes physics teaching is poor because of the lack of more philosophical subjects, that would help improve the student's power of abstraction, reasoning, of evaluating alternatives. Another contribution of this subject, for the professor, would come from the need for argumentation that is presupposed, that would take the teacher to further develop the writing skills.

> Of course they always feel a clash because "oh, but up to now our tests were about problem solving, now you come with a story of 'discuss'… wow, I can't do it… come on(" But a teacher must know(Then the epistemology also comes in this sense of argumentation, the question of relating ideas […].

The professor points out other possibilities with a focus on epistemology:

> […]I think it is fantastic, epistemology, and also in the part of teaching itself, of questioning this teaching, realizing that it is not trivial to teach physics […] the student has to understand what this physics is, what answers I will be searching for, what other answers are not part of the field of physics and why they are not. […] to reflect more on your student's learning, if you think learning can be made easier if I search for basing it in epistemology. If I search for the context of the content I'm working on, the context in which the concepts of the content were invented, built, will the student see more meaning in all that? Probably yes. […] I see it like that, epistemology not as a source of salvation, but as an extremely important element.

Finally, regarding class methodology, the professor runs expositive classes, reading and discussion of texts, and applies a dissertating written test.

4.3 Professor 07RS

Eight epistemologists are considered: Popper, Kuhn, Lakatos, Laudan, Bachelard, Toulmin, Feyerabend and Maturana. The professor considers it unacceptable to have an epistemology course without mentioning Bachelard, Toulmin, Feyerabend and Maturana. The students are placed in pairs and organize a seminar about the epistemologists. Also each week during the semester they present conceptual maps or V diagrams about the epistemologist they study. The materials used for consultation are texts prepared by the professor. At the end of the course, each student presents a paper about an epistemologist, or more than one, or another relevant topic. The students also present a seminar and paper at the end of the semester about history. For this subject, they study from medieval to current physics; there are 12 topics that are worked in pairs. The professor believes that the contribution of epistemology for the graduate is on the representational change it brings.

5 Conclusions

Even though the summary of the course is the same for each professor, it is evident that each conducts the course in a different way. Professor 03RS believes you can mostly work with history of science; 06RS believes HS and PS are inseparable. Because of that, the courses acquire totally different characteristics. This is healthy for the institution and for the qualification of the graduates. On the other hand, it reveals the importance of a discussion on the nature of HPS.

The insertion of HPS in physics programs in Brazilian universities is relatively recent, but there is a movement aiming at broadening this insertion. That suggests the necessity of investigating other similar experiences, analyzing methodologies and approaches, as well as the views of history and philosophy of science brought by the professors who teach the courses. In this case study, the professors were physics graduates and the subject was under the responsibility of a physics department. As a result of this there is no interaction with the history and philosophy programs.

This brings up the question whether, inside the universities, these programs have contributed to science teacher training. This study suggests we are still far from significant institutional interaction between history, philosophy and science education. This has a direct effect on the subjects that are taught to future physics teachers. However larger investigations on this subject are required.

References

Abd-El-Khalick F, Lederman N (2000) Improving science teachers' conceptions of nature of science: a critical review of the literature. Int J Sci Educ 22(7):665–701

Freire Jr O (2002) A relevância da filosofia e da história das ciências para a formação dos professores de ciências. In: Silva Filho WJ et al (eds) Epistemologia e Ensino de Ciências. Ed. Arcádia, Salvador, pp 13–30

Langevin P (1933) O valor educativo da História das Ciências. Revue de Synthése, tomo VI, n. 1, abr., 1933. Tradução de Regina Prosperi Meyer. Mimeo

Lederman NG (1992) Student's and teacher's conceptions of the nature of science: a review of the research. J Res Sci Teach 29(4):331–359

Massoni NT (2005) Estudo de caso etnográfico sobre a contribuição de diferentes visões epistemológicas contemporâneas na formação de professores de Física, Dissertação, Porto Alegre, Instituto de Física, UFRGS

Matthews MR (1993) História, filosofia e ensino de ciências: a tendência atual de reaproximação. Caderno Catarinense de Ensino de Física 12(3):164–214 (agosto)

Matthews MR (1994) Science teaching—the role of history and philosophy of science. Routledge, London

Ostermann F (2000) História e filosofia da ciência no ensino de física. mimeo, Porto Alegre, UFRGS

Paty M (2002) Ciência: aquele obscuro objeto de pensamento e uso. In: Silva Filho WJ et al (eds) Epistemologia e Ensino de Ciências. Ed. Arcádia, Salvador, pp 145–154

Peduzzi LOQ (1998) As concepções espontâneas, a resolução de problemas e a história e filosofia da ciência em um curso de mecânica. 1998. 849f. Tese (Doutor em Ensino de Ciências Naturais). UFSC, Florianópolis

Rosa K (2006) A inserção de História e Filosofia da Ciência na formação de professores de Física: as experiências da UFBA e da UFRGS. Dissertação. (Mestre em Ensino, História e Filosofia das Ciências). UFBA, Salvador

Rutherford FJ, Ahlgren A (1995) Ciência para todos. Gradiva, Lisboa

Snow CP (1995) As duas culturas e uma segunda leitura: uma versão ampliada das duas culturas e a revolução científica. Edusp, São Paulo

Teixeira E (2003) A influência de uma abordagem contextual nas concepções sobre a natureza da ciência: um estudo de caso com estudantes de física da UEFS. Dissertação. UFBA/UEFS, Salvador, 130 p

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