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SCIENCE IN QUESTION: WHAT DO UNDERGRADUATE PHYSICS STUDENTS IN UESB THINK ABOUT THE NATURE OF SCIENTIFIC KNOWLEDGE?

LA CIENCIA EN CUESTIÓN: ¿QUÉ PIENSAN LOS ESTUDIANTES DEL CURSO DE LICENCIATURA EN FÍSICA DE LA UESB SOBRE LA NATURALEZA DEL CONOCIMIENTO CIENTÍFICO?

CIÊNCIA EM QUESTÃO: O QUE PENSAM ALUNOS DO CURSO DE LICENCIATURA EM FÍSICA DA UESB SOBRE A NATUREZA DO CONHECIMENTO CIENTÍFICO?

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Abstract
This article had the objective of characterizing conceptions about the nature of science constructed by students of the last year from the Physics Degree Course in UESB, Vitória da Conquista Campus. We used the categories: discovery, knowledge, process, explanation and education, extracted from the research conducted by Abell and Smith (1994), and the conceptions related to them were extracted from the responses considered most representative of each category, obtained by the research conducted with students from the Biological Sciences Course by Figueiredo et al. (2014). The results revealed that most Undergraduate Physics Students consider Science as a process, whereas, for most Biological Sciences Students, Science is related to knowledge.

Keywords: Teachers' Training; Ludwik Fleck; Nature of Science.

Resumen
Este artículo tuvo como objetivo caracterizar las concepciones sobre la naturaleza de la ciencia construidas por estudiantes del último año del Curso de Licenciatura en Física de la UESB, Campus de Vitória da Conquista. Utilizamos las categorías: descubrimiento, conocimiento, proceso, explicación y educación, extraídas de la investigación efectuada por Abell y Smith (1994), y las concepciones relacionadas con ellas se extrajeron de las respuestas consideradas más representativas de cada categoría, obtenidas en investigaciones previas conducidas con estudiantes del Curso de Ciencias Biológicas de Figueiredo et al. (2014) Los resultados revelaron que la mayoría de los estudiantes de Licenciatura en Física consideran la Ciencia como un proceso, mientras que, para la mayoría de los estudiantes de Ciencias Biológicas, la Ciencia está relacionada con el conocimiento.

Palabras clave: Formación de profesores; Ludwik Fleck; Naturaleza de la Ciencia.

Resumo
Este artigo teve como objetivo caracterizar concepções sobre natureza da ciência construídas por estudantes do último ano do Curso de Licenciatura em Física da UESB, Campus de Vitória da

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Conquista. Utilizamos as categorias: descoberta, conhecimento, processo, explicação e educação, extraídas da pesquisa realizada por Abell e Smith (1994) sendo que as concepções relativas a elas, foram extraídas das respostas consideradas mais representativas de cada categoria, obtidas em pesquisa anterior realizada com alunos do Curso de Ciências Biológicas por Figueiredo et al. (2014). Os resultados revelaram que a maioria dos alunos de Licenciatura em Física considera Ciência como um processo, enquanto que, para a maioria dos estudantes de Ciências Biológicas, a Ciência está relacionada ao conhecimento.

Palavras chaves: Formação de Professores; Ludwik Fleck; Natureza da Ciência.

Introduction

The idea that learning implies the transmission of immediate knowledge from one generation to the next is, although there are exceptions[3], rooted in educational theory and practices. In this perspective, the school has been restricted to basic contents, generally prescribed in textbooks emphasizing the memorization of equations, the classification systems and the nominalization of phenomena, as well as the solvability of questions by algorithms. Still according to this conception, teaching is understood as a transmission/ transfer of academic knowledge. This positivist view of teaching, fundamentally logical and empiricist, understands that the production of scientific knowledge takes place from unique methodological procedures (scientific method), eminently inductive and experimental. Based on the belief of a pre-existing reality that needs to be discovered, the knowledge derived from scientific methodology consists of collecting data through careful observation and experiments and the subsequent derivation of laws and theories from these data by some type of logical procedure – which was described by Alan F. Chalmers (1993) as naive inductivism. It is considered to be true from a logical viewpoint, since it does not depend on the context, imposing a technical rationality that makes the teacher responsible for holding uncovered and unquestionable truths.

One of the basic characteristics of the scientific method is the possibility of solving problems through assumptions and hypotheses, which should be tested through exhaustive observations or experiments. In order to develop statements from empiricism, obtaining experience data, acquired through observation and experimentation, we should obey the principle of objectivity. According to this principle, the rational choice among theories should not involve social values or

value judgments. It should only describe reality, without making any prescriptions; your propositions are purely factual.

The postulate of objectivity implies, among other aspects, that the phenomena are observed by methods called objective, i.e., reproducible and independent, not of the existence of observers, but of the subjectivity of the observers. The objectivity of the scientific methodology would then be obtained through the separation between an observing subject and an inert object, whose secrets would be revealed through this observation. In this perspective, it would not be up to the scientist, for example, to discuss the political use of his discoveries. "Everything happens as if the subject were a mere translator of what is outside of himself". These are characteristics of a scientific activity that Professor Conceição Almeida identifies as being of a science of asepsis (ALMEIDA, 2012).

The teaching of sciences (Physics, Mathematics, Biology and Chemistry) still practiced in many of our schools, focuses only on the final product of scientific activity, disregarding the process of producing this knowledge and assigning to non-scientists the role of mere spectators of discoveries made by science. Not different from the university culture, where the curricula of almost all courses are permeated by this view of science as a hierarchical set of information, full of rules, classifications, formulas, tables and graphs that are not very contextualized in relation to the presented phenomena. This process generally excludes the history and the context of production of scientific facts, personal reflection about the study material and the possibilities for personal creation.

Harres (2008) states that scientific knowledge is not restricted to knowing scientific facts (such as the distance from the Earth to the Sun, the age of the Earth, the differences between mammals and reptiles, etc.), but to understanding about the operation of science, in a more human and dynamic perspective, thus providing the student with an adequate view of the nature of science. He states that: "a type of teaching concerned with the nature of science will possibly enable students to develop a more humane view of science [...]" (HARRES, 2008, p. 37).

Many other researchers (FIGUEIRÔA, 2009; FORATO, 2009; ALVIM; ZANOTELLO, 2014; SILVA, 2014; GANDOLFI; FIGUEIRÔA, 2017; SCMIEDECKE, 2016) highlight the

importance and need for an adequate understanding of the nature of science for the training of students, at all levels of education, in order to provide scientific and technological knowledge to the majority of the schooled population in Brazil. Scholars of this theme have been questioning the distance between the models and the theories used in classrooms and the understanding of natural phenomena, as well as the lack of dynamism in science teaching – a didactic-pedagogical work that favors the undesirable "dead science" (DELIZOICOV; ANGOTTI; PERNAMBUCO, 2011).

In Biology, for example, the conclusions of the Human Genome Project (HGP), at the beginning of this century, allowed us to awaken to the limitations of science and, also, to the rupture of concepts and the naive linear view of scientific progress. Perhaps this is why, as biophysicist and philosopher Henri Atlan states, there is an urgent need for consistent reflection about problems arising from the biotechnological innovations with which we live and which we think we are used to (ATLAN, 2009).

Having made these quick considerations, we present our option for the epistemological view of Ludwik Fleck (1896-1961) as the north of this investigation. Fleck belongs to the medical field. His ideas related to "style of thinking" and "collective thinking" make it possible to use his epistemology as a basis for research in various areas of knowledge, without restricting it only to the field of health (SCHEID; FERRARI; DELIZOICOV, 2011).

In 1935, Fleck published his book named Genesis and development of a scientific fact. The prologue of this book criticizes the view of the fact as something fixed, permanent and independent of the scientist's subjective opinion. In turn, Fleck (2010) emphasizes that science should be understood as an activity historically developed by collectives of thinkers, stating that knowledge would have a socio-historical origin. In his dissertation, he addresses the progression of the concept of syphilis and the development of the Wassermann reaction, used for the serological diagnosis of this disease, with a view to understanding its main categories: style of thinking, collective thinking, esoteric and exoteric circles and formation of pre-ideas or proto-ideas, intra and intercollective circulation (FLECK, 2010).

Fleck claims that science should be understood essentially as a collective process. When addressing scientific knowledge, Ludwik Fleck is clearly opposed to the empiricist-inductivist model, assigning the subject an active role (FLECK, 2010).

In the search for the construction of a type of school knowledge appropriate to today's educational needs, we consider it essential to take into account the scientific conceptions of Undergraduate Physics Students, since they constitute an authentic epistemology about school knowledge that may influence their future pedagogical choices – as, for example, the choice of the textbook by the teacher. We recognize the impossibility of establishing a correspondence between the scientific conceptions of the undergraduate students and their behavior in the classroom, based only on a study about the undergraduate student's conception of science. Nevertheless, this research collaborates with the studies carried out around the initial teacher education, which indicate the need for epistemological discussions that could contribute to the understanding of the complexity in the construction of scientific facts, reinforcing the idea of making a reformulation not only in the conception of science of textbooks, but especially in the conception of science of initial and continuing teacher education courses (SCHEID; FERRARI; DELIZOICOV, 2011).

From this perspective, the objective of this study is to characterize the conceptions about the nature of science of students from the Physics Degree Course of the State University of Southwestern Bahia (UESB), Vitória da Conquista Campus.

Methodology

The research in question is a qualitative study, which is characterized by a subjective assessment with human beings, considering their conceptions about the studied universe, in this case, Scientific Knowledge. The researched group involved students from the sixth and eighth semesters from the Physics Degree Course held in UESB, Vitória da Conquista Campus.

The instrument used for the construction of the data was a structured questionnaire containing five objective questions, each one addressing a conception of

science. Students were instructed to select only one of the alternatives that best expressed their conception of science.

The questions that characterized the study categories adopted by the researchers were based on similar investigations that present definitions and conceptions about the nature of science, conducted by Abell and Smith (1994) and Figueiredo et al. (2014). We used the categories: discovery, knowledge, process, explanation and education, extracted from the research conducted by Abell and Smith (1994), and the conceptions related to them were extracted from the responses considered most representative of each category, obtained by the research conducted with students from the Biological Sciences Degree Course by Figueiredo et al. (2014).

In the research with Biological Sciences Students, the participants were invited to respond to an open question that asked them: "for you, what is science?", assuming that the response could be classified in up to two categories; but, in this investigation, we selected, among the responses of the students from the Biological Sciences Course, those that best described the categories defined by Abell and Smith (1994). These best responses, adopted as conceptions of Biological Sciences, were then presented to Undergraduate Physics Students, in order to make them mark a single option. We indicate below the options to which students were invited to respond:

> **Discovery:** Science is a knowledge that we have about the world and it is through it that we make new discoveries. Therefore, it is very important for our development.
>
> **Knowledge:** Science refers to the genesis of knowledge. All areas of knowledge, whether human, exact, agrarian, health and natural, permeate the field of Science; thus, such areas would not have been possible without its presence.
>
> **Process:** Science is the production of knowledge for the understanding of the environment in which we live the improvement of life. It is the study of life and its correlation with reality to enable citizens to intervene in everyday situations in a participative and constructive way. It is the construction of knowledge and its reconstruction from observations and questionings that lead to an attempt at explanation.

Explanation: Science is having wisdom, regardless of the area; regardless of being academic or not, Science is studying, it is discovering the whys and the wherefores and how it affects knowledge.

Education: Science is the sharing of knowledge and information in classes of scientific topics such as Chemistry, Physics and Biology.

Results

The research data were obtained in the regular period of the Physics Degree Course, totaling twenty-two questionnaires responded by the students, fifteen in the sixth semester and seven in the eighth semester.

Table 01: Conception about Science of Undergraduate Physics Students

Discovery	Knowledge	Process	Explanation	Education
4.5	4.5%	77.3%	13.6%	___

Source: Authors' files

Regarding the conceptions of science, 4.5% of the research participants classified it as discovery, another 4.5% as knowledge; 77.3% of the surveyed students understand science as a process and 13.6% as an explanation. The category related to education was not addressed by any of the research subjects. The category related to process emerges among the others as the predominant concept among students from the Physics Degree Course in UESB in Vitória da Conquista. The sum of the percentages of the other categories did not exceed 77.3% of the responses in the winning category. These students seem to recognize the role of subjectivity in scientific activity and its socio-historical origin, as defended by Fleck (2010), breaking, at the same time, with the naive inductivist view described by Chalmers (1993).

In this investigation, we can infer that the students from the Physics Degree Course in UESB perceive themselves as subjects in the construction of knowledge to understand the world and conceive that the function of science is to develop theories for the better understanding of this world. Accordingly, with regard to the research devices used to produce knowledge, these students perceive themselves as capable of producing realities and not just describing them. Conversely, fewer students still

seem to conceive of science as a collection of pre-existing facts about the world. In this case, scientific knowledge would be objective, permanent, produced through a supposedly neutral scientific method, with the central role of observation acquired through the separation between a "sovereign subject and an inert object, but ready to speak, as soon as it is touched by subject". (ALMEIDA, 2006).

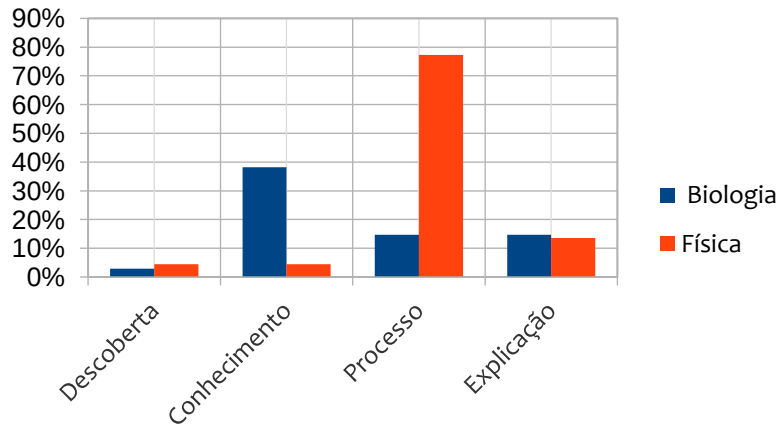
Table 02: Conception about Science of Undergraduate Physics and Biology Students

Category	Course	
	Biology (a single category)	Physics
Discovery	2.9%	4.5 %
Knowledge	38.2%	4.5%
Process	14.7 %	77.3 %
Explanation	14.7%	13.6%
Education	0	0
Total	70.6 %	99.9%

Source: Authors' files

The result of this research with the group of Undergraduate Physics Students in UESB, considering the Fleckian epistemological framework, allows us to suppose that, for most of these students, science is possibly affected by social, political and philosophical values, as well as by intelectual standards of the culture in which it is practiced.

Graph 01: Comparison between Biology and Physics



Source: Authors' files

When compared with the data obtained with the students from the Biological Sciences Degree Course, considering the Fleckian epistemological framework and the responses classified in only one category, we can highlight, in the groups of surveyed students, the prevalence of a "style of thinking" characteristic of a

"collective of thoughts". In the comparison among the researches carried out, we can identify varied epistemological conceptions in different proportions, suggesting the occurrence of a coexistence of different "styles of thinking" (FLECK, 2010). Thus, for most Physics Students, science seems to be seen as a social enterprise conditioned to the subject's view, with errors and successes, characteristic of human action. While, for most Biology Students, the idea that only scientific knowledge is able to perceive, understand and decode the phenomena of nature prevails.

We hope you will take a moment to reflect about the results of this research with professors and students from the Physics and Biological Sciences Degree Courses (Licentiate and Bachelor), especially with regard to understanding the nature of scientific knowledge, providing a less stereotyped understanding about scientists and scientific activity, as well as providing subsidies for the work of the teacher responsible for training teachers, thus enriching the content to be included in the training curriculum.

It should also be considered that, depending on the characteristics of the proposed investigation, once studies of this nature begin to be conducted at the Institution, we can:

- Contribute to increasing the number of research and reflections about cultural issues and the debate about the nature of scientific knowledge and its implications in undergraduate courses, especially in other undergraduate courses; initially, with the perspective of favoring the expansion of thematic diversity during the preparation of end-of-course papers in undergraduate and graduate courses;
- Promote seminars aimed at the academic community, where the implications of the research results are discussed;
- Expand the possibilities of teachers and students to participate in interinstitutional research, enabling academic exchange with researchers from other institutions interested in similar studies;
- Contribute to the dynamism and the consolidation of the Teaching and Research Group in Teaching and Scientific Knowledge (GEPECC, as per its Portuguese acronym).

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