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IDENTIFYING SCIENTIFIC PRACTICES IN A SCIENCE, TECHNOLOGY AND SOCIETY THEMED WORKSHOP

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Abstract: Recent international documents and educational standards have recommended Science Education be based on three dimensions (Scientific Practices, Crosscutting Concepts, and Disciplinary Core Ideas). This has resulted in an increased interest in research involving Scientific Practices in Science Education. The objectives of this article are to: I) Identify the scientific practices that high school students engaged in during a thematic workshop; and II) Discuss the use of thematic workshops as an approach to promote Scientific Practices. The workshop was developed based on the Science, Tecnhology and Society approach and aimed at discussing the composition, properties and effectiveness of male contraceptives. The workshop was conducted in a public school in Southern Brazil and the workshop footage and student questionnaires were analyzed according to Content Analysis. Three transcriptions of classroom situations are presented to discuss the promotion of Scientific Practices in specific classroom contexts. The analyses show that students engaged in six of the eight Scientific Practices discussed by the National Research Council. The results contribute to international discussions on Scientific Practices and discussions regarding the use of thematic workshops as an approach to promote Scientific Practices.

Keywords: Scientific Practices, Thematic Workshop, National Research Council.

1. Introduction

Scientific Practices are derived from a conceptual framework for Science Education, published in 2012 by the National Research Council (NRC), entitled: *A Framework for K-12 Science Education*: *Practices, Crosscutting Concepts, and Core Ideas*. The framework was developed from the recognition that there was a need for strengthening national science education documents and that research on science learning and teaching could inform further discussion of the standards for science education (NRC, 2012).

The NRC presents some gaps found in science education in the United States such as: 1) There is no organization to teach science throughout the school years; 2) The emphasis is on accounting for the length of content, with little regard to its depth; and 3) Students are not provided with opportunities to get engaged in science and experience how science is done. These difficulties do not seem far from the challenges faced in the Brazilian context, as pointed out by several authors (Silva, Ferreira & Viera, 2017; Moreira, 2018).

The NRC (2012) recommends that K-12 science education be built around three main dimensions: 1) Scientific and engineering practices, that mirror the activities developed by scientists and engineers to build knowledge, theories and models about the world; 2) Crosscutting concepts that unify the study of science and engineering through their common application in all fields; and 3) Disciplinary core ideas from four subject areas, which consist of specific content and thematic areas.

The relevance of this research can be justified due to the importance given to Scientific Practices in recent international educational reforms, which have advocated science teaching be based on Scientific Practices, Crosscutting Concepts and Disciplinary Core Ideas through new standards (NRC, 2012; NGSS, 2013). The *Next Generation Science Standards* (NGSS), for example, represent an interstate movement in the United States that sets new standards for Science Education, which are

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coherently organized to provide students with a scientific education with international references (NGSS, 2013). The standards follow NRC discussions (2012) and have the same three dimensions.

According to the NTSA - National Science Teaching Association, 44 states (representing 71% of US students) already have education standards influenced by the NRC (2012) and 20 states have already adopted the standards (NGSS, 2013), representing more than 35% of students of the United States. Scientific Practices have also been the focus of research in several studies not only in the United States (Osborne, 2014; Bybee, 2011; Duschl & Bybee, 2014), but also outside of the US (Prins, Bulte & Pilot, 2018; Evagorou, Erduran & Mäntylä, 2015). In fact, a review conducted by Costa (2021) has shown that research involving Scientific Practices in Science Education has been conducted by institutions in Spain, England, Brazil, Turkey, Holland, Australia, South Africa, Cyprus, Sweden, Norway, Cyprus, and Finland, characterizing Scientific Practices as a research theme with international repercussions.

Therefore the objectives of this article are to:

I) Identify the Scientific Practices that high school students engaged in during a thematic workshop.

II) Discuss the use of thematic workshops as an approach to promote Scientific Practices

2. Scientific Practices

According to the NRC (2012), Scientific Practices describe the major practices that scientists employ as they investigate and build models and theories about the world. The NRC (2012) presents and describes eight Scientific Practices in detail, which are considered essential for science learning in K-12 education, listed in Table 1.

Table 1. *Scientific Practices for Science Education*

1. Asking questions
Science starts with a question about a phenomenon, such as: "Why is the sky blue?" or “What Causes Cancer?”, and seek to develop theories that can provide explanatory answers to such questions. A basic practice of scientists is to ask questions that can be answered empirically, to establish what is already known and to determine which questions can still be answered.
2. Developing and using models
Science often involves building and using a wide variety of models and simulations to help develop explanations of natural phenomena. Models make it possible to go beyond what is observable and imagine a world that has not yet been seen.
3. Planning and carrying out investigations
Scientific research can be conducted in the field or in the laboratory. An important practice of scientists is to plan and carry out a systematic investigation, which requires the identification of what should be collected, how it should be collected, what should be treated as a dependent variable, etc. The observations and data collected from such work are used to test existing theories and explanations or to review and develop new theories and explanations.
4. Analyzing and interpreting data
Scientific investigations produce data that must be analyzed. Since the data generally does not speak for itself, scientists use a range of tools, such as - tabulation, graphical interpretation, visualization, and statistical analysis - to identify the significant characteristics and patterns in the data. Sources of error are identified and the degree of certainty is calculated. Technology makes collecting a large amount of data much easier, providing many secondary sources for analysis.
5. Using mathematics and computational thinking
Mathematics and computing are fundamental tools for representing variables and their relationships. These are used for a series of tasks, such as the construction of simulations, statistical analysis of data and the recognition of quantitative relationships. Mathematical and computational approaches allow predictions of the behavior of physical systems, along with the confirmation of such predictions. In addition, statistical techniques are invaluable in assessing the significance of patterns or correlations.
6. Constructing explanations
The goal of science is to build theories that can provide explanatory accounts of world phenomena. A theory is accepted when it proves to be superior to other explanations about the phenomena. Scientific explanations

are explicit applications of the theory to a specific situation or phenomenon. Students' goal is to build coherent and logical explanations of phenomena that incorporate their current understanding of science, or a representative model consistent with the available evidence.
7. Engaging in argument from evidence
In science, argumentation is essential to identify strengths and weaknesses in a line of reasoning and to find the best explanation for a natural phenomenon. Scientists must know how to defend their explanations, formulate evidence based on a solid database, examine their own understanding in view of the evidence and comments offered by others and collaborate with colleagues in the search for the best explanation for the phenomenon investigated.
8. Obtaining, evaluating, and communicating information
Science cannot advance if scientists are unable to communicate their findings clearly and persuasively, as well as learn about other people's results. One of the main practices of science, therefore, is the communication of ideas. This includes oral information, information in writing, in tables, diagrams, graphs and equations. Science requires the ability to derive meaning from scientific texts (from journals, the internet, conferences and lectures), in order to evaluate scientific knowledge, its validity and integrate this information.

Source: extracted and adapted from NRC (2012)

The use of Scientific Practices in science education is justified since the acquisition of skills involved in these Practices supports a better understanding of how scientific knowledge is developed (NRC, 2012). Students' engagement in Practices also involves doing science, which is a relevant aspect of science education, as it can cause peaks of curiosity, interest and motivation and allows students to realize the creativity involved in the scientist's work. The dimensions also go against the tendency to reduce Scientific Practices to a single set of procedures, which should be avoided, as this tendency only emphasizes empirical research, to the detriment of other Practices, such as modeling, critique and communication, which are taken into account in the framework.

The Practices derive from what scientists actually do as part of their work. Thus, the opportunity for students to immerse themselves in these Practices and explore why they are fundamental to science and engineering are critical movements that promote appreciation for scientists' abilities as well as the nature their work. The NRC (2012) also highlights the importance of using the eight practices iteratively and in combination, as the Practices are not considered a linear sequence of steps that should be developed in the order presented.

3. The Science, Tecnhology and Society Themed Workshop

The thematic workshop analyzed in this research was inspired by the proposals of Ferreira, Loguercio, Samrsla and Del Pino (2001) and Swiech (2016), which deal with the relevance of associating social issues with technology for the benefit of public health. This is related to the Science, Tecnhology and Society (STS) approach. For Solomon (1993), the relevance of inserting the STS movement in the educational field helps to consolidate the scientific and technological literacy of students and, consequently, of society as a whole.

In this study, the analyzed workshop was based on the STS approach and discussed the male condom as an effective contraceptive method for preventing STIs and unplanned pregnancies. The aim of the workshop was to investigate, through three experiments, chemical and physical properties of the condom, which make it an effective barrier contraceptive. These properties were elasticity, resistance and impermeability. During the workshop, chemical, social and economic aspects which were favorable to the use of the male condom were also discussed. The main idea was to discuss this contraceptive method with students and the polymer technology behind the condom within the context of Chemistry. The content addressed throughout the classes was the concept of polymers, due to the latex contained in condoms. The thematic workshop was conducted in three Chemistry lessons, totaling 150 minutes.

In the first lesson, students' previous knowledge and hypotheses were investigated, as well as, students awareness regarding condom use. In the first lesson, students' previous knowledge and hypotheses were investigated, as well as, students awareness regarding For this, students answered a Pre-Lab Questionnaire (Figure 1) in groups of three to four students.

1. Why is it important to use condoms in sexual intercourse?
2. What is a condom made of?
3. Do you think the material from which the condom is made of is responsible for its effectiveness?

Figure 1. *Pre-Lab Questionnaire*

Next, information about condoms and polymers was presented to the class by reading the text *The Chemistry Behind the Condom* (Figure 2), followed by a discussion regarding the properties of the material found in the condom, the condom's composition and its effectiveness. Finally students answered, in their groups, the question "Why are condoms so effective as barrier contraceptives?".

Recent data from the Ministry of Health indicate that 40,000 new cases of sexually transmitted diseases (STDs), such as HIV, syphilis and hepatitis, are diagnosed per year in the country. In February 2017, the Ministry of Health reported that cases of HIV and AIDS among 15-24 year-olds, had increased by 85% over the past 10 years and that in 2016, 6 out of 10 young people had unprotected sex.
The condom is a barrier contraceptive considered to be the most well known, affordable and effective method used during intercourse to decrease the likelihood of an unplanned pregnancy and the transmission of sexually transmitted infections such as HIV/AIDS, gonorrhea, HPV, herpes, chlamydia, among others.
There are two types of condoms: the male condom, which is made of latex and should be placed on the erect penis before penetration and the female condom, used internally in the vagina. Male and female condoms are distributed free of charge in any public health service and their use is free as well as a right.
Given the information presented, answer: Why are condoms so effective as barrier contraceptives?

Source: adapted from http://www.aids.gov.br/pt-br/publico-geral/prevencao-combinada/preservativo

In the second lesson, students conducted investigative experiments aimed at understanding the chemical and physical properties of condoms that make them an effective barrier contraceptive (Figure 3 and 4). The experiments were done by the students who volunteered to conduct them in front of the class, while all students wrote their observations and hypotheses for the observed phenomena, as well as filled in the tables contained in the script. The script was elaborated based on Ferreira et al. (2001).

1. Choose the brand 1 or rand 2 condom to perform the experimental tests (your group should only use this brand until the end of the lesson).
2. Unroll the condom completely and measure its fully extended length without stretching it. Write down the measured value in Table 1 in the relaxed length section.
3. Secure the condom base and stretch it from the tip as far as it will go. Measure this length and write it down in Table 1 in the extended length section.
4. Take another condom of the same brand and unroll it completely. At the laboratory sink, fill a 500mL beaker with tap water and fill the condom with water. Do not let the condom begin to expand. Write down the amount used in the initial volume column of Table 1.
5. Continue adding water to the condom, always tracking the volume being added. You will notice that the condom will expand greatly.
6. Do this until the condom breaks. Write down the maximum volume of water used in the maximum volume section.

Table 1 - Condom Physical Properties

	Mass	Relaxed length	Extended length	Initial volume	Maximum volume
Brand 1					
Brand 2					

Figure 3. *Experiment 1*

In the laboratory sink fill a plastic basin with water to half of its volume.

1. Take another condom of the same brand and unroll it completely.
2. Add 300 mL of tap water and a drop of dye to the condom.
3. Make a tight knot at the base of the condom to seal the mixture.
4. Place the condom in the water basin so that half of it is submerged (the knot should stick out of the water) and move the condom in the basin a few times. Write down your observations in Table 2.

Table 2 - Condom Impermeability

Brand	Before adding dye		After adding dye	
	Water color in basin	Water color in condom	Water color in basin	Water color in condom
Brand 1				
Brand 2				

Figure 4. *Experiment 2*

The third lesson aimed at defining the concept of polymers through the observations from the experiments done in the previous lesson; and at identifing latex as the component of condoms, responsible for their effectiveness. For this, the results of the experiments performed in the previous class were discussed and the students read a *Supporting Text* (Figure 5). The discussions arising from the phenomena observed in the previous lesson promoted the introduction of the concept of polymers; latex; and the properties of latex. Lastly, the *Post-Lab Questionnaire* (Figure 6) was distributed to be answered in groups.

Latex is a product extracted from plants, which is composed of small polymeric particles in aqueous medium, which can be natural or synthetic. In nature, latex is found as a whitish secretion produced by some plants such as poppy and the Pará rubber tree. When wounded on the stem, these plants react by producing latex, which has the function of causing the wound tissue to heal.
Latex is widely used in the industry for making condoms, gloves and surgical drapes and is a material that can cause allergic processes (contact dermatitis) of varying intensity. Its composition occurs, on average, with 35% of hydrocarbons, highlighting the 2-methyl-1,3-butadiene 1,3 (C_5H_8) commercially known as isoprene, the rubber monomer.
Latex has remarkable elastic properties: its tensile strength is greater than 30 MPa and it can be stretched up to 800% before breaking.

Figure 5. *Supporting text*

Answer the following questions justifying your ideas.

1. In the second experiment, how much water did the condom need to break? Why is this value so high compared to the initial volume?
2. What was the difference in initial and final condom measured length? Which property guarantees such a big difference?
3. What does the third dye experiment tell us about the functioning and effectiveness of condoms?
4. How important are these distinct characteristics in condom action?
5. Define the concept of Polymers and associate it with the functioning and effectiveness of the condom. Why are condoms so effective as barrier contraceptives?

Figure 6. *Post-Lab Questionnaire*

4. Research participants and data collection

Data collection was conducted in a public school in southern Brazil. The workshop was carried out by three pre-service teachers of the Pedagogical Residency Program, a government program initiated in 2018, promoted by CAPES (Higher Education Personnel Improvement Coordination), which aims to improve the initial education of pre-service teachers, creating a link between higher education institutions and schools. The structure of the thematic workshop was planned at the university and discussed at meetings with the members of the program . A class of 35 students from the first year of high school and a class of 34 students from the third year of high school were selected to compose the participants of this research. Thus, a total of 69 students participated in the workshop.

5. Methodological Procedures

This research analyzed the video recordings of the thematic workshop and the questionnaires answered by the students throughout the workshop. In analyzing the answers given to the questionnaires (Figure 1 and 6), first year student answers were coded as FQXX and third year student answers were coded as TQXX, where the first letter corresponded to the student's class (first year F and third year T) and the second letter Q corresponded to the instrument used for data collection (the questionnaires).

The process of coding the workshop footage was different, because it was not possible to identify students in relation to their names. The analysis was organized into 3 examples (EX1-EX3), which were coded as FFXX for 1st year students and TFXX for 3rd year students. The second letter F of the code corresponded to the instrument, the video footage. The last two numerical sequences of the code corresponded to the students' speeches arranged in ascending order of manifestation in the respective example. Thus, in Example 1, TF01 represents the first statement from students. When more than one student spoke out giving the same answer aloud, this was identified as "Students".

The analytical procedures were performed according to Content Analysis, as proposed by Bardin (2011), which has as one of its main intentions the inference of knowledge related to the conditions of message production. Content Analysis is considered by Bardin (2011) as a set of communication analysis techniques that aims to overcome uncertainties and enrich the reading of the collected data. Thus, Content Analysis was used in this research to identify the Scientific Practices that students engaged in during the workshop.

Content Analysis is structured in three steps: 1) Pre-analysis; 2) The exploration of the material; 3) Treatment of results, inference and interpretation. Pre-analysis is the phase of organization, with the aim of systematizing the initial ideas and making the material operational. This step consisted of reading the answers to the questionnaires and observing the footage in order to identify the Scientific Practices students engaged in. The setting of objectives also corresponded to this step.

The exploration of the material can be described as the systematic administration of the decisions made earlier. This phase consists of coding and enumeration operations based on previously formulated rules and requires a thorough study, guided by hypotheses and theoretical references. This step includes coding, classification and categorization (Bardin, 2011). Coding is a transformation such as clipping, aggregating, and enumerating to achieve a representation of the content or its expression. In this study, student answers were coded. For categorization, the NRC Scientific Practices (2012) were used as *a priori* categories in order to allocate students' statements or responses to which practice they engaged in. The allocation criteria were the descriptions of each Scientific Practice presented by the NRC (2012) and the similarity of meanings to the researchers. The categorization was performed by two researchers and to verify the reliability between evaluators, each researcher categorized documents previously categorized by the other researcher and compared the results. Therefore, each document was categorized at least twice. 81% of reliability among raters was reached and any disagreements were resolved by discussion until all researchers agreed with the categorization.

Finally, in the last step, during the treatment of results, inference and interpretation, the analyst must propose inferences and advance interpretations regarding the intended objectives (Bardin, 2011). In this study this step consisted of presenting results about the categorization and discussing the trends observed.

Therefore, this study involved three main phases. The first consisted of filming the thematic workshop, the second phase consisted of analyzing the students' statements and answers and the third phase in categorizing the identified Scientific Practices. We highlight that this research work is part of a larger project, approved by the Research Ethics Committee of the authors' Institution.

6. Results and Analyses

The Results and Analyses have been divided into two subsections, regarding the analysis of the questionnaires and the workshop footage.

6.1. Analysis of the Questionnaires

The fragmentation of students' answers to the proposed questionnaires resulted in 99 context units and 231 analysis units. We observed that the questionnaires provided students with engagement in four Scientific Practices: Planning and carrying out investigations (SP3); Analyzing and interpreting data (SP4); Constructing explanations (SP6); and Obtaining, evaluating, and communicating information (SP8). Most of the answers indicated SP8 (40%); followed by SP6 (36%); SP4 (14%) and SP3 (10%). We consider that the higher incidence of SP8 is related to the use of texts during the workshop (*The Chemistry Behind the Condom* and the *Supporting Text*).

The SP6 was also mostly in the first and third lessons, from which 91% of incidences arose. In these lessons students sought to construct explanations for the question: *Why are condoms so effective as barrier contraceptives*?; the *Pre-Lab Questionnaire*; and the *Post-Lab Questionnaire*. We observed that the incidences of SP6 identified in the second class were related to explanations about the phenomena observed in the experiments, from which students justified properties such as resistance, impermeability and elasticity of the male condom according to the results of the experiments.

SP4 was identified only in the second and third lessons. 63% of incidences came from the second lesson and 37% from the third class. In the second lesson many students interpreted the results of the experiments and associated them with the properties of the male condom, such as resistance, impermeability and elasticity. In the third lesson students also commented on the experiments and properties of the male condom and related these properties with its composition.

SP3 was identified only in the second lesson, which was a moment for investigating the properties of the male condom. In this class the students held discussions about the empirical results, identified the relevant variables and qualitatively controlled the variables in order to observe each property in isolation.

Following, we select and discuss some excerpts from the students' responses to the thematic workshop questionnaires in order to discuss their categorizations.

Students TQ18, TQ26 and TQ32, when asked why condoms are so effective as barrier contraceptives, answered:

As disease transmission occurs with contact, condoms prevent physical contact with the sexual organs, so there is no disease transmission and no possibility of pregnancy. And another positive factor is that condoms are easily accessible and disposable [TQ18, TQ26 e TQ32].

We observed that the students sought to construct an explanation for male condom efficiency through information in the text. Thus we identified SP6 and SP8. The students justified their explanation due to five factors: lack of contact between sexual organs with condom use; non-transmission of diseases; the prevention of a pregnancy; easy access; and the fact that the material is disposable. We see that the students used information contained in the text to construct the explanation as well as prior information. We point out that at this time there were no explanations that made reference to the properties of the male condom, nor to its composition.

In the second class lesson students wrote and discussed their observations and expectations about the experiments. Students TQ07, TQ16 and TQ25 wrote:

We didn't expect the condom to stretch as much as it did, and also how much volume it could hold, we could see how resistant it is with this experiment. [...] *We could see that the condom is effective, because of its impermeability; nothing from inside it leaked* [TQ07, TQ16 e TQ25].

In this excerpt we identified SP3, SP4, SP6 and SP8. The students performed three investigative experiments in order to investigate the elasticity, resistance and impermeability of the condom by controlling variables and measuring the variation in length, volume and color, respectively, we considered that the students were involved in carrying out investigations.

Thus, we identified SP3 in this excerpt. We noticed that the students presented two of their interpretations, derived from the experimentation and observation of the phenomena: "we could see how resistant it is [the condom] with this experiment" and "We could see that the condom is effective, because of its impermeability, nothing from inside it leaked". In these fragments we verify the simultaneous engagement in SP4 and SP8, because the students interpreted the phenomena and used their interpretations to construct explanations about the effectiveness of the condom. For the NRC (2012) SP4 involves exploring relationships between variables, making inferences through data sets, and using data as evidence. This way we also identified the students' engagement with SP8.

6.2. Analysis of the Workshop footage

The fragmentation of the filming resulted in 5 context units and 9 analysis units. We observed the engagement, in descending order, of students with: Constructing explanations (SP6); Asking questions (SP1); Planning and carrying out investigations (SP3), Analyzing and interpreting data (SP4); and Engaging in argument from evidence (SP7), respectively. SP1 and SP7 were not identified in the analysis of the questionnaires. In the questionnaires, students had no opportunities to get involved in SP1: Asking questions. In the case of filming, SP1 could be identified due to the dialogic interactions between the students and the pre-service teachers. SP7: Engaging in Arguments from Evidence was also not identified in the analysis of the questionnaires, only in the footage.

According to the NRC (2012), for SP7, students must build scientific arguments; identify possible weaknesses in other people's scientific arguments; and discuss the reasoning and evidence of students' arguments. In this case, SP7 was identified due to the elaboration of articulated arguments and explanations. We also observed a moment when a student identified a possible weakness in a pre-service teacher's scientific explanation. Next, we discuss 3 excerpts from the thematic workshop, which show students' engagement in these Scientific Practices.

6.2.1. Excerpt 1

In this example students developed the last qualitative experimental test to understand the condom's impermeability property.

Pre-service teacher 2: So the other student put dye and water here and the solution turned blue. Now, let's put it into the beaker. What do you think will happen?

FF01: Is there water in there? It will become clearer.

Pre-service teacher 2: What happened?

FF02: Nothing.

Pre-service teacher 2: What happened now?

FF02: Nothing.

Giggling.

Pre-service teacher 2: We put the condom in the beaker with water and nothing happened. So what can we say about this?

FF03: It does not allow liquid to leak.

FF04: It is impermeable!

Pre-service teacher 2: Ah! It is impermeable. This property was discussed in class.

This excerpt presents students' engagement in SP3, SP4, and SP6. According to the NRC (2012), planning and carrying out investigations involves systematic ways of gathering natural world data in the field or in the laboratory. In this example students investigated the possible exchange of substances between the solution inside the condom and the beaker solution from which the condom was submerged. The pre-service teacher sought to raise the students' considerations about the results obtained in this experiment.

Even though apparently nothing was observed, in terms of changes in the solutions, there were interpretations of the students. The pre-service teacher had to question them and wait a while for the students to reflect until the answers from FF03 and FF04 emerged, which considered that the observed phenomenon of dye found inside the condom had not leaked to the outside and changed the coloration of the beaker's water. The students said this was related to the condom's impermeability. Analyzing and interpreting data includes understanding the data or results produced during investigations, as patterns that are not always obvious (NRC, 2012). For the NRC (2012) to attribute meaning to a result observed through experimentation or observation itself is a scientific activity.

Following are the selected examples from the third year high school students.

6.2.2. Excerpt 2

In this example, pre-service teacher 1 resumed the results of Experiment 1 held in the previous class. The experiment in question sought to investigate the condom's resistance property by varying the volume between the empty condom and the full condom needed to make it burst.

Pre-service teacher 1: 8.550L, let's round it out to 8.5L. This condom was able to expand 8.5L. It is a very large variation. Then finally it broke with over 8.5L. When it broke, we overcame its resistance. The force of the water exerted on the walls of the condom was so great that it broke. And the name of this property we tested is resistance. Which is defined as the ability of the material to resist an applied force. In our case, it is the force that water exerted on the walls of the condom.

TF01: So if we put something denser, does it burst faster? Like if we filled it with air instead of with water?

Pre-service teacher 1: So let's talk a little bit about density. Density here will not influence resistance. What we are talking about is volume. So 1L of air occupies the same space as 1L of water. So, in this case here, we were working with volume, so it would be independent if it was 8.5L of air or 8.5L of water. In this case, it is easier to measure 8.5L of water than 8.5L of air, so that is why we worked with water.

In this excerpt we identified SP1, with the concern expressed by student TF01's question about the condom's behavior when using another material to test resistance. We observed that the student asked a question to develop or refine a model or explanation about the natural world, in the case of this example, the phenomenon observed in the previous class. This doubt was conceptually structured, based on the student's understanding of the relationships between density, volume and resistance.

6.2.3. Excerpt 3

In this example, the pre-service teacher discussed the results obtained from the previous class experiments and questioned the students about other materials and their respective elasticities, resistances and qualitative impermeabilities.

Pre-service teacher 1: And a plastic bag? Is it elastic?

Students: Yes.

Pre-service teacher 1: Is it elastic? Have you guys ever stretched it? We are able to stretch it! How about impermeability?

Students: Yes.

Pre-service teacher 1: Impermeable also.

TF02: But teacher, for it to be elastic, doesn't it have to expand and then return to its size?

Pre-service teacher 1: True. You're right. The plastic bag is not elastic because it does not return to the initial size. It was a test to see if you were paying attention. And is the plastic bag impermeable?

Students: Yes.

Pre-service teacher 1: Yes, if you have no holes, the water will be contained in it. And resistant, is it?

TF03: It depends.

TF04: Not so much.

Pre-service teacher 1: Does it tear easily?

Students: Yes.

Pre-service teacher 1: So it is not resistant. Ok guys. So what other material has all three properties?

TF05: Party balloons?

Pre-service teacher 1: Party balloons. Nice. Is it resistant?

Students: Yes.

Pre-service teacher 1: Is it elastic?

Students: Yes.

Pre-service teacher 1: We can fill it with a considerable amount of air, perhaps less than a condom, but it does fill up.

Students: Yes.

TF06: But it depends on the balloon. There are some that fill more than others.

TF07: True, it depends on the brand.

Pre-service teacher 1: But is it impermeable? I don't know, we would have to test it.

TF08: I think so, we can play water balloon fights.

Pre-service teacher 1: Water balloon fights. That's true. It is impermeable. Nice. How about surgical gloves? Is a surgical glove elastic?

Students: Yes.

Pre-service teacher 1: When we take off the glove, we pull our fingers, and it goes out and back to its original shape. Resistant?

Students: Yes.

Pre-service teacher 1: Yes, a little, right? It depends, it could end up tearing.

TF09: It depends on the brand.

Pre-service teacher 1: It depends on the brand, right? And is it impermeable?

Students: It is.

Pre-service teacher 1: So what do condoms, surgical gloves, and balloons have in common?

TF10: Elasticity, resistance and impermeability.

Pre-service teacher 1: Yes. And what else do they have in common?

TF11: Material.

Pre-service teacher 1: The same material! So is there a relationship there, with these three properties and the material? Of the object? The material of the surgical glove, balloon and the condom? It seems like there is, right?

In this excerpt we identified the presence of SP1, SP6 and SP7 in interactions between the pre-service teacher and the students. Student TF02 asks a question to the pre-service teacher, which requires rectification on his part. TF02 understands the plastic bag as a non-elastic material due to the inability of the material to return to its original shape after being stretched, that is, in addition to asking this question TF02 thinks about the concept of elasticity.

Later, it is possible to identify SP7, when the pre-service teacher asks students about three materials (condoms, surgical gloves and party balloons) and the physical properties studied (resistance, elasticity and impermeability) and asks if they have anything in common. It is noted that students begin to elaborate arguments or explanations that articulate with each other, relating these materials with the properties that have been studied and later with their materials. Following this interaction, the pre-service teacher handed out *The Supporting Text*, read with the students and formally introduced the concept of polymers.

We note that what culminated in the students' involvement in SP7 at the end of the excerpt is the reiteration of SP6 throughout the interaction between the students and the pre-service teacher, from which they, together, construct explanations about the elasticity of the plastic bag, the impermeability of the balloon due to evidence in water balloon fights and the elasticity of the surgical glove.

7. Conclusions

During the workshop students engaged in six of the eight scientific practices. Incidences of the following Practices were observed: Asking questions (SP1); Planning and carrying out investigations (SP3); Analyzing and interpreting data (SP4); Constructing explanations (SP6); Engaging in argument from evidence (SP7); and Obtaining, evaluating and communicating information (SP8). A higher incidence of SP8 (40%) and SP6 (36%) and a lower incidence of SP4 (14%) and SP3 (10%) were found in the questionnaires. In the analysis of the footage we located excerpts that showed the students' involvement in SP1, SP3, SP4, SP6 and SP7, of which SP1 and SP7 were identified only in the footage, due to the dialogic interactions between students and pre-service teachers.

During the workshop, we observed the combination of SP6 with SP8, especially in the first class, when students sought to construct explanations from the information obtained from the texts. The combination of SP6 with SP8 accounted for 100% of the total number of incidences of SP6 and 88% of the total number of incidences of SP8. Therefore, students always engaged in SP6 combined with SP8. The opposite was not always the case, since there were cases where we identified students engaging in SP8 combined with SP3 or SP4.

All the students engaged in SP3 in the second lesson, which was the moment to investigate, through three experiments, chemical and physical properties of the condom, which make it an effective barrier contraceptive. These properties were elasticity, resistance and impermeability. It is noted that students used their interpretations of the experiment results in the second lesson to construct explanations regarding the male condom's efficiency.

We consider that the workshop, in addition to involving students in six of eight scientific practices, due to its STS focus also served to raise students' awareness about safe and healthy sex practices. Students discussed condom use; the risks of unprotected sex; the properties of the condom; its composition; and the relationship between its properties, its composition and its effectiveness.

Finally, the thematic workshop did not promote the involvement of SP2: Developing and using models and SP5: Using mathematics and computational thinking. The experiments were conducted with a qualitative approach in order to discuss the concepts of polymers and latex and to investigate the properties of the male condom, so the students did not symbolically represent the relationships between variables; nor did they express relations or quantities in algorithmic or mathematical forms. Reaseach and posterior reflective movements like these help could help teachers' reflection on student learning with Scientific Practices, and more specifically, promote deaper levels of teacher reflection, such as critical reflections regarding student engagement in Scientific Practices (Costa, Broietti & Passos, 2020). This is relevant since Scientific Practices can favor science teaching in which the understanding of the world does not only depend on accumulated specific content that must be applied to a problem, but science as a process. (Broietti, Nora & Costa, 2019).

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