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CHANGES IN THE CONCEPTION OF SCIENCE IN THE INITIAL TRAINING OF BIOLOGY TEACHERS

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Abstract: Based on activities developed by students of the Biological Sciences Degree course, the transformations in the conceptions of science were analyzed, establishing as a reference the beginning of the third and sixth semesters of the course. Gathering images produced by students about what came to mind when they heard the word "Science" in both semesters, and the answers to the question "What do you think changed in your conception of science throughout the degree course?", the authors identified transformations and permanence. For example, in the third semester, Student 1 exhibited a simplistic view of science, decontextualizing it from its social reality, however, in the sixth semester, this view appeared to have been completely reversed, evidencing a transformation in her conception of science. Therefore, it was possible to conclude that there were fundamental changes, but that there are still signs of disciplinary fragmentation in the students' conceptions.
Keywords: conception of science, initial teacher training, image interpretation, biology teacher training.
Objective: Identify and analyze changes in conceptions of science in the initial training of teachers in a Biological Sciences course.

INTRODUCTION

Science is commonly conceived as a body of objective knowledge, a scope of discoveries and superior in relation to other forms of knowledge (LEWONTIN, 2000; MORIN, 2005). The scientist himself tends, although recognizing the harmful or deadly aspects of the powers created by scientific activity, to look at Science as pure, noble and disinterested; it fragments Science in its own conception and diverts its intentions to hold politics and society responsible, as perverting its use (MORIN, 2005).

Elitism is another element present in the common sense about Science. For Briccia (2013), understanding the area as destined for crazy geniuses, who work in isolation, makes it difficult for students to win, as they do not see themselves as interested or capable of producing scientific knowledge. Teachers present scientific work as rigid, objective, finished, mechanical and reducible to memorizable statements, belittling its construction processes (BRICCIA, 2013).

According to Cachapuz et al. (2005), presenting and transmitting knowledge as finalized implies ignoring the problems that generate explanations, in addition to the difficulties, limitations and the path taken to reach them. It even closes itself off from the possibility of new developments that question current scientific knowledge and place it in contradiction. It is important to break with the idea of Science as problematic because, as Bachelard (1967) states, for the scientific mind, all knowledge is an answer to a question; nothing is given, everything is constructed. This includes generative problems, which do not arise by themselves, but must be formulated by the scientist. The problems that guide investigations often come from (historical) human needs, such as solving previous technological problems (CACHAPUZ et al., 2005). For this reason, the unproblematic and ahistorical view of Science is particularly simplistic, as it ignores the relationships between science-technology-society, and distorted, as it disregards the crises and non-linearities of scientific development (Id, Ibid.). Another factor that contributes to this neglect of its different contexts is its fragmentation, which is very present in empiricist epistemology (SILVA, 2013).

Science is a social institution, a human productive activity and inseparable from the political and economic forces that govern our society (LEWONTIN, 2000). This is because, at the same time as it is historically

contextualized, permeated by individual and collective interests and guided by assumptions that influence the observer, the contributions of Science are always appropriated by the dominant social and economic forces in society (BRICCIA, 2013; LEWONTIN, 2000).

The subjective character of Science cannot be ignored either. The impression that an observer has of an object depends on their past experiences, knowledge and expectations (CHALMERS, 1993), that is, perception and knowledge dialogue and constantly feed each other (NAJMANOVICH, 2001). When proposing an explanation, the observer uses a theoretical language, whose precision and conceptual clarity determine the precision and clarity of that explanation (CHALMERS, 1993). This is why it can be said that theories precede observation. The visual experience depends on the perspective of the person looking, and assuming that there is a privileged perspective is, according to Najmanovich (2001), absurd.

Even though Science is not the only way to know the world, scientific literacy is relevant because it provides the development of intellectual tools that guide the resolution of everyday situations and the formation of critical citizens capable of taking a position on the dilemmas of Science (SCARPA; SASSERSON; SILVA, 2017). Engaged in scientific literacy, society can participate in the development of public policies involving science, technology and paying attention to their impacts (KRASILCHIK; MARANDINO, 2007).

Science cannot be conceived as an accumulation of truths, but must be understood as a field of dialogued opposition of theories and explanatory principles (MORIN, 2005). It is, first of all, a cognitive domain, that is, a domain of actions that an observer/community of observers use, based on a validation criterion, to accept their actions as valid (MATURANA, 2001). It is the acceptability criterion itself that defines and delimits the domain, separating its actions from any other actions (Id, Ibid.). Therefore, science is seen as a domain composed of observers, who generate explanations about the world and who determine a particular criterion of coherence to validate their explanations as scientific (MATURANA, 2001; MORIN, 2005).

According to Hodson (1982), several philosophers endeavored to define a particular method for Science, without there being a consensus. This way, there would not be a single method, but a diversity of scientific methods throughout history, which would adjust to the situation of the time. For Santos (2003), the complexity of "truth" requires methodological pluralism, which combines, for example, quantitative and qualitative methods.

The scientific method is not a pre-determined sequence of steps, through which the scientist observes and tests his object of study, producing exact results, according to a conception widespread among science teachers (CACHAPUZ et al., 2005). It can be stated, however, that a reformulation needs to go through a collective stage, where it is subjected to criticism and/or testing by the scientific community, so that it can be admitted (not permanently) into the body of scientific knowledge (HODSON, 1982). It is this dialogue with the community and in the field of empirical verification with the world of phenomena that moves Science away from a simple social "ideology" (MORIN, 2005). The collective becomes important for this validation when it is accepted that the behavioral phenomenology of a group surpasses the sum of the individual behaviors of the beings that configure it (COLOM, 2004).

Currently, there are diverse conceptions

of Science that circulate in society and in educational institutions. According to Nóvoa (2022), the current school crisis is thought of by basically two trends. The first is based on privatization and individualization, proposing the expansion of home education, the economic privatization of the educational field and devaluing the collective meaning of school. The second trend, on the other hand, values public commitment to Education, but is faced with the need to refound the school model, that is, rebuild the work community without devaluing diversity (NÓVOA, 2022). To avoid the devaluation of teaching as a profession, understanding that it is not enough to know the subject to teach, the second trend seeks to renew the field of teacher training while valuing the initial and continued training dimensions (Id, Ibid.).

The renewal of teacher training needs to mobilize knowledge relating to the scientific contents of the subjects, as well as scientific knowledge in Education. However, this knowledge is only sufficient to train teachers if they establish a close relationship with their knowledge and their professional culture (NÓVOA, 2022). Hence the relevance of investigating, in the training of Biology teachers, the predominant conceptions, considering that the teacher has a role in the formation of students' conceptions about the nature of Science (CANAVARRO, 2000). According to Canavarro (2000), the most common conception among teachers is close to authoritarian absolutism, linked to behaviorism, the frequent use of manuals and the appreciation for mechanical memorization.

Images can be an important tool in identifying these conceptions of Science. For Souza (2014), images have been considered as accompanying verbal language resources and simply motivating learning, being placed in the background and having their pedagogical potential ignored. Images are polysemic and, just like written text, they can transmit values, ideas, concepts and messages, configuring themselves as interpretations of reality (SOUZA, 2014).

The visual message communicated by an image, as it is composed of different types of signs, configures it as a language, a communication tool between people (JOLY, 2012). But images are not restricted to establishing interpersonal relationships; They are, moreover, a form of intercession between the individual and the world itself and an instrument of knowledge (Id, Ibid.). According to Joly (2012), using images as an analytical tool requires understanding the function of the message they transmit, the expectations of reception and the context of their production.

METHOD

COLLECTION OF THE MATERIAL THAT WAS ANALYZED

The data for this research were obtained from classes in the Science Teaching Methodology I and II (MEC I and II) course of the third and fourth semesters of the undergraduate degree in biological sciences. In the first part of this subject (MEC I), teacher A asked the students to draw the first thing they think of when they hear the word "science" and, in class, the works were presented and all the students discussed their views on science and of scientists present in the drawings. Over the two semesters, the concepts of science present in society were discussed and whether or not these views correspond to scientific practice.

In the fifth and sixth semesters, students take the subjects Biology Teaching Methodology I and II (MEB I and II), in which, in addition to discussing the different conceptions of science, students also discuss

the definition of science itself, and the importance of this discussion in the training of science and biology teachers. In the first MEB II class, teacher B sent the activities (eleven in total) carried out during the MEB I subject with all the feedback and revisions that the students had the opportunity to make, in this file, in addition to other questions about the subject which will not be used in this article, the questions were asked: "What do you think has changed in your conception of science throughout your degree course?

Explain your answer considering the path of your learning." and "If you had to draw a new picture today, what would it be?"

For the analysis, drawings made by two classes of the undergraduate course in the MEC I discipline, the drawings of the same students carried out in the MEB II discipline after three semesters of the course and the answers to question 1 were gathered.

MATERIAL ANALYSIS

After gathering the drawings and answers and organizing them in a table, a comparison was made between the two drawings of each student. The images were analyzed according to the conceptions of science presented in the theoretical framework, which are a simplistic, fragmented, rigid, unproblematic and ahistorical vision, as opposed to a vision of science influenced by social and economic, subjective and collective forces. Furthermore, each student's current drawing was compared with the answer to question 1, and the agreements and inconsistencies between the answer and each student's drawing were highlighted.

DATA ANALYSIS

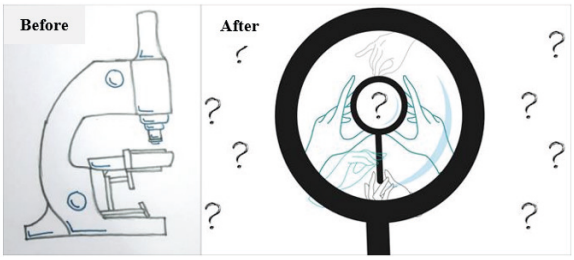


Figure 1. Representations of Student 1 (1º Semester/22). *My conception was changed by three very significant events: the debate on the subject in the undergraduate courses, the execution of my semester internships and the elaboration of my scientific initiation. Developing my own research project, I experienced some of the flexibility of the scientific method, which goes against the vision of rigid Science.*

> There is no need for a laboratory at your disposal to carry out quality research and having a laboratory at your disposal also does not guarantee that it will be. Through discussions in the degree subjects, I understood that the construction of scientific knowledge is guided by paradigms that influence the observation and interpretation of a certain phenomenon, which goes against the ahistorical view of investigations. The assertiveness of the new findings had also been criticized, determining that scientific knowledge is open, subject to changes and reformulations. The analysis of the episodes described during the internships allowed awareness about the current fragmentation of Science into multiple subjects that are rarely discussed, and which become increasingly specific and displaced as we advance in the academic training process. Briccia's (2004) phrase becomes true: "Science is, therefore, an interpretation of man, who interprets the world from his perspective" (p.38).

Analysis: In the first representation, the student illustrated science with a microscope, constituting a simplistic view, as it reduced it to an instrument. It can be said that this "reduction" disregards the complexity of scientific construction and,

considering students who have no contact with microscopes, the idea that they are capable of producing science can be removed from their reality (BRICCIA, 2013). In the second representation, there is a magnifying glass, hands and question marks. The hands can refer to the idea of science as a social construction, with several explanations for the same question, which can be explained by the magnifying glass, breaking with the perspective of unproblematic Science and reaffirming the idea that "nothing is given, everything is constructed", with all knowledge being an answer to a question (BACHELARD, 1967). Furthermore, the collective is important for validating this response, as it is accepted that the behavioral phenomenology of a group surpasses the sum of the individual behaviors of the beings that configure it (COLOM, 2004). The student cites Briccia (2004), who defines science as an interpretation of man, completing the student's second representation, which illustrates the scientist's role of interpretation and investigation.

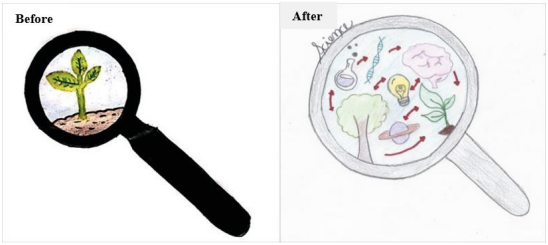


Figure 2. Representations of Student 2 (1st Semester/22). *In my view, I continue to see science as interdependent on several factors related to the environment, just as I outlined. What I learned during the course is that it is much more complex than I thought, as millions of "webs of relationships" can be linked to the conception of science.*

Analysis: In both representations of the student there is a magnifying glass. This can represent doubt, investigation and interpretation. In the first drawing, the magnifying glass shows the image of a plant sprouting from the ground, while in the second the magnifying glass shows several typical representations of biological sciences interconnected by arrows. We can see the drawing of a DNA molecule, a volumetric flask, a brain and a light bulb, which can represent the world of ideas, the planet Saturn, which can represent the universe, a tree and a sapling, which can represent botany and life. All of these drawings are linked to planet Earth, which is at the center of the drawing, implying that science is the study of nature, of life. These connections between the drawings do justice to the student's speech and, from this, it is possible to interpret that there was a change in the student's conception of science, who sought to bring in his second drawing a web of relationships, which, although seeking to interconnect several areas of biology, is considerably simplistic, as it ignores the relationships that exist between science, technology and society in general (CACHAPUZ, et al. 2005). In other words, in the same way that in his first drawing he represented a restricted area of biology, in the second he represented several areas interconnected by arrows, but concomitantly fragmented.

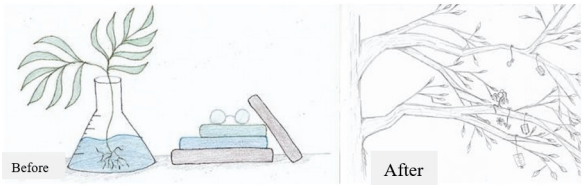


Figure 3. Representations of Student 4 (2nd Semester/22). *What changed most in relation to the beginning of the course was my way of seeing the way research is done, not being more separated from the object of study. Furthermore, today I criticize the idea of discovery, so I no longer see the scientist as the one who discovers how the world is made, but rather as the one who interprets and gives explanations based on observation of what is around him and what he learned during your life.*

Analysis: In the first drawing, the student illustrated an Erlenmeyer flask with water and a plant, next to a stack of books with glasses on top. In his speech, the student reports that at the beginning of the course he saw the scientist as "the one who discovers how the world is made", which is related to his first drawing, as it brings items related to the scientist as a person who has a lot of intelligence and that discovers things, which makes it difficult to approach students, who do not see themselves as capable of producing scientific knowledge (BRICCIA, 2013). His conception of science can be framed within the empiricist view, as he believes that knowledge is acquired from experiences, and having the scientist as the one who "discovers" things, when, in reality, there is a subjective character to be considered in every way. any scientific activity, because by separating the observed research object from its observing subject, the social and historical character of the scientist is excluded (CHALMERS, 1993; SILVA, 2013; NAJMANOVICH, 2001).

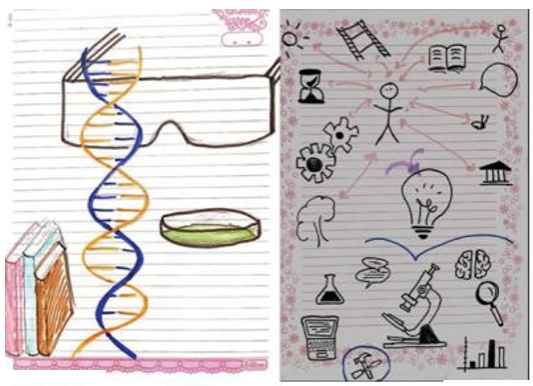
In her second drawing, the student drew a tree trunk, which gave rise to several branches. On one of the branches, there is a person sitting, observing what is around him. The person has hair made from leaves, which can be interpreted as if they were also part of the tree. It is also possible to notice items hanging from the branches, such as a potted plant, notes, and something that appears to be a volumetric balloon. The student presents in her speech that she currently sees the scientist as the one who interprets and gives explanations based on her observations and knowledge learned throughout her life, and this explanation is related to what is observed in the second drawing, in which a person observes the nature while also being part of what he observes. This way, it appears to have developed a less simplistic conception, considering the relationships between science and society, without disjunction of the scientific object from its scientific subject (CHALMERS, 1993; CACHAPUZ et al., 2005).

Figure 4. Representations of Student 5 (2nd Semester/22).

> I believe that my conception of science has not changed completely, but rather has become more complex. At the beginning of the course, science for me was the study of nature and its phenomena based on human observation, with the aim of clarifying doubts, proposing the truth.
>
> Currently, I believe that science is a human activity, which has research as its basic principle, but which does not correspond to an absolute truth, as knowledge is changeable. Furthermore, it is made by combining the knowledge of several people.

Analysis: In her first representation of what she defines as science, the student illustrated a microscope containing several items related to biological sciences. This representation, by using a microscope, could indicate a simplistic view, by relating scientific work to an instrument, but when adding several items, the interpretation changes. It is possible to consider the drawing as a representation of several areas of science, within an item that usually defines the scientist. In his explanation, the student says that he did not change his conception of science, but made it more complex. Before, he saw science as the study of nature based on human observation, in search of truth. This can relate to the first drawing as it features a microscope as the focus of the drawing, representing observation and

investigation. Afterwards, the student began to see science as a human activity, but one that does not represent the truth, as knowledge is changeable and constructed together. In his second drawing, we can see something that matches this speech, when observing the atomic models, for example, we can understand the ability to mutate knowledge, commented by the student in his speech. The construction of knowledge together is also observed in the drawing, as we see people working together: we see a boy on top of a stack of books, a boy and a woman taking notes on a board and a woman with a magnifying glass in front of a representation of a DNA molecule. This representation of the collective breaks with the view of the isolated scientist (BRICCIA, 2013), in addition to representing that the conduct of a group exceeds the sum of the individual conduct of the beings that configure it (COLOM, 2004).



Before **After**

Figure 5 Representations of Student 7 (2nd Semester /22). *It has changed in MANY aspects. Before the course, I didn't have a very well-defined conception of Science. He knew that it was an area of knowledge that dealt with the study of nature. He immediately thought of experiments in the laboratory, cells, DNA, etc. But he didn't think much about the way science was practiced, about how it is a product of human activity, how it reflects the social, economic, political, historical and individual aspects of the context in which it is produced...*

Analysis: In her speech, the student says that at the beginning of the course she did not have a defined vision of what is considered science, which is related to her first drawing, where we see items related to the scientist stereotype: books, which can be related to the image of scientist as someone intelligent, a petri dish, a DNA molecule and protective glasses, which can relate to the idea of a scientist as someone who works inside laboratories and discovers things, which demonstrates the elitist idea that science it is restricted and isolated (BRICCIA, 2013). However, she reports that she began to see science as a product of human activity, reflecting social, economic, political, historical and individual aspects of the context in which it is produced. This change can be observed in his second drawing, in which a human being and his relationships are observed, which can be interpreted as follows: the relationship between the human being and nature, represented by the drawing of the tree and the insect; the relationship between human beings and the universe, represented by the sun; the relationship between human beings and art, represented by photographic film and the museum; the relationship between human beings and the community and movement, represented by gears; the effect of time on human beings and their relationships, represented by an hourglass; the relationship between human beings and other human beings and the way in which interaction occurs, represented by the drawing of another person and speech balloons and the relationship between human beings and study and research, represented by the book. These relationships between the items and the human being are indicated by double-headed arrows, which indicates that there is an exchange in that relationship. From this, we have the idea that Science is a human activity inseparable from the political and economic forces that govern

our society, highlighting the relationships between science, technology and society, scientific development, which is non-linear (CACHAPUZ, et al. 2005; LEWONTIN, 2000). This individual illustrated by the student, within all his relationships, originates a lamp, which can represent ideas and thoughts. The lamp covers various items related to science and research. In addition, speech bubbles are also observed, which indicate the interaction, again. This way, the student's speech and his representation of what he defines as science are related and complement each other.

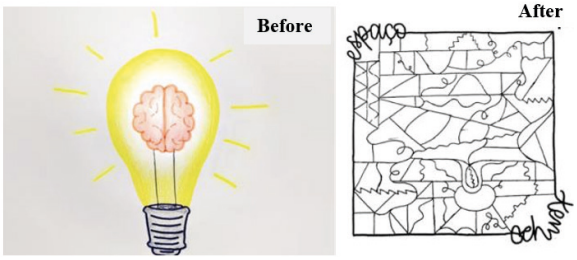


Figure 6. Representations of Student 8 (2nd Semester/22). A lot has changed, today I see science as something broader and more moldable, like modeling clay in the construction process. Something that hasn't changed is the difficulty in defining what science is. It is philosophical and complex.

Analysis: In her first drawing, the student illustrated a light bulb with a brain in the center, as the energy that makes the light bulb work. The structure of the lamp is commonly associated with ideas and thoughts, which are often brilliant and extraordinary. This representation can be related to the view of science as something about extremely intelligent people, fantastic minds that make discoveries (BRICCIA, 2013). In his speech, the student reports that he started to see science as something broad and moldable, like modeling clay, which may sound like the idea of putting science into a mold, and also that it is in constant transformation, being modified by those who make it, in a way that highlights science as a construction (BRICCIA, 2013; BACHELARD, 1967). The student also reports that there are difficulties in defining what science is, as it is something philosophical and complex. In his second drawing, it is observed that the student tried to represent what he said, since the drawing brings this philosophy and complexity. There is a square with several lines inside, which intersect and complete each other: crooked, straight, horizontal, vertical, diagonal, circular, zigzag, interlaced and irregular lines. In the corners of the square, the words "space" and "time" are written, which could represent that all these lines are within the immensity of space and time. The lines can represent areas of science, people, relationships, interactions, moments in society, ups and downs, among many other things, which becomes complex, as the student herself states, as it is difficult to define.

CONCLUSION

The analysis of the images and responses produced by the students revealed that many aspects of their conceptions were transformed. In some cases, however, students remained attached to the view of science as discovery, associated with a closed and objective method, even though they had come to understand teaching as something different from the mechanical transmission of knowledge. A clearer change was observed in the students' written responses than in the drawings (which were often inconsistent), where they referred to science as historical and subjective.

Furthermore, it was possible to notice during the analysis of the images that all the drawings present representations focused only on biological sciences, with no representations linked to other areas, such as human sciences. This is probably due to the fact that the drawings were made only by biology students and, due to disciplinary fragmentation,

students still present a fragmented vision, only having their area of expertise in mind when thinking about the term "science".

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REFERENCES

BACHELARD, G. La notion d'obstacle épistémologique. Em: **La formation de l'espirit scientifique**. Paris: Librarie philosophique J. Vrin, 1967. p. 15–26.

BRICCIA, V. Sobre a natureza da Ciência e o ensino. Em: **Ensino de Ciências por investigação: Condições para implementação em sala de aula**. 1ª ed. São Paulo: Cengage Learning, 2013. p. 111–128.

CACHAPUZ, A. C. et al. Superação das visões deformadas da ciência e da tecnologia: Um requisito essencial para a renovação da educação científica. Em: **A Necessária Renovação do Ensino das Ciências.** São Paulo: Cortez Editora, 2005. p. 37–70.

CANAVARRO, J. M. Avaliação das concepções de professores e alunos acerca da natureza da ciência. Em: **O que se pensa sobre a ciência**. Coimbra: Quarteto Editora, 2000. p. 19–80.

CHALMERS, A. F. A dependência que a observação tem da teoria. Em: **O que é ciência afinal?** São Paulo: editora brasiliense, 1993. p. 46–63.

COLOM, A. J. A teoria do caos ou a desconstrução da teoria. Em: **A (des)construção do conhecimento pedagógico novas perspectivas para a educação**. Porto Alegre: Artmed, 2004. p. 89–129.

HODSON, D. Existe um método científico? **Education in Chemistry,** v. 19, p. 112–116, 1982.

JOLY, M. A análise da imagem: desafios e métodos. Em: **Introdução** à **análise da imagem**. 14. ed. Campinas: Papirus Editora, 2012. p. 41–68.

KRASILCHIK, M.; MARANDINO, M. Alfabetização Científica e Cidadania. Em: **Ensino de Ciências e Cidadania**. São Paulo: Editora Moderna, 2007. p. 11–16.

LEWONTIN, R. C. Um ceticismo racional. Em: **Biologia como Ideologia: a doutrina do DNA**. Ribeirão Preto: Funpec, 2000. p. 5–22.

MATURANA, H. Ciência e vida cotidiana. Em: **Cognição, ciência e vida cotidiana**. Belo Horizonte: UFMG, 2001. p. 125–160.

MORIN, E. Para a Ciência. Em: **Ciência com Consciência**. 8ª ed. Rio de Janeiro: Bertrand Brasil, 2005. p. 15–36.

NAJMANOVICH, D. A linguagem dos vínculos: da independência absoluta à autonomia relativa. Em: **O sujeito encarnado – questões para pesquisa no/do cotidiano**. Rio de Janeiro: DP&A, 2001. p. 65-96

NÓVOA, A. Os professores e a sua formação num tempo de metamorfose da escola. Em: **Escola e professores proteger, transformar, valorizar**. Salvador: SEC/IAT, 2022. p. 55–74.

SANTOS, B. S. Metodologia e hermenêutica II. Em: **Introdução a uma ciência pós- moderna**. 4. ed. São Paulo: graal, 2003. p. 47–120.

SCARPA, D. L.; SASSERON, L. H.; SILVA, M. B. O. Ensino por Investigação e a Argumentação em Aulas de Ciências Naturais. **Tópicos Educacionais**, v. 3, n. 1, p. 7–27, 2017.

SILVA, A. T. R. Currículo e representações sociais de homem e natureza: implicações à prática pedagógica. **Revista Brasileira de Educação**, Rio de Janeiro, v. 18, n. 55, p. 861-876, 2013.

SOUZA, L. H. P. Imagens científicas e ensino de ciências: a construção de representação simbólica a partir do referente real. Em: **Imagens na educação em ciências**. 1. ed. Rio de Janeiro: Editora Lamparina, 2014. p. 111–134.