TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 13, Sayı 4, Aralık 2016

Journal of
TURKISH SCIENCE EDUCATION
Volume 13, Issue 4, December 2016

http://www.tused.org

Assessment on How Pre-Service Science Teachers View the Nature of Science

Elaine A. COLAGRANDE[1], Simone A.A. MARTORANO[2], Agnaldo ARROIO[3]

[1] Dr., University of São Paulo, São Paulo-BRAZIL
[2] Prof. Dr., Federal University of São Paulo, Diadema-BRAZIL
[3] Prof. Dr., University of São Paulo, Faculty of Education, São Paulo-BRAZIL

Received: 26.05.2016 **Revised:** 31.08.2016 **Accepted:** 06.12.2016

The original language of article is English (v.13, n.4, December 2016, pp.293-307, doi: 10.12973/tused.10186a)

ABSTRACT

This study presents the results of a pedagogical activity developed with a group of pre-service science teachers from a Brazilian Federal University. The activity was designed so that the pre-service teachers (PSTs) could express their conceptions about the nature of science through several ways of representation by means of drawing, writing, or diagrams. The PSTs were asked to describe their thoughts about five themes: science in human life, the construction of scientific knowledge, the work of a scientist, the relationship between science and technology, and science and society. Our findings brought to light very important points about the nature of science as well as further discussions with the group. Indeed, activities such as the proposed one can lead PSTs to a meta-reflection about their conceptions about the nature of scientific knowledge by aiding them in the construction of new models and strategies for science teaching in their classroom practices.

Keywords: Nature of science, scientific knowledge, teacher training.

INTRODUCTION

While planning educational activities to be developed with their students, natural science teachers generally aim at a specific goal, which is to assist students in understanding the so-called "scientific situations" in chemistry, physics, and biology. These situations correspond to different scientific events happening throughout human history and in different contexts, which make up part of the curriculum’s areas of knowledge, for instance, atomic models, the study of force and motion, and the evolution of living beings. However, such knowledge is presented in science textbooks as concepts that are often “ready-made,” “finished,” and “true.” As a matter of fact, if teachers do not think about the nature of scientific knowledge and teach their students solely what is ready-made, they can foster misconceptions about science.

Teachers’ beliefs about science as a way of knowing include the understanding of the nature of science. As highlighted by Lederman (2007), understanding of the nature of science

Corresponding author e-mail: elainecola@gmail.com

© ISSN:1304-6020

is a critical point of scientific literacy. Daily behaviors and scientific activities are influenced by people’s views of the nature of science.

In the context of this paper, it is important to highlight what is accepted by the authors as views, conceptions, and beliefs. The view refers to a superficial part of the idea, stereotype observed by the individual. The conception is elaborated from the view and the concepts that the individual knows and establishes a relationship between them. Belief corresponds to the deeper, internal level of the individual; it is a representation built by the individual from experience and learning in his or her life and is what he or she supposes to be true.

An understanding of pre-service teachers’ (PSTs') conceptions and beliefs about the nature of science is important to improving the actions and activities developed in the PSTs’ training courses.

This research is part of an ongoing doctoral thesis, which presents an activity of reflection conducted with a group of 21 PSTs from the Federal University of São Paulo - Diadema in Brazil and is aimed to investigate the PSTs’ conceptions about the construction of scientific knowledge, the work of scientists, and the relationship between science and society.

This activity was made part of the main research and the aim was to understand whether activities planned to encourage the explication of thoughts about these issues could favor the understanding of the nature of science by the pre-service science teachers investigated. The activity was applied at the start of an elective subject offered in the science teachers’ training course. The information gained from this activity can contribute to an understanding of the PSTs’ conceptions about the nature of science. Generally, the data from research that investigates conceptions about the nature of science are obtained from questionnaires and interviews. The activity was intended to obtain the data by encouraging other ways of expression by PSTs, such as drawing or diagrams.

Literature Review

For decades, numerous academic researchers have been debating how views, conceptions, and beliefs about the nature of science, of both students and teachers, may influence educational activities (Abd-El-Khalick, 2001; Abd-El-Khalick & Akerson, 2004, 2009; Abd-El-Khalick & Lederman, 2000; Acevedo Días, 2010; Almeida & Farias, 2011; Harres, 1999; Lederman, 1992; Lederman, 2006; Lederman et al., 2001; Matthews, 1995; Osborne et al., 2003; Sarieddine & Boujaoude, 2014; Rubba & Harkness, 1993; Tobaldini et al., 2011; Torres et al., 2015; Vázquez et al., 2008; Wellington & Lakin, 1994). There is no specific definition for the "nature of science." The understanding about it involves different conceptions regarding the development of science. According to Acevedo Días (2009), some researchers understand nature of science (NOS) as the epistemology of science. Other researchers also emphasize the sociological and psychological aspects of science, with scientific activities and characteristics of the knowledge produced (p. 356). Lederman (1992) indicates that "the nature of science refers to values and assumptions inherent to the development of scientific knowledge" (p. 331).

According to Comas, Clough, and Almazroa (1998),

> [...] the phrase "nature of science” is used to describe the intersection of issues addressed by the philosophy, history, sociology, and psychology of science as they apply to and potentially impact science teaching and learning. As such, the nature of science is a fundamental domain for guiding science educators in accurately portraying science to students. (p.5)

Abd-El-Khalick (2001) asserts that the conceptions of NOS have changed throughout the development of science. The dynamic character of science, the imagination and creativity of those who develop science, and the observations of the scientist influenced by theories present in their minds are important aspects of NOS. The study of NOS, based upon contributions from the history, philosophy, and sociology of science, plays a very important role by which PSTs can deepen their reflections on the management and construction of scientific knowledge. Therefore, preparing PSTs through activities that promote a deep reflection on how science has been built, given its dynamic character, becomes essential to enable such teachers to adequately interpret scientific situations and concepts in their classroom practices so that their students can develop their own networks of meanings.

The activity applied in this study was carried out based on an explicit and reflective approach as reported in the studies of Fouad Abd-El-Khalick and other researchers (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002; Abd-El-Khalick & Akerson, 2009) that is aimed at studying the nature of science with PSTs.

According to Abd-El-Khalick and Akerson (2009), the explicit-reflective approach "represents an overarching framework intended to guide instruction about NOS" (p.2163). According to the researchers, the term "explicit" is curricular in nature, and the term "reflective" is instructional in nature. Abd-El-Khalick and Akerson (2009) explain that an "explicit" approach entails planning instructional sequences for teaching NOS in an intentional way, encouraging students to understand NOS, and the "reflective" approach entails giving opportunities designed to encourage learners to examine their science learning experiences from within an epistemological framework. Acevedo Días (2009) asserts that the reflective component in the planned activities can be identified throughout reflective essays written by students or answers to planned questions about NOS. Irez and Çakir (2006), in their study about strategies of teaching NOS, highlighted the following:

> [T]he reflection orientation in science teacher education is characterized by asking students to describe their ideas, beliefs, and values about science teaching and learning and by offering experiences that help them clarify, confront, and possible change in their personal theories. (p. 9)

In this sense and based on a theoretical framework, the activity was aimed at promoting a meta-reflection on the construction of scientific knowledge so that these future teachers could express both their ideas and conceptions about NOS, which will certainly influence and frame their classroom practices.

THE METHODOLOGY OF RESEARCH

The research was carried out in the first semester of 2015 within an elective subject of a science teacher training course at the Federal University of São Paulo, Diadema, São Paulo, Brazil. Such research is part of a university program called "Projeto Zero," which addresses the initial and continuing education of science and mathematics teachers by articulating projects and educational actions aided by researchers from different research areas in order to improve the quality of teaching and teacher education.

In this university and specifically in the science teacher training course, the first two years comprise the basic cycle in accordance with general subjects and disciplines in specific educational areas; within these two years, the PTSs select their future area of teaching from among physics, chemistry, biology, and mathematics.

The research is interpretative in nature. The activity recounted in this paper was applied in the initial stage of the elective subject, which presented an exploratory character. The methodology was performed to identify the views of the PSTs about NOS at the start of the research. In the first meeting of the elective subject, the PSTs were asked about various aspects of NOS through different instruments of data collection, of which this activity was made a part.

The sampling

In this phase, 21 pre-service science teachers with ages ranging between 19 and 30 years (mean 24.5) were enrolled in an elective subject. Each individual who voluntarily participated in the study signed a written consent form after receiving information about the study goals.

Data collection

The PSTs were asked to express their conceptions about NOS in several different ways, thus sharing tacit knowledge about it. In this stage of the research, we began by asking participants for their thoughts on five themes: science in human life, the construction of scientific knowledge, the work of a scientist, the relationship between science and technology, and science and society. The PSTs could perform their representation by drawing, diagrams, or even writing in order to preserve each individual's skill.

Our pedagogical activity was designed in accordance with previous studies in order to meet the goals of this study, in which we adopted an "explicit" approach, given the sequence of purposely planned activities, for discussions about the construction of scientific knowledge as well as a "reflective" approach so that the PSTs could reflect and analyze (in different ways) their ideas about NOS. We also encouraged them to share those ideas with the other participants. A similar study was carried out by Sevim and Pekbay (2012), in which teaching activities were designed with an explicit and reflective approach to induce insights in PSTs, and, according to the researchers, the results showed that the self-reflections encouraged in the activities promoted an improvement in the views about the nature of science.

Data analysis

The analysis of the results was carried out through content analysis, according to Bardin (2011), by the creation of categories of analysis, which emerged from each proposed theme based upon the responses of the PSTs. It should be noted that such categorization has the subjective views of the study's authors, and it was created from the answers of this specific group. The categorization was based on similar elements in the representations of the PSTs, and they were grouped by common characteristics identified. Thus, the tables were built with categories and the frequencies of answers. These categories represent data that is important to the understanding of the initial PSTs' conceptions about NOS.

FINDINGS

In the first part of the study, 21 pre-service science teachers responded to a questionnaire about their school education backgrounds and academic profiles. Figure 1 shows the type of institution (private or public) that each individual attended for their basic education. Such data suggest different backgrounds in terms of educational levels based upon the number of classes, syllabi, textbooks, and materials used in the classes among other factors conditioned by the educational system adopted by each institution.

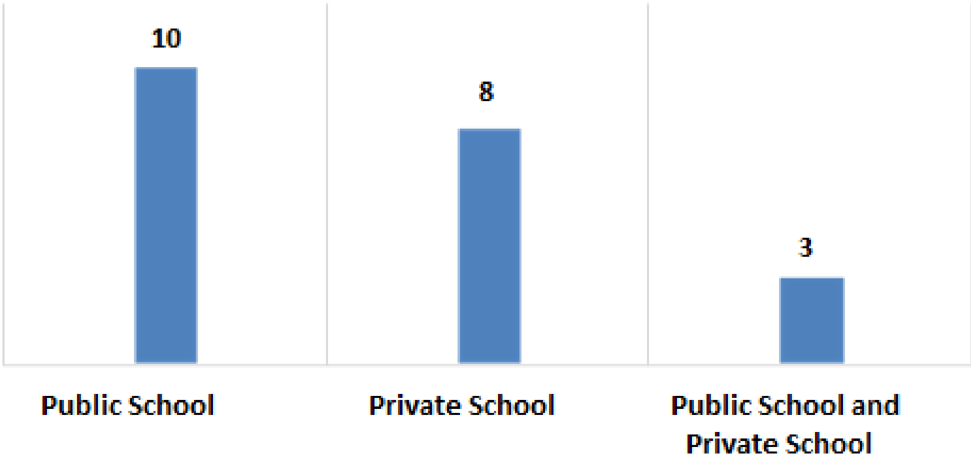

Figure 1. *Training of basic-education teachers.*

Two-thirds of the respondents are in the final stage of the course. The group of PSTs was comprised of five participants in the area of physics, two in chemistry, 13 in biology, and one in mathematics, which brought diversity to the discussions during our study. Two-thirds of the group had never worked as teachers before.

Throughout the activity, the 21 PSTs used more than one form of representation, as follows: three students used drawings and diagrams, five students used diagrams and writing, eight students used drawing and writing, and one student used solely writing, but none of them chose only to draw. Nevertheless, by the end of the activity, they reported that it was quite difficult to perform the activity since they had no "script" to follow, leading them to more deeply reflection on how to express themselves. However, they highlighted a positive side of the activity, which enabled them to express their thoughts on the subject in several different ways. Tables 1–5 show the categories created.

Theme 1 - science in human life

The objective of Theme 1 was to assess the PSTs views concerning the role of science in human life. The frequency of responses shown in Table 1 indicates that eight PSTs understand that science is aimed at providing benefits for humans.

Table 1. *Categories for Theme 1*

Category	Frequency
Science is everything	4
Science as a way to explain the world	2
Science used for human benefit	8
Science as human development product	5
Other responses	2

Theme 2 - the construction of scientific knowledge

The objective of Theme 2 was to understand the views of PSTs on how scientific knowledge is built. Based upon the frequency of responses shown in Table 2, it is possible to conclude that seven PSTs believe that the construction of knowledge takes place through scientific methods (defined steps and linear sequence of procedures). Conversely, seven other PSTs believe that it takes place by questioning the phenomena of the world around us.

Table 2. *Categories for Theme 2*

Category	Frequency
It occurs by the scientific method.	7
It occurs by questioning the phenomena of the world.	7
It occurs by the interaction between human beings and the world.	4
Other responses	3

Theme 3 - the work of a scientist

The objective of Theme 3 was to identify how PSTs view the work of scientists. The frequency (Table 3) shows five answers as “Scientists make discoveries and prove theories, which is in alignment with the views presented in Theme 2, highlighting the sequential and linear scientific methods.

Table 3. *Categories for Theme 3*

Category	Frequency
Scientists make discoveries and prove theories.	5
Scientists are influenced by the social environment.	2
Scientists study the phenomena of the world around us.	6
Scientists seek for answers.	3
Other responses	5

Theme 4 - the relationship between science and technology

The objective of Theme 4 was to identify the views of PSTs on this matter, given the rapid technological advances currently present in our society due to scientific studies, which affect the daily life of citizens.

Table 4. *Categories for Theme 4*

Category	Frequency
Technology facilitates the study of science.	5
Science produces technology.	8
Science & technology linkages as they depend on one another	4
Other responses	4

Theme 5 - science and society

The objective of Theme 5 was to identify how PSTs view scientists, as they are society members and therefore might be influenced by a variety of factors involving scientific concepts and cultural and social issues.

Table 5. *Categories for Theme 5*

Category	Frequency
Science meets the needs of the society.	11
Science influences the actions of society.	4
Science is the product of society's aspirations.	2
Other responses	4

DISCUSSION

For each proposed theme, PSTs' views are presented herewith along with forms of representation, which were briefly described according to each PST´s response (from PST 1 to PST 21). Some examples of representations were selected and presented as follows.

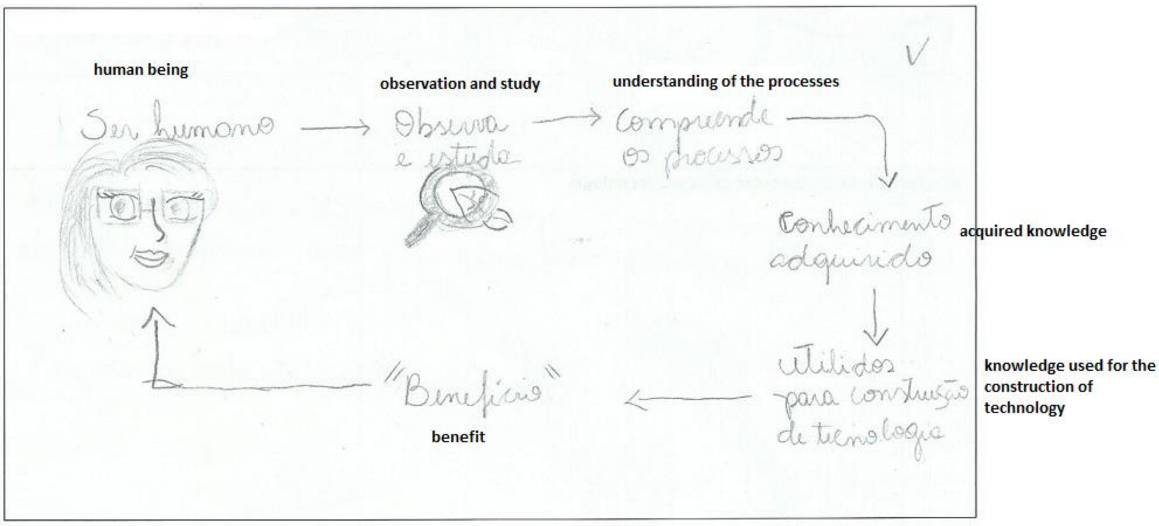

Figure 2. *Response of PST 17 about Theme 1.*

The main idea of Figure 2 is related to knowledge providing benefits to humans. The social values implicit in this representation can be noted. Only two PSTs pointed out that science can explain the phenomena around us (Table 1). On the other hand, five PSTs pointed out that science is the direct result of human development throughout time in accordance with one of the NOS aspects that refers to scientific knowledge as partly the product of human imagination and creativity (Khishfe & Abd-El-Khalick, 2002; Lederman, 2007; Sevim & Pekbay, 2012). The discussion about the limitations and dynamic character of science is important.

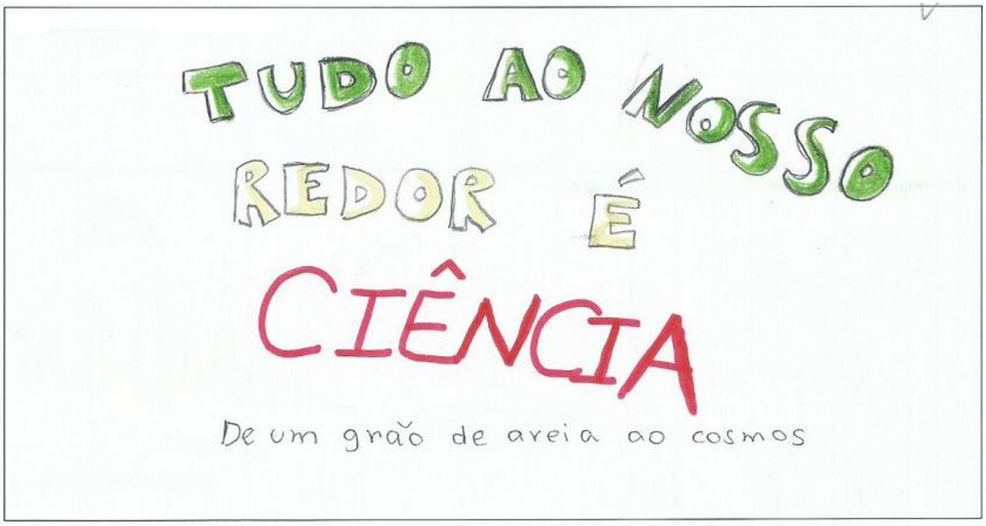

Figure 3. *Response of PST 7 about Theme 1. Legend reads: Everything around us is science, from a grain of sand to the whole universe.*

PST 7 states that he/she believes that everything around us is science without explaining or detailing his/her own views (Figure 3). This implies the importance of sharing ideas and thoughts as well as analyzing other points of view by means of debates and discussions with the other participants because there are different conceptions about the question "What is science?" and the debates can encourage more reflection about it, including, for instance, discussions on the ideas of Karl Popper, who established the criteria to identify science and non-science (contributions of philosophy of science).

Figure 4 shows the sequence of scientific methods, from observing the phenomena to the development of theories. This view of the scientific method as a sequence of pre-established steps was also identified in the study of Sarieddine and Boujaoude (2014), from questionnaires and interviews. In this representation (Figure 4), it can be noted that the role of experimentation is essential for a theory to be accepted or discounted.

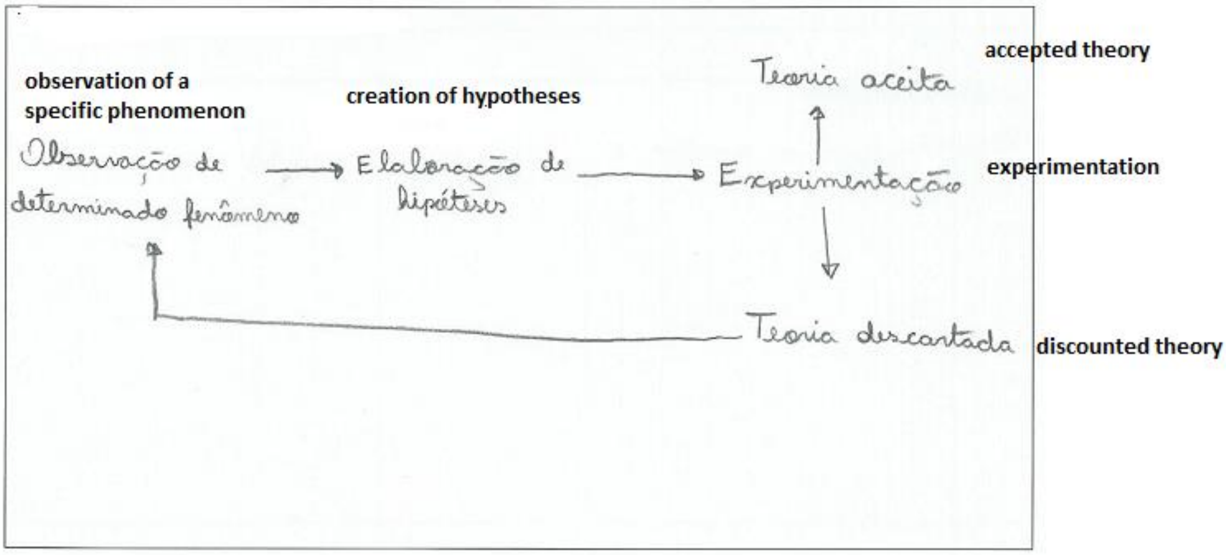

Figure 4. *Response of PST 6 about Theme 2.*

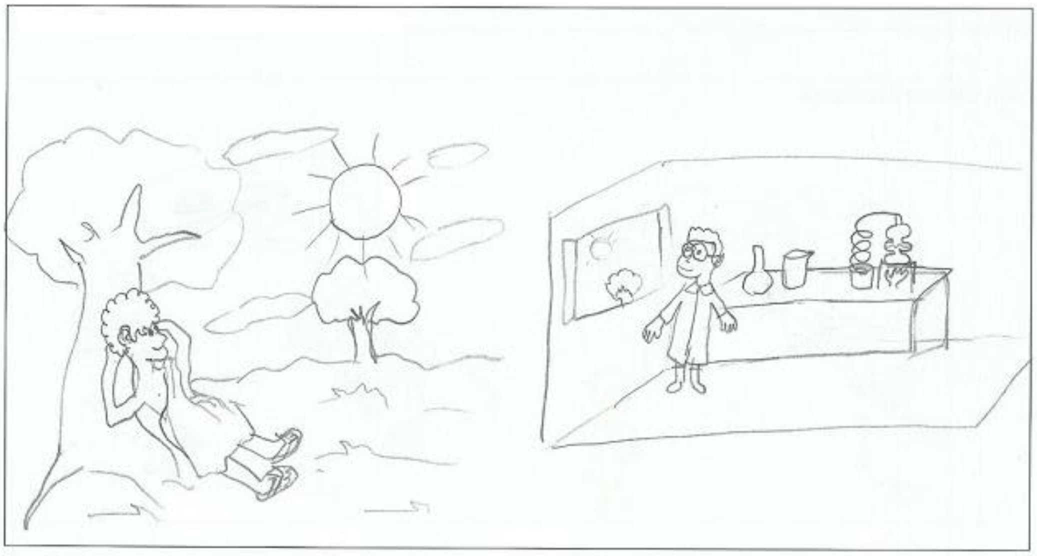

Figure 5. *Response of PST 4 about Theme 2*

This drawing (Figure 5) suggests that the environment interferes with how each human being observes science and scientific situations. When asked what the design was all about, PST 4 reported that the construction of scientific knowledge does not only take place in laboratory facilities. Also, according to PST 4, a certain phenomenon can be explained based on study and reflection.

Figure 6. *Response of PST 17 about Theme 2. Legend reads: to study, to think, to observe, to understand, to behold, to experience, to dedicate, not give up, to respect, to rethink, to be resilient, to dare, to make a mistake, to make a mistake again, to make connections, to pay attention, to make it right, and to have a breakthrough.*

Moreover, the response of PST 17 (Figure 6) expresses the idea of scientists as human beings, subject to making mistakes. It also points out the resilience needed to find ways to understand a certain phenomenon. When asked what the design was all about, PST 17 reported that scientific work is full of mistakes, which are not "bad" but rather "necessary" to obtain the scientific knowledge we currently have. Furthermore, many scientific theories dating from other periods in history were discredited, probably due to the "poor" technology available in such periods.

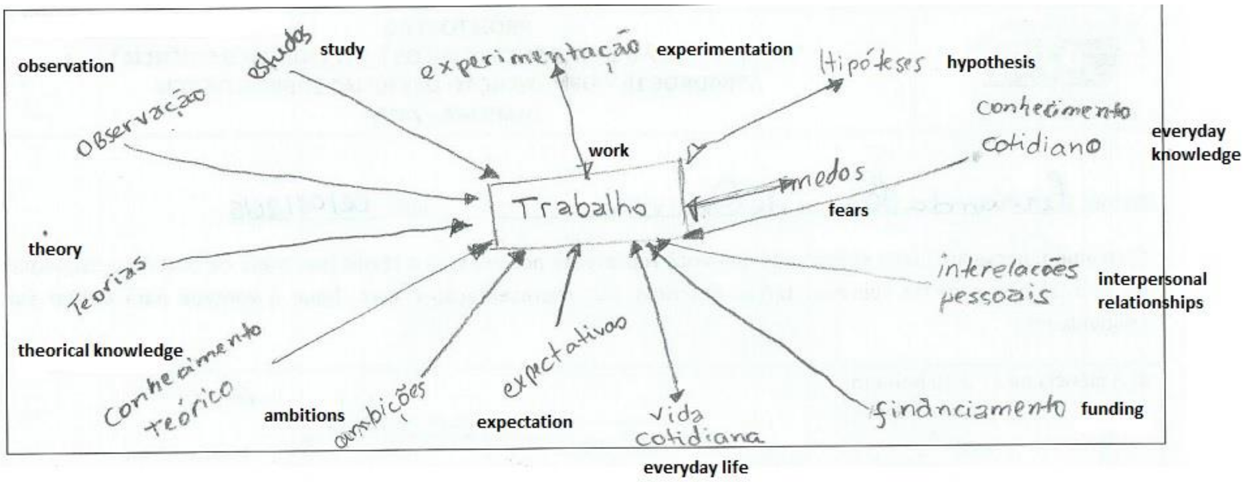

Figure 7. *Response of PST 9 about Theme 3.*

Based upon the illustrated response seen in Figure 7, PST 9 shows the influence of the social environment on the work of scientists, showing important factors that exert this influence, such as the study, theories, expectations, and personal and interpersonal relations as well as research funding, which play an important role in the continuity of scientific work. Vázquez et al. (2007) argued that science arose in society and scientists share uses, values and established interpersonal relationships with each other. In this sense, science is a human enterprise. This issues can be discussed from the contributions of history and the sociology of science.

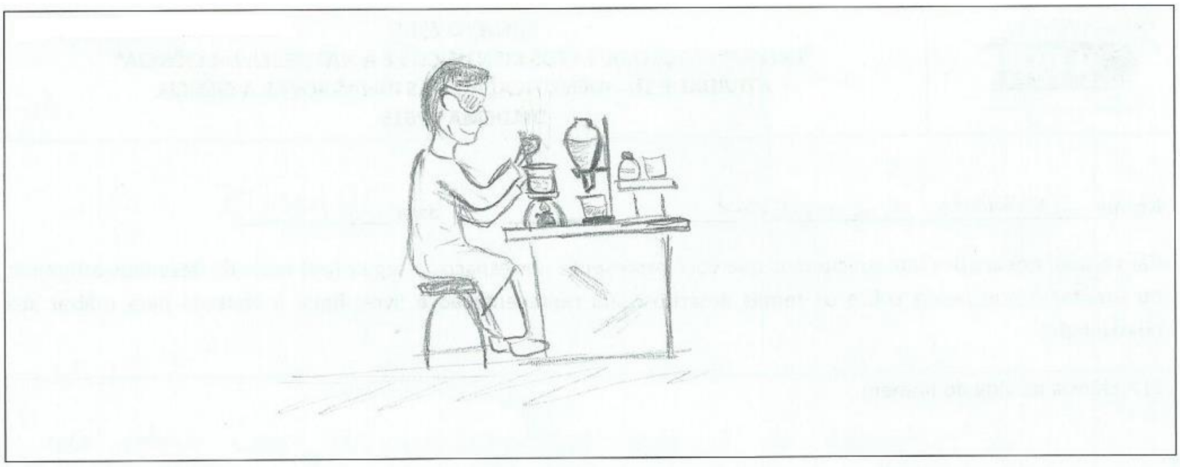

Figure 8. *Response of PST 16 about Theme 3*

The response shown in Figure 8 suggests that the work of scientists takes place within laboratory facilities. This kind of representation is quite common in other studies dealing with the same subject, such as Kosminsky and Giordan (2002) and Zanon and Machado (2013). Similar designs also appear in other parts of the world, such as the study of pre-service Israeli teachers by Koren and Bar (2009), in which data collection for image analysis of PSTs' views about the scientists and their scientific work are based on drawings. Likewise, in our study, scientists are generally represented within laboratories.

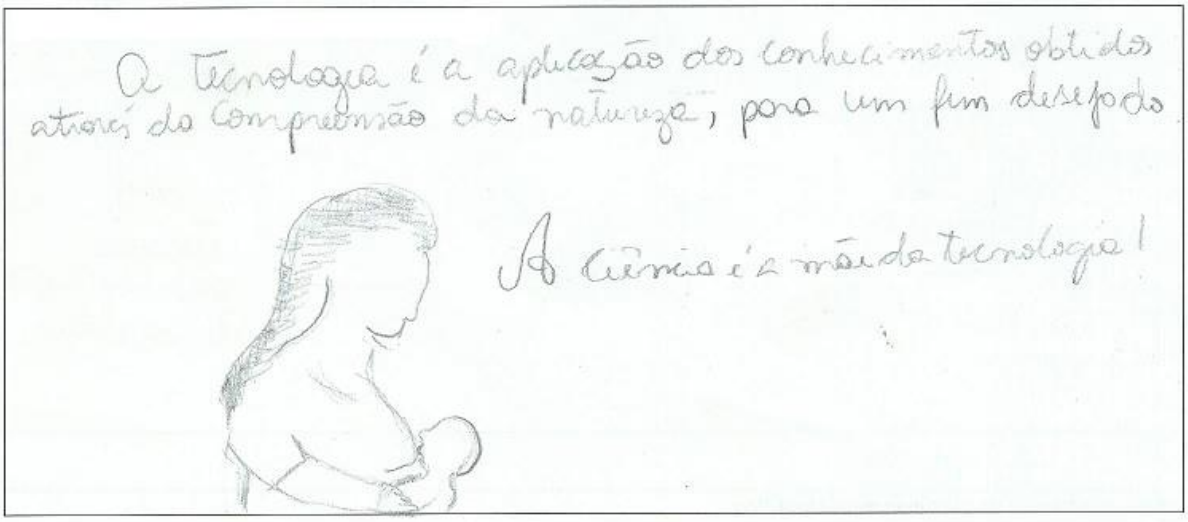

Figure 9. *Response of PST 17 about Theme 4. Legend reads: Technology is the application of knowledge obtained through the understanding of nature for the desired end-use. Science is the mother of technology!*

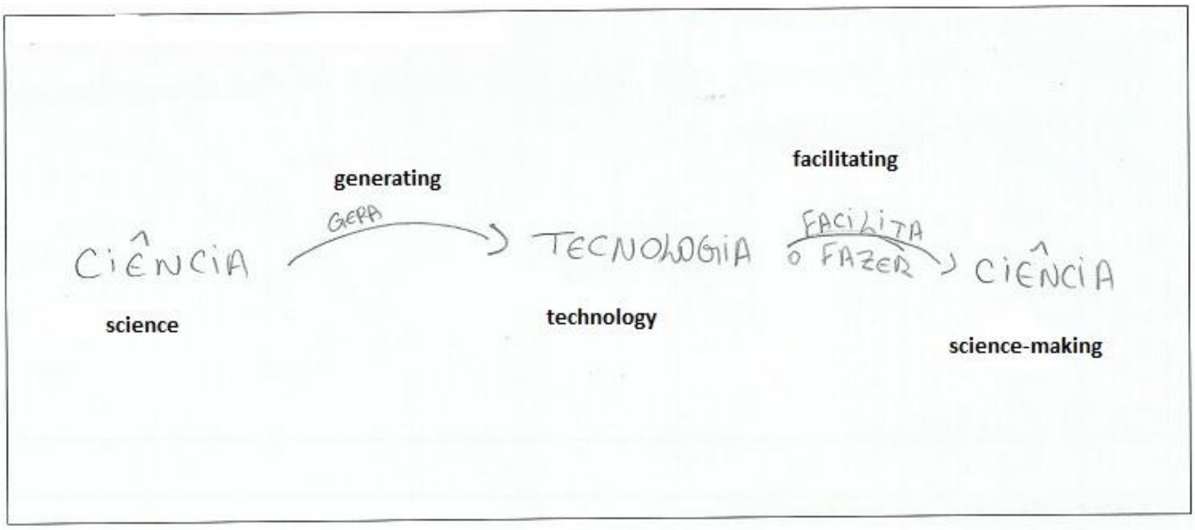

Figure 10. *Response of PST 21 about Theme 4.*

Both the responses of PST 17 (Figure 9) and PST 21 (Figure 10) suggest that technology has arisen from science. Thirteen PSTs understand that science produces technology, as technology facilitates scientific studies. In fact, this view may have been influenced by textbooks, which often feature technology as an application of the knowledge produced by science. According to Ferreira-Gáuchia, Vilches, and Gil Pérez (2012), throughout history, the advances in technology did not necessarily mean that technology had ties to science since the technology has existed for much longer than science. For instance, the Early Stone Age includes the most basic stone toolkits made by early humans, perhaps based solely on observation without any scientific knowledge. This idea rules out the concept of technology as a byproduct of science. Moreover, according to Ferreira-Gáuchia, Vilches, and Gil Pérez (2012), it is quite important that more recently, science has become dependent on technology to build its body of knowledge in such a way that we can call it "techno-science" (Ferreira-Gáuchia et al., 2012). Indeed, technology evolves and develops new tools rapidly and efficiently, whereas science uses them to build new knowledge.

Regarding Theme 5, all participants chose to respond by the written method. The frequencies shown on Table 5 indicate that more than half of the PSTs understand that science meets the needs of society. Examples of responses:

PT 12: *Science should focus on benefits for society and seek for improvements, greater good solutions, and lower social impact.*

PT 1: *Science is to serve society through discoveries and help in understanding the laws of nature*.

Again, it can be seen that science is expected to be useful for society according to the described answers. However, the essential role of science is not only to produce benefits for society but also to provide knowledge and accessible explanations for the phenomena observed by human beings. As a matter of fact, society itself is not always in complete agreement with science. Further discussions regarding this issue are required in order to facilitate the formation of pre-service teachers' pedagogical competence.

CONCLUSIONS AND SUGGESTIONS

There is no single way of thinking about science and discussion about different views on science with PSTs is important. The study of the nature of science, by means of knowledge of history, philosophy, and sociology of science, offers relevant contributions to the understanding of the construction of scientific knowledge. The activity, developed in an explicit and reflective approach, contributed to encourage reflection about this issue by the PSTs investigated.

Throughout this pedagogical activity, the 21 pre-service science teachers expressed their thoughts and views about science and its construction. At the end of the activity, the PSTs were asked to share their impressions and feelings. The group reported that the activity itself was much more difficult than answering the questions on their views about science since they had no “script” or “rule” to follow but were just told to express their thoughts, beliefs, and values regarding the five proposed themes.

On the other hand, their speeches corroborated that the activity was quite productive and successful since they were able to show their views in several different ways besides simply writing, which will certainly aid these PSTs in their classroom practices. Our findings suggest that the PSTs made an effort to organize their thoughts and views about the nature of science, which promoted a meta-reflection on their own ideas about such issues. Consequently, the activity showed an explicit and reflective approach as discussed in the methodology.

It is important to mention that there was no interference of any kind by the researchers while the activity was carried out. The answers to the questions expressed the initial ideas of the PSTs and were an important model of their views about science. This was not the only tool used to understand the views of the pre-service teachers, but from it, important points have arisen for the next steps of the study. Activities such as this may promote opportunities for reflection on the issues involving the nature of science and can be used for debates and discussions within basic-education teacher training.

Finally, our results showed the ongoing need for further studies and activities, such as the proposed herewith, within natural science graduation courses, based upon the engagement of the PSTs who performed the activity. As it is an important field of research, we suggest the establishment of study groups within universities for discussions about the nature of science in order to enhance pre-service teachers` training as well as in-service teachers' continuous formation.

ACKNOWLEDGEMENTS

The authors wish to thank the pre-service science teachers from the Federal University of São Paulo - Diadema who participated in the study and also acknowledge "Projeto Zero," which has encouraged this research (http://www.projetozero.com).

REFERENCES

Abd-El-Khalick, F. (2001). Embedding nature of science instruction in preservice elementary science courses: Abandoning scientism, but... *Journal of Science Teacher Education, 12*(3), 215-233.

Abd-El-Khalick, F., & Akerson, V. L. (2004). Learning about the nature of science as conceptual change: Factors that mediate the development of pre-service elementary teachers'views of the nature of science. *Science Education, 88*, 785–810.

Abd-El-Khalick, F., & Akerson, V. L. (2009). The influence of metacognitive training on preservice elementary teachers' conceptions of nature of science. *International Journal of Science Education, 31*(16), 2161-2184.

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of the nature of science: A critical review of the literature. *International Journal of Science Education, 22*(7), 665-701.

Acevedo Díaz, J. A. (2009). Enfoques explícitos versus implícitos en la enseñanza de la naturaleza de la ciencia [Explicit *versus* implicit approaches in nature of science teaching]. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 6*(3), 355-386.

Acevedo Díaz, J. A. (2010). Formación del profesorado de ciencias Y enseñanza de la naturaleza de la ciencia [Science teachers training and nature of science teaching]. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 7*(3), 653-660.

Almeida, A. V., & Farias, C. R. O. (2011). A natureza da ciência na formação de professores: Reflexões a partir de um curso de licenciatura em ciências biológicas [The nature of science in teacher education: Reflections from a course of teacher preparation in biological sciences]. *Investigações em Ensino de Ciências*, *16*(3), 473-488.

Ferreira-Gauchía, C., Vilches, A., & Gil-Pérez, D. (2012). Concepciones Acerca de La natureza de La tecnologia y de las relaciones ciência, tecnologia, sociedad y ambiente en la educacion tecnológica [Conceptions about the nature of technology and science, technology and society relationships and environment in technological education]. *Enseñanza de las ciências***,** *30*(2), 197-218.

Harres, J. B. S. (1999). Uma revisão de pesquisas nas concepções de professores sobre a natureza da ciência e suas implicações para o ensino [A review of research on teacher's conceptions about the nature of science and their implications for teaching]. *Investigações em Ensino de Ciências*, *4*(3), 197-211.

Irez, S., & Çakir, M. (2006). Critical reflective approach to teach the nature of science: A rationale and review of strategies. *Journal of Turkish Science Education, 3*(2), 7-23.

Koren, P., & Bar, V. (2009). Perception of the image of scientist by Israeli student teachers from two distinct communities in Israel: Arabs and Jews. *Eurasia Journal of mathematics, science e technology education, 5*(4), 347-356.

Kosminsky, L., & Giordan, M. (2002). Visões de ciências e sobre cientista entre estudantes de ensino médio [Visions of science and scientists among high school students]. *Química Nova na Escola*, *15*, 11-18.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331- 359.

Lederman, N. G. (2004). Syntax of nature of science within inquiry and science instruction. In L. B. Flick & N. G. Lederman (Eds.), *Scientific inquiry and nature of science* (pp. 301–317). Dordrecht: Kluwer Academic.

Lederman, N. G. (2006). Research on nature of science: Reflections on the past, anticipations of the future. *Asia-Pacific Forum on Science Learning and Teaching*, *7*(1). Retrieved from http://www.ied.edu.hk/apfslt/

Lederman, N. G. (2007). Nature of science: Past, present and future. In S. K. Abel & N.G. Lederman (Eds.), *Handbook of research on science education* (pp. 831-879). Mahwah, New Jersey: Lawrence Erlbaum Publishers.

Lederman, N. G., Schwartz, R. S., Abd-El-Khalick, F., & Bell, R. L. (2001). Preservice teachers' understanding and teaching of the nature of science: an intervention study. *The Canadian Journal of Science, Mathematics and Technology Education*, *1*(2), 135-190.

Matthews, M. R. (1995). História, filosofia e ensino de ciências: a atual tendência de reaproximação [History, philosophy, and science teaching: The present rapprochement]. *Caderno Catarinense de Ensino de Física*, *12*(3), 164-214.

McComas, W., Clough, M., & Almazroa, H. (1998). The role and character of the nature of science. In W. F. McComas (Ed.). *The nature of science in science education* (pp. 3-39), Netherlands: Kluwer Academic Publishers.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What "ideas-about-science" should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching***,** *40*, 692–720.

Rubba, P. A., & Harkness, W. L. (1993). Examination of pre-service and in-service secondary science teachers' beliefs about science-technology-society interactions. *Science Education*, *77*(4), 407-431.

Sarieddine, D., & Boujaoude, S. (2014). Influence of teacher's conceptions of the nature of science on classroom practice. *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(2), 135-151.

Sevim, S., & Pekbay, C. A. (2012). A study toward teaching the nature of science to pre-service teachers. *Journal of Turkish Science Education*, *9*(3), 207-227.

Tobaldini, B. G., Castro, L. P. V., Della Justina, A., & Meglhioratti, F. A. (2011). Aspectos sobre a natureza da ciência apresentados por alunos e professores de licenciatura em ciências biológicas [Aspects over the nature of science presented by teaching graduation course of biological sciences]. *Revista Electrónica de Enseñanza de las Ciencias*, *10* (3), 457-480.

Torres, J., Moutinho, S., & Vasconcelos, C. (2015). Nature of science, scientific and geoscience models: Examining students' and teachers' views. *Journal of Turkish Science Education*, *12*(4), 3-21.

Vázquez-Alonso, A., Manassero-Mas, M. A., Acevedo, J. A., & Acevedo, P. (2007). Consensos sobre la naturaleza de la ciencia: La comunidad tecnocientífica [Consensus on the nature of science: The techno-scientific community]. *Revista Electrónica de Enseñanza de las Ciencias*, *6*(2), 331-363.

Vázquez-Alonso, A., Manassero-Mas, M. A., Acevedo, J. A., & Acevedo, P. (2008). Consensos sobre a natureza da ciência: A ciência e a tecnologia na sociedade [Consensus about the nature of science: Science and technology in society]. *Química Nova na Escola*, *27*, 34-49.

Wellington, J., & Lakin, S. (1994). Who will teach the "nature of science"? Teacher's views of science and their implications for science education. *International Journal of Science Education*, *16*(2), 175-190.

Zanon, D. A. V., & Machado, A. T. (2013). A visão do cotidiano de um cientista retratada por estudantes iniciantes de licenciatura em química. [The daily view of a scientist portrayed by undergraduate students in chemistry beginners]. *Ciências & Cognição*, *18*(1), 46-56. Retrieved from <http://www.cienciasecognicao.org/revista/index.php/cec/article/view/783/pdf>