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The science vision of high school female students who participated in a university extension program

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ABSTRACT

The Engineer of the Future (ENGFUT) extension program, supported by the University of Caxias do Sul (UCS), has been promoting, for over a decade, the interaction of high school students and teachers with careers related to Exact Sciences and Engineering. Through activities carried out at the institution, under the supervision of faculty members and scholarship students. As part of ENGFUT, the Encouraging Girls in Science and Technology (EMC&T) project, dedicated to high school female students, aims to encourage them to consider professional careers in scientific and technological fields. In this context, this work reports an assessment carried out regarding the views on the Nature of Science of EMC&T participants, in order to improve the activities and workshops offered and, thus, enable the construction of a vision of Science as a result of a dynamic, social and historical process. To carry out this evaluation, the Discourse Analysis was used to analyze the answers to an open questionnaire applied to the 37 project participants. The analysis showed that participants who have a greater understanding of the Nature of Science come from private schools and public schools located in small towns in the region. The results of the analysis indicated that the conception of Science of the majority of the students who participated in the EMC&T is consistent with aspects of the Nature of Science present in the literature, among which, that Science is not definitive and universally agreed, with disagreement and the refutation of hypotheses, and that the development of Science also results from the social and cultural influence in which it is immersed.

KEYWORDS: Conception of Science. Nature of Science. High school. Gender.

INTRODUCTION

The low number of women in Engineering and Exact Science programs and of professionals working in these areas are research topics for researchers concerned with gender issues and the importance of female participation in Science and Technology (S&T) (GONZÁLEZ-GONZÁLEZ *et al*. 2018; TESSARI; VILLAS-BOAS, 2013; ECCLES, 2007). To face this situation and increase the presence of women in S&T, the National Council for Research and Development (CNPq) has launched calls for projects (namely, 18/2013 – MCTI/CNPq/SPM-PR/Petrobras – Girls and Young People Doing Exact Sciences, Engineering and Computing and 31/2018 CNPq/MCTIC – Girls in the Exact Sciences, Engineering and Computing) aimed at encouraging high school female students to choose professional careers in these areas. In addition to CNPq, the ELAS Fund, with the support of Instituto Unibanco, also launched two calls for projects aiming at the insertion of girls in the areas of technological and exact sciences through the promotion of gender equality and recognition of the school as a strategic space in promoting this transformation.

In turn, the Financier of Studies and Projects (FINEP), before the aforementioned calls, launched two calls for projects (MCT/FINEP/FNDCT – PROMOVE – Engineering in High School – 05/2006 and MCT/FINEP/CT-PETRO – PROMOPETRO – 02/2009) which aimed to attract young people, of both sexes, in the areas of S&T. The Engenheiro do Futuro (ENGFUT)[2] extension program, from the University of Caxias do Sul, was created after the approval in FINEP's public call 05/2006 and, since then, it has received resources from FINEP, CNPq and FAPERGS, through multiple calls.

ENGFUT is currently an institutional program of the University of Caxias do Sul (UCS) which aims to promote the interaction of high school students and teachers with careers in the Exact Sciences and Engineering areas. To this end, at the institution and under the supervision of faculty members and the collaboration of undergraduate and high school scholarship students, several actions are carried out with the school community such as a scientific fair, symposium and courses for teachers, scientific rally, and one exclusively dedicated to female students, called Encouraging Girls in Science and Technology (EMC&T), in which the girls carry out experiments in laboratories, participate in chats with engineers and scientists, participate in practical interdisciplinary workshops (hands-on) and visits to companies in the region, among other activities.

The Encouraging Girls in Science and Technology project, therefore, aims to encourage them to consider professional careers in scientific and technological fields, given the small number of women who choose to pursue these areas. According to data from the 2017 Higher Education Census, of the 20 courses that had more female enrollments that year, only about 5% of these enrollments were in the Engineering areas (BRASIL, 2018, p. 51).

It is understood that discussions and reflections on Science (in the classroom and in activities such as those offered by ENGFUT) enable students to understand the process of construction of scientific knowledge. As a consequence, there is better quality and understanding of the knowledge worked on in Biology, Chemistry and Physics classes, for example, and interest in these areas is aroused (TEIXEIRA; FREIRE JR.; EL-HANI, 2001). Without comprehending how scientific knowledge develops, understanding and therefore interest in the Exact Sciences is diminished. Allied to this, it is known that part of the choice for professional careers involves personal interest in the corresponding area (LENT; BROWN; HACKETT, 1994).

Therefore, the activities developed at ENGFUT are, as noted, of a scientific nature. But what does it mean to say that something is scientific? An understanding of Science is approached by Martins (1999), based on philosophical foundations. For the author, a boundary between what is scientific or non-scientific cannot be established. However, he suggests that "[…] it is more convenient to introduce a *comparison of scientific values*, without establishing an absolute qualitative difference, but only quantitative and comparative" (MARTINS, 1999, p. 16, emphasis added). In view of this perspective, Science is understood as a process whose purpose is to give greater scientific value to a study. This increase is related, for example, to the possibility of attributing quantitative laws to the study, employing measurement instruments and controlled experiments to corroborate the hypotheses, seeking to integrate this study with other parts of Science (MARTINS, 1999).

Abd-El-Khalick, Bell and Lederman (1998), for example, approach Science through its fundamental aspects, called the Nature of Science - NOS. The Nature of Science concerns aspects inherent to scientific knowledge, that is, characteristics that determine what Science is (ABD-EL-KHALICK; BELL; LEDERMAN, 1998). Other authors also use NOS in their works (ALAN; ERDOĞAN, 2018; MESCI; SCHWARTZ, 2017; DAGHER; ERDURAN, 2016; PORRA; SALES; SILVA, 2011; TEIXEIRA; FREIRE JR.; EL-HANI, 2001, 2009; LEDERMAN *et al*., 2002; ABD-EL-KHALICK; LEDERMAN, 2000).

Despite the difference between the views of Science by Martins (1999) and the Nature of Science, it is understood that both can complement each other. However, it was decided here to follow the NOS approach, which has elements that can be used for the purposes of this work.

Thus, it is observed that approaches to NOS can in fact favor professional choice in scientific and technological areas. As well observed by Villas-Boas, Martins and Giovannini (2012, p. 48), "Through interactive and potentially meaningful activities it is possible to involve high school students and motivate them in the areas of science and technology".

Then, taking into account the participation of students in EMC&T activities, we sought to identify their conceptions about Science, as the choice for scientific and technological careers also involves understanding what science is and how it is developed. Thus, this work aims to assess the initial perceptions about the Nature of Science of high school female students in order to promote scientific literacy, improve the activities and workshops offered at EMC&T and also encourage them for scientific and technological careers.

The following text describes the theoretical foundation that guided this investigation, the methodology applied in data collection and analysis, and a discussion of the results is presented. The text ends, then, with the authors' considerations on the carried out research.

THEORICAL FRAMEWORK

In this section, the theoretical aspects that supported the investigation described in this article are presented. Initially, we see what are the aspects related to the construction process of Science and then their implications for school education are discussed.

NATURE OF SCIENCE

When seeking a definition for Science, there is a risk of obtaining an incomplete concept, in addition to the fact that there is no consensus on all its aspects among specialists. For example, the National Curriculum Guidelines for Basic Education, an official document that guides Brazilian schools in the organization, articulation, development and evaluation of their pedagogical proposals, conceptualize Science as "[…] the set of systematized, socially produced knowledge throughout history, in the pursuit of understanding and transforming nature and society" (BRASIL, 2013, p. 195). For Trujillo (1974 *apud* LAKATOS; MARCONI, 2011, p. 22), "Science is a whole set of rational attitudes and activities, aimed at systematic knowledge with a limited object, capable of being submitted to verification". Lakatos and Marconi, in turn, propose the following definition:

> Science, therefore, consists of a set of propositions and statements, hierarchically correlated, in an ascendind or descending way, gradually going from particular facts to general ones, and vice versa (ascending connection = induction; descending connection = deduction), proven (assured to be substantiated) by empirical research (submitted to veritfication) (LAKATOS; MARCONI, 2011, p.24).

In short, it is necessary that knowledge can be testable and refutable to be considered scientific (KOSMINSKY; GIORDAN, 2002).

In order to have a more comprehensive understanding of Science, it is common to approach aspects of the Nature of Science (NOS – Nature of Science). Briefly, NOS refers to the epistemology and sociology of Science, forming a set of fundamental and determining characteristics of scientific knowledge (ABD-EL-KHALICK; BELL; LEDERMAN, 1998).

Although there is no consensual view of the NOS, the scientific community agrees on many aspects, considered essential. Furthermore, those points related to the nature of Science that generate discussion are complex, thus being beyond the scope of understanding of Basic Education students. It is difficult, for example, that observation and experimentation are not fundamental in theoretical formulations (TEIXEIRA; FREIRE JR.; EL-HANI, 2009). Therefore, it is possible to determine some characteristics that are in accordance with the current view of Science.

Among the aspects of Science indicated by Lakatos and Marconi (2011), Porra, Sales and Silva (2011) and Lederman *et al*. (2002), the main ones are:

a) the scientific knowledge is provisional, dynamic and changeable, as it is not possible to give na undoubted character to Science. According to Popper (1963 *apud* LEDERMAN *et al*., 2002, p. 502) "[...] scientific hypotheses, theories, and laws can never be absolutely proven irrespective of the amount of supporting empirical evidence";

b) the scientific knowledge is empirical, based on observations and descriptions of natural phenomena in society. It is necessary, therefore, the possibility of verifying the statements framed in Science, through observation or experimentation of any kind;

c) the scientific knowledge cannot be separated from the experiences of scientists, since "theoretical and disciplinary commitments, beliefs, prior knowledge, training, experiences, and expectations actually influence their work" (LEDERMAN *et al*., 2002, p. 501);

d) the scientific knowledge is socially and culturally immersed, as Science affects and is affected by society. This implies the dependence of scientific construction with the time and with available investmentes and technologies, involving different social spheres and the work of other scientists. As a result, there is often the creation of tools and products that change everyday life and the ways of doing Science;

e) the scientific knowledge depends on methodical investigation, making use of observations, comparisons, measurements, tests, creation of hypotheses, concepts and theories. However, as Lakatos and Marconi put it:

> […] the scientific method does not have infalible recipes for finding the truth: it contains only a set of prescriptions, on the one hand, falible and, on the other, susceptible to improvement, for the planning of observations and experiments, for the interpretation of their results, as well as for the definition of the research poblem itself (LAKATOS; MARCONI, 2001, p.36).

Thus, it is emphasized that there is no single scientific method, that is, a step-by-step necessary for the construction of scientific knowledge;

f) disagreement between scientists is possible, precisely because of the dependence on sociocultural and individual factors that scientific knowledge presents;

g) the scientific knowledge is explanatory, as it seeks to understand how and why things are as they are and their relation to other facts.

As noted, no matter how complex the understanding of what Science is, there are some aspects that can characterize scientific knowledge, and thus facilitate understanding of it and how it is constructed.

Hereafter, the implications of understanding Science in Education are discussed.

IMPLICATIONS ON EDUCATION

Understanding the nature of Science is considered essential in Basic Education, being guided, for example, that high school curricula should organize and guarantee actions that promote reflection on the construction of Science (BRASIL, 2013). In the Common National Curriculum Base – BNCC (BRASIL, 2018), the areas of Natural Sciences in Elementary and High Schools must enable the student to develop the ability to understand the world and transform it. Furthermore, the student should be able to understand Science in a social and historical context, and how this context influences the construction of scientific knowledge. From this perspective, the BNCC indicates the promotion of scientific literacy among students, in line with Chassot's view (2003) that being scientifically literate is knowing how to read the language in which nature is written.

The comprehension of phenomena, especially in Exact Sciences disciplines, is more effective when accompanied by discussions about NOS. Thus, the approach of the relations of scientific knowledge with History, Art, Economics, Politics and, mainly with people (that is, the scientist immersed in a historically and culturally formed society) who do Science, is essential for students to understand how Science is built (TEIXEIRA; FREIRE JR.; EL-HANI, 2001; KOSMINSKY; GIORDAN, 2002).

According to Kosminsky and Giordan (2002), the lack of knowledge on the processes of construction of scientific knowledge, as well as its characteristics, both on the part of teachers and students, results in learning difficulties and lack of motivation to study Science. Also from this perspective, Duschl states that:

> When pupils learn about what is known, without also learning how we have come to know it, [...] it eliminates any chance of students understanding the social, cognitive and epistemic dynamics that make science an objective way of knowing (DUSCHL, 2000, p.187).

Based on the analysis of other research carried out on students' conceptions of NOS, Teixeira, Freire Jr. and El-Hani (2009) point out that they have inadequate conceptions. Among them, we observe: the view of scientific knowledge as immutable and absolutely true; the view of scientific knowledge being devoid of any theoretical and/or subjective influence; the conviction in the existence of a unique scientific method; misunderstandings of concepts such as theory, fact, and law; and the belief in scientific knowledge devoid of influences from the creativity and imagination of scientists. The authors also claim that the teachers themselves also have inadequate epistemological conceptions, which vary according to their cultural context, their teaching experiences and their levels of performance and training.

Mesci and Schwartz (2017) evaluated the conceptions of future teachers about NOS aspects. The authors applied questionnaires and conducted interviews with 14 undergraduate students in the fields of science education, before and after they participated in a course on NOS and scientific investigation. Initially, most students had a superficial or erroneous view of most aspects of NOS. At the end of the course, the researchers found that only some of the students continued to not fully understand some aspects, such as the difference between laws and scientific theories.

Lock (2002) points out as a possible cause for this deficiency in the understanding of scientific foundations the excess of lectures adopted by teachers. This choice for expository lectures is due to the configuration of school curricula and the content of the questions in exams. Science teachers transmit information to students, leading them to know only what to do on the tests, with no space for discussion of how the of knowledge was reached. As the author notes:

> However, there is more to the science subject culture than content-dominated lessons, associated with closed-ended practical work and a limited range of teaching and learning strategies. Perhaps as a consequence of these, science teachers become accustomed to their students leaving lessons with a stock of new-found knowledge. They are much less used to students leaving with a dilemma to ponder or a new issue to chew over with friends in the dinner break (LOCK, 2002, p.180).

With their research on students' conceptions of scientists, Reis and Galvão (2006, p. 231) conclude that Science classes are mostly expository, factual, monotonous and convey "[…] an image of science as a set of static and definitive knowledge where there is no room for doubt, uncertainty and discussion". It is visible how the absence of explicit and/or implicit approaches to NOS leads to the difficulty of understanding and demotivation for the study of Science, in view of the expository content and memorization of the classes.

In a review of methodological proposals for teaching the nature of Science, Abd-El-Khalick and Lederman (2000) point out that explicit approaches are more successful. This type of approach makes use of elements from the history and philosophy of Science and/or instruction oriented towards the various aspects of NOS, with the aim of changing the epistemological conceptions of teachers and students.

Experimentation in Science teaching also plays an important role in this area. Arruda and Laburú (1996), based on the work of Thomas Khun, point out that the function of the experiment in Science, especially in Physics, is to value the paradigm that appears to replace another current theory. As the correspondence between reality and the experimental results related to this new theory grows, the more accepted it becomes, and Science, thus, develops. As the authors suggest, experiments can be used in classes at three levels of depth, which allow students to develop more interest in Science. In addition, some aspects of scientific knowledge can also be understood through experimental activities, such as the influence of the scientist's previous expectations and hypotheses on his observations and the lack of a single scientific method (ARRUDA; LABURÚ, 1996).

For Martins (1999, p. 19), "[…] it is essential that science education transmits a vision about the process of construction of scientific knowledge […]", since this remains while the results change. In view of this objective and the role that the teacher has in the construction of a conception of Science by the students, the change in the way of teaching scientific knowledge starts with the preparation of teachers in relation to the nature of Science. For Martins (1990), this preparation is acquired through two means: either through direct contact with the scientific environment (research and scientists), or through the study, in his training, of the History of Science. In the words of the author:

> It [the History of Science] can be used to counterbalance the purely technical aspects of a class, complementing them with a study of social, human and cultural aspects. Information (previously well-founded) about the life of scientists, the evolution of institutions, the general cultural enviroment of na era, alternative conceptions of the same period, the controversies and difficulties in accepting new ideas – all these can contribute to give a new vision of science and scientists, giving greater motivation to the study. It can also be used to facilitate the understanding of a certain topic: generally, scientific results currently accepted are not very intuitive and obvious, having resulted from a long evolution and discussion. Teaching this evolution

> facilitates the understanding of the final results and their real meaning (MARTINS, 1990, p. 4).

In summary, the History of Science enables students and teachers to understand ideas, arguments and equipment used in the past that can be useful for teaching, providing an alternative to routine activities based on textbooks, as it makes practical lessons more accessible through simple tools and experiments (MARTINS, 1990). Therefore, approaching the topic is fundamental for the development of better conceptions of NOS, both by students and teachers.

Given the above-mentioned works, it is concluded at first that activities that enable students to discuss and reflect on NOS can favor the construction of a view of Science consistent with that adopted by scholars in the field, in addition to awakening affection for Science. Consequently, it is possible that such activities encourage students to pursue scientific careers, as it is known that part of the choice of professions involves personal interest in the corresponding area (LENT; BROWN; HACKETT, 1994).

METHODOLOGY

To identify the vision of Science in the girls who participated in the EMC&T, a questionnaire with open questions was applied in the first meeting. The qualitative data generated in the responses were then analyzed using Discourse Analysis (MORAES, 2003).

The 37 girls, who participated in the EMC&T in 2017, studied in public and private secondary schools from Caxias do Sul (RS) and from cities nearby such as Flores da Cunha and São Marcos. The disclosure for EMC&T registration ocurred through an advertisement on the ENGFUT Facebook page and also via e-mail to teachers who are part of an ENGFUT mailing list. To select the girls, they were asked to write an essay in which they would express the reasons that encouraged them to participate in EMC&T and send it to the coordination for evaluation.

After selecting the students, which resulted in a group consisting of 19 girls from public schools and 18 from private schools, the EMC&T activities began in March 2017, consisting of workshops (Polymers, Technology and Information, Robotics, Astronomy, Chemistry, Civil Engineering, Aerodesign, Electromagnetism), chat with scientists and visits to companies in the region. These activities happened on Friday afternoons until their end, in December that year.

The investigation described in this article is of a qualitative nature, which seeks to understand a given phenomenon through the analysis of information about it. For Moraes (2003), the interpretation of qualitative data can be developed using Discourse Analysis method. According to Moraes (2003), this method is composed of three elements: unitarization, categorization and communication. And, as a result, there is the production of metatexts, which encompass the understanding of the event constructed by the researcher.

Unitarization involves, above all, the concentration of the corpus – a set of documents containing research information – through repeated contact and profound reading of the material. Thus, moments of disassembly and codification of units of analysis follow, that is, fragmentation of the corpus into elements of complete meaning and subsequent identification of these according to their origin. Then, the categorization establishes relations between the units of analysis produced, framing them into categories arising from three distinct processes, namely: a priori categories (created by the researcher before the analysis itself, generally based on the theoretical foundation of the research), emerging categories (created from the corpus information during the analysis) and mixed categories (created initially and complemented or reorganized during the analysis). This classification intends to create order from the analysis units, enabling a clear view of the relations between the parts (the units) and the whole thing (the categories). Finally, the understandings reached (through what the author calls the capture of the new emerging) are communicated through metatexts built from the analysis performed (MORAES, 2003).

The girls' responses were then analyzed through Discourse Analysis, aiming to identify their conceptions about Science.

The *corpus* of the research consists of the responses obtained through the questionnaire applied to the 37 participants at the first meeting of the project, in 2017. This questionnaire (Chart 1), consisting of three questions, was prepared from the questionnaire presented by Porra, Sales and Silva (2011), which, in turn, was adapted from the VNOS-C (Views of Nature of Science – Model C) built by Lederman *et al.* (2002).

The first part of the analysis happened by reading the answers and labeling them by E1, E2, …, E37, where the initial letter refers to the word *estudante* (student in Portuguese) and the number that follows it orders them, in relation to the respondent's name, in alphabetical order.

Then, a new reading of the individual questions was performed and, at that time, accompanied by the registration of the central ideas of each answer, identified by E1.1, E2.1, …, E37.1, where the number after the point refers to the first question, and so on.

The next step in the analysis consisted of compiling and counting the items noted in the previous step. The *yes* or *can* answers were separated from their denials for each question, accompanied by the justifications indicated, indicating the number of times they appeared. The justifications were then labeled with numbers, where equal numbers represent arguments of the same category or equivalents (for example*, the arguments proven study, tried study and exact study* of the answer *yes* to the first question were taken as similar). Then, the justifications were counted again, now grouped in their respective categories.

The categories were formulated a priori, based on NOS aspects found in the literature. The analysis in relation to the a priori categories happened by calculating the number of responses that presented one of the aspects. Also, one response could fit into more than one category, being counted more than once.

Next, the results obtained and their discussion are presented.

Chart 1 – Questionary applied to EMC&T participants

Questionary applied to EMC&T participants
SPEAKING OF SCIENCE Knowing how Science development process happens is a very important issue so that we can issue an opinion when we are faced with situations where it is necessary to position ourselves as citizens in the face of issues involving Science, for example. In this context, we would like to know your opinion on some questions that involve the nature os Science. Student: School: Grade: Careers of interest: 1. Currently, we can say that we live in a society that highly values scientific culture, after all you must have seen products that have the expression "scientifically proven" on their label. In your opinion, is it possible to define Science? If so, what would your definition be? If not, what stops you from reaching a definition? 2. After scientists have developed a scientific theory (e.g., quantum theory, atomic theory, theory of evolution), can that theory be modified? If you believe that scientific theories remain unchanged over the years, justify your answer with a few examples. If you believe scientific theories change, explain why this happens. 3. A highly debated topic these days is global warming. Although many changes in the climate are already being felt by everyone, there is still no consensus among scientists about the causes of these changes. One group defends that such changes are consequences of man's interference in nature and another group believes that this is a natural process and that it would happen independently of human interference. In your opinion, is it possible for scientists to reach different conclusions from the same set of information? Justify your answer with some examples.

Source: Authors (2020).

RESULTS AND DISCUSSION

The analysis of the answers to the questions in the questionnaire, using Discourse Analysis, is presented in Table 1.

Regarding the first question, on the possibility of defining Science, it was observed that most students answered yes, it is possible (27 out of a total of 37). Among the justifications presented, the ones that appeared the most were: (i) Science is an exact study and proven by experiments (12 responses); (ii) Science studies everything and is everything (eight answers); and (iii) Science produces things (eight responses). A smaller portion related the concept to the study of the unknown and nature. As for the negative responses, the arguments were divided between not being possible to define it because everything is Science and it is in constant renewal, and nothing is certain. Only one response (affirmative) was not justified.

In the second question, about whether theories can or cannot be modified over time, the variety of responses was greater. Those who declare valid the possibility of modifying theories (31 students) support their assertion, for the most part, that there are new discoveries due to the advancement of technologies (20 responses). Smaller fractions justified due to changes in the world and people (five) and mistakes made in the development of the original theory (four). The negative responses were mainly based on the fact that, having proven the theories through a scientific method, it wouldn't be possible to refute them. Two affirmative answers were not justified and three students did not answer the question.

Finally, the third question, about whether the same information can lead to different conclusions, showed that 28 respondents consider such an occurrence to be possible. The main reasons were: (i) scientists have different ways of thinking, seeing and interpreting data (18 responses); and (ii) different study and analysis methods (seven responses). On the other hand, in the denials, three students stated that the same conclusion must be reached, as there is only one truth, and one stated that it is not possible to discuss proven information. Answers without justification accounted for eight in the affirmative and one in the negative. Four students did not respond. Table 1 summarizes the main reasons for the answers obtained in each question.

Thus, it is observed, at first, the predominance of belief in the empirical nature of Science, dependent on experiments and the material world. On the other hand, there is a clear understanding of the provisional character of scientific knowledge, which is not definitive and is always subject to change. Furthermore, more than half of the respondents understand that the expectations and experiences of scientists actually end up influencing their work. It is noteworthy mentioning that all these characteristics are in accordance with Lakatos and Marconi (2011) and Lederman *et al.* (2002).

The categorization of the justifications given by the girls in their responses is presented below.

In 35 responses to the questions in the questionnaire (three in the first question and 32 in the second) there was a reference to scientific knowledge being provisional and fallible. This aspect of NOS can be identified in the following excerpts (transcribed exactly as in the original text produced by the girls) from E2.2, E8.1 and E17.2:

> *E2.2: [...] new discoveries allow a greater explanation of subjects studied that can modify and/or improve theories, even because they are theories, therefore changeable.*
> *E8.1: [...] science is something that is constantly being renewed. Every day a new discovery takes the place of an idea that is now outdated*
> *E17.2: I believe that there can be changes and that happens because research leads to new discoveries and a new truth.*

Table 1 – Main justifications for the responses to the questions

Question	Justification
1. Is it possible to define Science?	Yes, Science (a) is an accurate and experienced study that proves something (b) studies everything and is in everything that exists (c) produces things from new discoveries and Technologies (d) studies the unknown, the nature and origins of things No, because (a) it covers many things (b) it is under constant renewal, not being sure about anything
2. Can scientific theories be modified?	Yes, they can due to (a) new discoveries due to advances in studies and technologies (b) world and people are evolving (c) mistakes made in the elaboration of the original theory No, they can't due to (a) they are proven by the scientific method
3. Is it possible to have different conclusions based on the same information?	Yes, due to (a) different views, interpretations and ways of thinking (b) different study methods, analysis and context No, because (a) there is only one truth, so the same conclusion must be reached (b) there is no discussion of substantiated information

Source: Authors (2020).

It is interesting to verify that most respondents see Science as an area in constant renewal. This aspect is essential for understanding the processes of construction of scientific knowledge, as its inductive laws, despite being highly likely, are fundamentally plausible (LAKATOS; MARCONI, 2011). It follows from this that the claims of Science cannot be universally proven true. When you keep this in mind, you understand how scientific knowledge can evolve over time.

The fact that scientific knowledge is socially and culturally immersed was another aspect of NOS present in the answers to the questions (10 records in the first question, 15 in the second and 1 in the third). Linked to this characteristic, it was also observed that four girls (in response to the first question) see that scientific knowledge creates observation and experimentation tools. The next examples (from E2.1, E21.1 and E11.2, respectively) portray these aspects:

> *E2.1: Yes, science is what studies the cause and effect of everything around us in an attempt to improve our daily lives, creating and improving technological resources that make our daily lives easier, for example.*
> *E21.1: [...] science exerts a lot of power in society, science is fundamental.*
> *E11.2: [...] I don't think that changing a theory should generate its disbelief, since, at the time it was made, it was adequate.*

Analyzing the other records framed in these aspects, most likely, it was in view of the technological development that the girls presented their answers. However, it is known that this mutual dependence between Science and society is reflected both in products arising from studies and productions of Science and in the relations between sociocultural factors (time, location, current ideologies) and scientific study interests. As Lederman *et al*. (2002, p. 501) observe, "Science, it follows, affects and is affected by the various elements and intellectual spheres of the culture in which it is embedded". It is in this broader scenario that technology appears, as it determines and is determined by many of the scientific advances that have happened in societies. Thus, Science and technology are together a system that possesses feedback (LAKATOS; MARCONI, 2011).

In this line, it is understood that the greatest relevance of understanding this aspect in the general framework of the development of scientific knowledge resides, perhaps, in the fact that this is the result of the work of other scientists, as stated by Lakatos and Marconi (2011). Thus, therefore, it is understood that Science involves a web of people and knowledge built (and still under construction) throughout humanity. In Science, you never work alone; there is a mutual exchange between the subject and the scientific community.

Perhaps one of the most interesting aspects of NOS observed in the corpus was that scientific knowledge is influenced by scientists' prior knowledge and expectations (one occurrence in the second question and 14 in the third) and, linked to this, disagreement between scientists is always possible (26 records in the third question). These characteristics can be seen in the following excerpts from E2.3, E12.3, E22.3 and E24.3:

> *E2.3: […] different points of view, methods, and research focuses, even on the same subject, allow different conclusions to be reached.*
> *E12.3: […] each one has a different point of view, being able to draw different conclusions.*
> *E22.3: […] scientists can see the situation based on the theories they believe.*
> *E24.3: […] each scientist can bring with a new theory according to how he/she interpreted the information.*

Lederman *et al*. (2002, p. 501) state that beliefs, prior knowledge and expectations "[…] form a mindset that affects the problems scientists investigate and how they conduct their investigations, what they observe (and do not observe), and how they interpret their observations". This implies that, as much as the same set of facts is available to different scientists, they do not necessarily reach the same conclusions, given their varied experiences and ways of approaching the subject studied. It would be expected that the vast majority of respondents would believe that, as common sense suggests, scientists were not influenced by internal and external factors in their studies. Furthermore, many believe that there is a single universal truth about what is studied, making it impossible for scholars to disagree. In fact, some records of this flawed conception appeared in the answers, such as, for example, student E10.3:

> *E10.3: They should come to the same conclusions. Each one may have started out differently, but usually there is only one truth.*

However, as already noted, the opposite occurred: many participants accept that it is not possible to separate the human being from the scientist.

One of the most fundamental aspects of Science was registered in only 11 responses to the first question. Scientific knowledge, being empirical, is related to the need for observational or experimental verification of what is intended to be characterized as scientific knowledge. This aspect is observed in the following excerpts from E4.1, E6.1 and E26.1:

E4.1: [...] much of the knowledge we have today is because of science, as science manages to prove many things through study.
E6.1: [...] science for me is all knowledge that can be proven, tested and experimented.
E26.1: [...] it is possible to define science because it is through it that popular myths are studied and proven.

For Lakatos and Marconi (2011), one characteristics of Science is that its statements can be verifiable, validated by experiments. For the authors (2011, p. 35), "However, not all factual sciences make experiment possible: some fields of Astronomy or Economics achieve great accuracy without the help of experimental proof". The observation that the verifiability of scientific knowledge is part of the girls' vision (at least some of them) is important, considering that this is a basic characteristic of Science. It is extremely important to know that scientific claims cannot be based on "think", as they would then be unfounded.

Table 2 summarizes the categories (NOS aspects) present in the answers given by the respondents. Columns Q1, Q2 and Q3 show the amount of explanations framed in each aspect, respectively, in questions 1, 2 and 3.

Table 2 – Categories observed in the responses to the questions

Categories	**Responses**		
	Q1	**Q2**	**Q3**
Scientific knowledge is provisional and can be refuted.	3	32	-
Scientific knowledge is socially and culturally immersed.	10	15	1
Disagreement is always possible.	-	-	26
Scientific knowledge is influenced by prior knowledge and expectations of scientists.	-	1	14
Scientific knowledge is empirical (observational or experimental).	11	-	-
Scientific knowledge creates observation and experimentation tools.	4	-	-

Source: Authors (2020).

It is observed, in Table 2, that some aspects of NOS were more present in questions that pointed directly to this conception, as in the case of the first and third category in questions 2 and 3, respectively. The first question, being more comprehensive, opened space for several responses related to different aspects of NOS. Due to the low number of questions addressed, some aspects were not found in the responses – for example, the fact that there is no single way of doing Science, even though there have been mentions of the existence of a scientific method.

The analysis shows that most of the students understand that Science is not definitive and of universal agreement, with the possibility of disagreeing and refuting hypotheses. In addition, it is found that the dependence and social and cultural influence of scientific knowledge, whether through the production of things to improve daily life or to develop Science itself, or through the study of everything around us, is present in the participants' understanding. Thus, it is observed that the conception of Science of most girls is consistent with what the literature manifests.

Comprehensively, about 54% of girls understand two or more aspects of NOS. Studies available in the literature evaluating science concepts, with undergraduate students, show similar or lower results than those obtained in this paper, with percentages between 24% and 48% of students presenting concepts of Science consistent with the literature (ABD-EL-KHALICK; LEDERMAN, 2000; LEDERMAN *et al*., 2002; TEIXEIRA; FREIRE JR.; EL-HANI, 2009).

What could be the reason for this result? The girls' selection process to participate in EMC&T may have induced this, considering that the application to participate in this project came from the interested students themselves. Thus, at first, it is reasonable to assume that the participants are already curious about Science and, therefore, have a better understanding of it. In addition, for the selection of girls, they were also asked to write an essay in which the candidates described the reasons why they would like to participate in the EMC&T. Therefore, the high rate of students who presented a view of Science that agrees in many aspects with academic views is due precisely to the fact that the group is composed of girls who are already interested in the subject.

Another important aspect to be emphasized in the analysis is that, among the participants who understand at least two aspects of NOS, eleven come from private schools and nine come from public schools. However, the best and most elaborate responses were from students who come from private schools and from public schools located in neighboring small towns.

Most of the answers were easily correlated with NOS conceptions. In others, on the other hand, the understanding of the views of Science was made difficult, either because of lack of clarity, or because the respondent contradict herself. Seven responses did not show any NOS aspect or were blank.

FINAL CONSIDERATIONS

The conception of Science of most girls who participated in the EMC&T is, in general, consistent with aspects of NOS present in the literature. For example, characteristics such as the dynamism and social, cultural and personal dependencies of Science are very present in the students' conceptions.

More than half of EMC&T participants have a view of Science that agrees in many aspects with academic views. But how did they construct this vision? Whether it was at school through mobilizing interventions, such as hands-on activities, appropriate readings, discussion in classes, presentation of quality scientific videos, participation in science clubs, scientific fairs, among others, the important thing is that during their trajectories there were movements that contributed to the construction of a conception of Science.

The best answers presented by students from private schools and from public schools in neighboring small towns may be related to their teachers and the pedagogical practices used by them in schools. These schools have a very important characteristic in common, which is a more stable faculty and is dedicated to lead out activities that certainly help in the development of more elaborate scientific-critical thinking, such as guiding research projects and promoting actions of a sociocultural nature.

The results of this investigation also sinalize the use of strategies that promote the learning of less experienced students through interaction with more experienced students, for example, through collaborative work, which is fundamental for the EMC&T workshops. Students who arrive with a better view on Science and Technology issues can positively influence other students. In addition, they can assist in replanning and conducting activities.

Finally, but not least, the importance of promoting activities that support the scientific and technological literacy of girls and boys is emphasized, allowing them to understand the existing relations between Science, Technology, Society and the Environment and to develop skills to act in the socio-economic development of the country, not only through extension activities, but through teaching and learning methods developed in the classroom, such as problem- and project-based learning and interdisciplinary islands of rationality.

A VISÃO DE CIÊNCIA DE MENINAS DO ENSINO MÉDIO QUE PARTICIPARAM DE UM PROGRAMA DE EXTENSÃO UNIVERSITÁRIO

RESUMO

O programa de extensão Engenheiro do Futuro (ENGFUT), com apoio da Universidade de Caxias do Sul (UCS), há mais de uma década, promove a interação de alunos e professores do Ensino Médio com as carreiras relacionadas com as Ciências Exatas e Engenharias por meio de atividades realizadas na instituição, sob a supervisão de docentes e bolsistas. Inserido no ENGFUT, o projeto Encorajando Meninas em Ciência e Tecnologia (EMC&T), dedicado às meninas do Ensino Médio, visa encorajá-las a considerar carreiras profissionais em campos científicos e tecnológicos. Nesse contexto, este trabalho reporta uma avaliação realizada a respeito das visões sobre a Natureza da Ciência das participantes do EMC&T, a fim de aprimorar as atividades e oficinas ofertadas e, dessa forma, possibilitar a construção de uma visão de Ciência como resultado de um processo dinâmico, social e histórico. Para realizar esta avaliação utilizou-se a técnica de Análise Textual Discursiva para analisar as respostas de um questionário aberto aplicado às 37 participantes do projeto. A análise mostrou que as participantes que têm uma maior compreensão sobre a Natureza da Ciência são oriundas de escolas privadas e de escolas públicas localizadas em pequenas cidades da região. Os resultados da análise indicaram que a concepção de Ciência da maioria das meninas que participaram do EMC&T é consistente com aspectos da Natureza da Ciência presentes na literatura, dentre esses, de que a Ciência não é definitiva e de concordância universal, sendo cabível o desacordo e a refutação de hipóteses, e de que o desenvolvimento da Ciência também resulta da influência social e cultural no qual está imerso.

PALAVRAS-CHAVE: Concepção de Ciência. Natureza da Ciência. Ensino Médio. Gênero.

NOTES

1 http://www.fundosocialelas.org/elasnasexatas/edital/.

2 https://engfut.wixsite.com/engfut.

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