ACTIO: Docência em Ciências
ISSN: 2525-8923
Teaching in Science

http://periodicos.utfpr.edu.br/actio

Experimenting science: analysis of a continuing education course for primary school teachers

Alesandra Rafael de Oliveira
pedalesandrar@gmail.com
orcid.org/0000-0002-0943-9728
Universidade Federal do Paraná (UFPR), Curitiba, Paraná, Brasil

Joanez Aparecida Aires
joanez.ufpr@gmail.com
orcid.org/0000-0002-2925-0826
Universidade Federal do Paraná (UFPR), Curitiba, Paraná, Brasil

ABSTRACT

This study aims to analyze - if and how - the 'Experimenting Science' course, for the continuing education of science teachers from the early years of elementary school can support them theoretically and methodologically for the development of experiments in Natural Science classes. It is understood that Science Education should make room for investigative experimental teaching as a didactic intervention capable of introducing reflections on the scientific making in the school environment, in order to contribute to the students' Scientific Literacy process. As a methodology, we opted for the qualitative and quantitative research - Case Study - based on Freitas and Jabbour (2011). The instruments for data constitution consisted of a questionnaire, direct observation of the course, registered in logbook, analysis of material and experiments conducted with elementary school students in Natural Science classes, made available in the 'Google Room', which constitutes an important platform for interaction between university and basic education. Experimentation activities remain in the virtual learning environment throughout the training and also later as a way to compose a database for research and planning support for teachers. For data analysis, the content analysis proposed by Bardin (2004) was used. The results show that one of the greatest concerns of the group of teachers is the lack of laboratory to perform the work with experiments, and they also reported that it is difficult to acquire materials for their accomplishment, besides the need to expand specific knowledge of the science area. However, the training clarifies that it is possible to incorporate into the class dynamics, pedagogical practices of experimentation, through the use of alternative materials, even in conventional classrooms. The course was considered by the teachers as an opportunity to acquire and improve theoretical and practical knowledge to support the planning and enrichment of Natural Science classes.

KEYWORDS: Science Teaching. Investigative Experimentation. Experimenting Science.

INTRODUCTION

This research aims to analyze whether and how the course "Experimenting Science", aimed at the continuing education of science teachers in the early years of elementary school, can instrumentalize the knowledge of these teachers, theoretically and methodologically, for the development of experiments in natural science classes, contributing to the promotion of reflections on making science in the school environment. On this issue, a reflection is made on what supports have been made available to elementary school teachers in order to theoretically support their pedagogical practices.

In view of this concern, this study analyzes the continued training course for teachers of Natural Sciences of the government school system of Curitiba, called "*Experimentando Ciência*" ("Experimenting Science"). This training, offered by the Department of Chemistry of the Federal University of Paraná through the *PET Química* ("TEP Chemistry" - Tutorial Education Program of Chemistry), proposes to instrumentalize the knowledge of these teachers through the practice of chemical experiments, which prioritize research, the survey of hypotheses, the study and construction of concepts and, especially, the demystification of the idea that science is only constituted in laboratories and by specialists

The course brings practical experiences, with accessible materials, possible to be handled by children since the first years of schooling. Considering that municipal schools do not have laboratories, such experiments are passive to be carried out in any environment, since most of the time the Natural Science classes are restricted to the conventional classroom, and few schools have rooms dedicated to this subject

Considering that the course "Experimenting Science" is basically in the development of chemical experiments, a discussion on epistemic and scientific practices will be presented below.

EPISTEMIC AND SCIENTIFIC PRACTICES

Sasseron (2018) and Longino (2017), mention that each area of knowledge has its own cultural and epistemological specificities, which contributes to the personal training of the subjects. However, the knowledge that makes up the school subjects is also constituted in social relations. Therefore, they can be considered as a way of organizing and directing the pedagogical practice of teaching. In this context, this study includes all the teaching strategies carried out by the teacher as practices.

According to Longino (2017), the theories derived from research and scientific experimentation are modified in social interactions and, most of the time, determine their objectives, so science should be thought for people in a collective way. In this sense, the author clarifies that "the forms of knowledge and their applications in technologies that empower the beneficiaries are preferred to those that produce or reproduce relationships of dependence" (LONGINO, 2017, p. 43). From this perspective, investigative experimentation differs from the traditional experimentation practices of teaching by discovery to the extent that it can help to solve the daily problems of contemporary society.

Lorenzetti and Delizoicov (2001), Francisco et al. (2008) and Sasseron (2018), guide that school practices traditionally, in most cases, consist of predefined stages, based only on scientific experimentation, without reflections and investigations, restricting the subjects to conceptual topics. "Thus, reflections that seek to identify important aspects of an experiment, with which the occurrence of motivation and cognitive development of students becomes more likely are necessary" (Francisco et al., 2008). In line with this, Rodrigues and Rodrigues (2018) state that we should "consider experimental practice to help the teacher stimulate the desire of students to be willing to participate, to investigate the situation and to develop scientific knowledge" (p. 16).

Currently, Science Teaching has addressed not only learning the specific contents of the Natural Sciences, but "also includes the acquisition of other scientific knowledge: knowledge related to the ways of understanding Science" (CAMPOS and CAMPOS, 2016, p.137). In this sense, this analysis proposes the scientific formation of individuals through the gradual appropriation of knowledge and concepts produced by humanity collectively throughout history (CAMPOS and CAMPOS, 2016).

According to Campos and Campos (2016), teaching practice must interact with scientific knowledge contextualized in contemporary social problems in different spheres: economic, cultural, political and historical. Thus, they argue that proposing challenging intentional actions that put existing knowledge to the test can favor the production of new knowledge. From this standpoint, "Experimenting Science" is constituted as continued formation, since in fact "the science teacher of the early years often has the task of teaching contents that were not part of his university academic formation" (CAMPOS and CAMPOS,201, p. 138, apud. BENETTI, 2011. P. 3).

Fabrício and Martins (2019), when investigating the perceptions of municipal teachers about continuing education and the possibilities of Scientific Literacy of students, elected continuing education as a crucial point, since "it is not easy for a generalist teacher to appropriate all areas of knowledge as a way to reformulate teaching conceptions and practices, so that an advance in the quality of that teaching is achieved" (p.12). In agreement, Barbosa and Aires, (2018), guide that "the act of reflecting upon one's own practice constitutes the moment in which the teacher thinks of himself as an educator, and thus builds a critical vision of his practice, transforming it" (p.1).

In addition, Rodrigues and Rodrigues, (2018) researching the views of early years' teachers on investigative teaching, clarify that teachers themselves "argue that there is no specific continuing education in science. In general, the training [...] is aimed at literacy in the Portuguese language and mathematics" (p.14), and justifies the difficulties related to "insufficient initial training, lack of continued training in the area of science and the priority given to literacy at that level of education" (p.16), so that although teachers understand investigative teaching as a methodology and recognise its importance in the study of scientific subjects, in the initial years, this is not a frequent practice. However, there is agreement among teachers that "bringing school content closer to everyday experience contributes more effectively to student learning" (p.14), by providing the opportunity to "develop autonomy to think and act in everyday situations, especially those involving knowledge of science" (p.16).

For this reason, Gonçalves et al., (2019) argue that the interest and development of research on teacher training in the early years has been increasing in recent years. In addition, "the area of Science and Mathematics has shown itself to make a relevant contribution to the continued training of teachers of the early years" (p. 9).

Faced with this reality, the concern arises to think about pedagogical practices that contemplate beyond the methodological procedures of conceptual learning, a critical vision of investigative experimental teaching. Furthermore, "research processes can gain space in didactic proposals, being used with the aim of dealing with science and science knowledge" (SOLINO et al., 2015, p. 3).

Therefore, it is necessary to develop pedagogical practices that stimulate the development of logical reasoning, the formation of concepts and the resolution of problems through critical investigation of reality. Making the understanding of the nature of science and the interference of science and technology in society incorporate into these practices.

In relation to such understanding, Sasseron (2018) mentions two didactic approaches: "**Epistemic Practice**" and "**Scientific Practice**". Although both are concurrent, they have a distinct role in students' Scientific Literacy.

Scientific practices, on the other hand, can be defined as: "working with new information; surveying and testing hypotheses; constructing explanations, elaborating justifications, limits and forecasts of explanations" (SASSERON, 2018, p.7). These actions are focused on the experiences lived by students in class from the propositions of the pedagogical practices of science teachers, in the mediation between school content and daily experience. Such actions are of utmost importance because they contemplate the investigation, argumentation and evaluation of the phenomena. Thus, we can consider that scientific practices are aimed more specifically at problem solving.

As for epistemic practices, it is assumed that the understanding of scientific phenomena and their experiments are constituted in research situations, that is, in the set of knowledge about the knowledge itself, by the perception, evaluation and organization of cognitive processes. Thus, "they are associated with the proposition, communication, evaluation and legitimization of ideas" (SASSERON, 2018, p.7). Thus, the reflections concerning the Nature of Science and the discussions of Investigative or Problematic Experiments are contemplated in this category, which is related to metacognitive aspects of the study of phenomena, that is, in the investigation, analysis and development of explanations.

From this perspective, as Sasseron (2018) guides, we understand that the school space must provide the student with the possibility to go through the epistemic and scientific practices in critical analysis of scientific reasoning, as a way to overcome gaps in learning. About this logic "there are special difficulties that the natural sciences do not usually encounter. There is indeed a great difference between the natural sciences and the cultural sciences" (CHEVALLAR, 2013, p.3). However, we conjecture that the formation of a scientific school culture is important to overcome these epistemological impasses.

METHODOLOGY

This study analyses the continuing education course "Experimenting Science" offered to science teachers of the early years of elementary school. As it is a qualiquantitative research, the methodology Case Study was chosen, based on Freitas and Jabbour, (2011). The choice of the method is justified by the possibility of detailed analysis of the data constituted due to its combinatorial and sequential character in the description and interpretation of the information referring to the populations and/or phenomena studied. That is, it allows the methodological triangulation in the research.

The data was compiled using an evaluation questionnaire with seven semi-structured questions, Q representing the respective questions followed by the number of questions, filled in by the participating teachers according to Table 1.

Table 1 - Questions answered by teachers participating in the training

	Questions
Q1	What is your academic background and how long have you been teaching?
Q2	How long do you work in Science Education, in which school year/cycle?
Q3	Does your school have a laboratory?
Q4	Do you feel safe exploring experiments in class?
Q5	Would you take the "Experimenting Science" course again?
Q6	What are the main difficulties for Science Teaching in municipal schools?
Q7	How do you describe the continuing education course "Experimenting Science"?

Source: Self-Authored (2019).

In addition to the teachers' evaluation questionnaire, the course materials were also analyzed (handout). Five reports of experiments carried out by teachers with students in schools were also consulted. These experiments were made available in the virtual learning environment (Google Room), intended for continued training for teachers of the government school system. In this environment the transpositions of the experiences worked during the formation are shared for the science classes in the schools.

The researcher also carried out direct observation of the course, with a record in the logbook and an analysis of the journalistic video that composed a report on this training. Produced by the *Agência Escola de Comunicação Pública da Universidade Federal do Paraná (TV Informa UFPR)*, the article disclosed contemplates the testimonial of all the participants of this continuous training directly and/or indirectly.

The formation under analysis took place in the second semester of 2018, and was a monthly meeting for five months. For this study the 21 participants constituted a group formed by 20 female teachers and a pedagogical coordinator (also codified by the letter P) who were identified as: P1, P2, P3...P21. The university professor teaching the course was identified as (PU) and the undergraduate students who make up the "Experimenting Science" team were identified as (EG). The participants of the analyzed report were identified as: Pro-

Rector of the university (PRU), and the representative of the Municipal Secretary of Education was identified as (RSME).

We used the Content Analysis methodology based on Bardin, (2004) which begins with the identification of the registration units, evident in the analyzed data (analysis organization). Afterwards, the context units containing the selected units of registration called coding are elected. Then the categories of analysis from the context units that make up the analysis corpus are defined as categorization. Finally, the aim is to analyze the data by processing the results, inferencing and interpreting the results.

The choice of the method is justified by the possibility of detailed analysis of the data due to its qualitative character. Therefore, this methodology made it possible to identify two categories emerging from the evaluation filled in by the teachers, and from the analysis of the descriptions of the experiments carried out in the schools with the students, which were posted in the virtual learning environment. In addition, the testimonies of the different training courses that contributed to the TV Informa UFPR material were also analyzed. These categories were named posteriori: Scientific and Technological Knowledge and Literacy Environment, which served as an instrument of analysis of the influences of the course "Experimenting Science" for the enrichment of the pedagogical practice of municipal teachers.

We understand that the category **Scientific and Technological Knowledge** is constituted by academic knowledge and scientific communication being perpetuated through the proposition of ideas, formulation of concepts, survey of hypotheses, justifications and scientific explanations. The category deals with Investigative Experimental Teaching as a possibility of stimulating scientific curiosity, study and investigation of the phenomena that contextualize Science Teaching (CHEVALLAR, 2013). By enabling students to go through epistemic and scientific practices, they can instrumentalize their scientific reasoning. In addition, the work with new information, survey of hypotheses and explanations, argumentation and justifications permeate this category as they contextualize the pedagogical practices of (the) teachers of Natural Sciences (SASSERON, 2018).

On its turn, the category **Literacy Environment** is characterized by the possibility of interaction with different methodological aspects of scientific culture. In other words, the pedagogical practices present in investigative experimentation can be an important didactic tool. This category seeks to analyze how the approach of experiments can provide the understanding of scientific concepts (LORENZETTI; DELIZOICOV, 2001; SASSERON, 2018).

ANALYSIS AND DISCUSSIONS

The following is an analysis of the experiments carried out by the teachers participating in the course, which were disclosed in the Google Room as a way of exchanging experiences and as a complement to the training workload. Some testimonials of the report made by the School of Public Communication TV Informa UFPR, at the end of the course, were also analyzed.

CATEGORY: SCIENTIFIC AND TECHNICAL KNOWLEDGE

The category **Scientific and Technological Knowledge** refers to the interactions proposed by "Experimenting Science", made possible in the virtual environment of the "Google Room". This platform constitutes a space of interaction between the university and Basic Education. Such interactions can contribute to overcoming existing gaps in Science Teaching through the proposition and legitimization of new ideas and broader understandings about the phenomena. The units of record and context of this category are described in Table 2 below:

Table 2 - Units of record and context present in the category Scientific and Technological Knowledge

Participant	Unit of Records	Unit of Context	Category
P3	Fluids	"the **fluids** behave in this way have constant viscosity and are not deformed"	Scientific and Technological Knowledge
P8	Creating hypotheses	" they **get** a hypothesis of why some things float and some things sink "	
P16	Acid	"a little girl said she thought it was because lemon is **acid**"	
P7	"with the naked eye"	"Allowing students to constitute the term "**with the naked eye**"	
P2	Practices	"So that's a lot of security, it's already changed **practices**"	
P19	Suitability	"Yes, by studying a little more **to suit** my students"	
EG	Degree	" Formerly, I didn't have the option of a **licensure** and today my vision is totally different and it's very worth the project "	
RSME	Course	"A poll was conducted and the "Experimenting Science" course was the most requested **course** for 2019"	

Source: Self-Authored (2019).

In this category the units of fluid records, creating hypotheses, acid and practices, refer to the methodology of experimentation and research in the teaching of Natural Sciences as a way to contextualize, motivate and qualify learning. By developing with the students of Elementary School the experiment "making quicksand" with corn starch and water, one of the teachers of the municipal network questioned in this research aimed to guide students on the observation and description of changes in physical materials resulting from actions on them.

After explaining the sequence of the experiment, the students reproduced the previously observed experience in groups as a way of comparing their results. Thus, this experiment allowed the exploration of scientific concepts such as: Newtonian and Non-Newtonian Fluids, viscosity, force, deformation, pressure, temperature, changes in the physical states of matter. Besides the scientific concepts, the teacher also clarified that this is a scientific experiment previously performed by the scientist Isaac Newton in his investigations about the applied force on a fluid and the response given to this action. Thus the students could better understand the relationship between the fluids and their definition.

According to Sasseron (2018), based on the understanding that the conceptual knowledge approach associated with process knowledge produces epistemic knowledge, there is a construction of relationships between everyday practices and teaching practices to stimulate the active intellectual role of students in their learning process.

The " float or sink " experiment also proposed to reflect on the differences that exist between the materials as a result of the action on them, by means of natural and artificial phenomena. This experiment provided a survey of hypotheses and conjectures about the density of the elements when placed in contact with water, which allowed the approach to the concept of strength and resistance. Unlike the previous experiment, it is perceived that this experiment was based on the effectiveness of the senses as a way to understand natural phenomena, having the simple observation as a strong point in this learning.

With regards to the experiment on "base acid", a reflection on the transformation of materials from chemical reactions resulting from actions on them was proposed. We worked on this experiment with apple and lemon and then applied it to the students in the schools. The experiment provided a survey of hypotheses and the acquisition of scientific concepts such as: ascorbic acid, antioxidant, oxygen and others. With the same purpose, there was also the experiment "milk has mixtures", which proposed the investigation of the reactions between different substances and detergent.

It was realized that such experiments are based on the efficiency of the senses as a way to acquire knowledge about the natural world. However, they did not provide reflections on the causes and consequences of phenomena in the natural environment, a fact that partially compromises their objective with regard to the understanding of such phenomena in the real world.

The experiment "homogeneous and heterogeneous mixture" when replicated by one of the teachers in the school where she works, she sought to formulate concepts on the definition of the elements and their composition, expand knowledge on the processes of saturation and separation between mixtures and

reflect on the expression "with the naked eye". In this experiment different methods for saturation and separation of mixtures were explored in order to understand how the process of separation between salt and sea water, the sieving of sugar, filtering of coffee, decantation of land in water and evaporation of water in the salt marshes occurs.

In this way, students were encouraged to reflect on the physical characteristics of the elements, how to recognize their components, differentiate homogeneous and heterogeneous mixtures, and interact with informative texts, dictionaries, videos and images as a way to contextualize the contents explored during the investigation of the substances. However, although the possibility of interdisciplinarity is mentioned among the contents present in the developed experiments, none of these experiments contemplated the action of these phenomena in daily life, nor did they seek to reflect on the environmental, social and/or economic relationships that permeate these concepts, laws and theories.

By providing experiments that can result in changes in materials, they could provide an opportunity to reflect on the reality and context in which these phenomena occur. Thus, some of the criteria of investigative experimentation such as observing the world around them and asking questions, analyzing demands, outlining problems and planning investigations were left aside from these experiments.

About this logic, we realize in experiments related to the course that there is a need to identify research problems that relate to the local reality of the students. However, in the information about the phenomena observed, the students demonstrated an understanding of the subjects addressed. We found in the experiment on base acid posted in the Google Room that when asked why some apples did not darken, one student raised the suspicion that it would be because the lemon is acid and antioxidant. This reveals the presence of scientific practices since the early years of elementary school and proves their effectiveness in learning scientific concepts.

In the registration units, **suitability** and **practice**, the teachers refer to the teaching activity and consider that the actions of the course "Experimenting Science" have brought more security to the approach of scientific contents in Natural Sciences classes. As reported by the teacher: P19 - "studying a little more to better suit my students". The teachers also claimed that through this training it was possible to broaden the understanding of science as a social construction. In addition, the university students who teach the course under the supervision of the professor (UP), responsible for "Experimenting Science" mentioned that in this opportunity to mediate with the public network teachers, the **licensure** became a possibility of professionalization and personal fulfillment for them.

As one university student (US) reported in the interview, the activities developed in "Experimenting Science" broadened her understanding of the possibility of professional action in the field of Education. This shows that even implicitly the education allowed her to reflect on the teaching formation and the presence of science in society. Another relevant aspect is the possibility of demystifying the idea that scientific research is constituted only in laboratories, and by specialists.

The statement of the representative of the Municipal Department of Education (RMDE) on the receptivity of municipal teachers to the training under analysis, reveals that teaching by experimentation has been seen as a possibility to acquire new knowledge, contextualize the classes and make them more attractive to students. This direction of work with new information is characteristic to scientific practice.

Thus, in the unit of records **course**, the RMDE reports on the opinion of teachers to consider this training as a possibility of change in their teaching methodology. We confirmed in the speech of the teachers participating in "Experimenting Science" that the course has been considered as an opportunity for professional qualification as we can see in the reports described below: P5 - "Necessary for the teacher, as it is a practical and viable course to be worked with our students". P3 - "The activities developed allow the educator to have more certainty in the theoretical contents, developing the experiments in an appropriate way". P1 - "The experiments are simple, according to the reality of the school". P17 - Very good, practical approach to the classroom, giving a North of how to develop the work with students". P7 - "Rich and important for the formulation of innovative classes".

In view of teachers' considerations about the possibility of working with investigative experimentation, we realized that "Experimenting Science" enabled us to reflect on the importance of the scientific and epistemic practices approach for a less book and abstract Natural Science Teaching (SASSERON, 2018).

CATEGORY ENVIRONMENT LITERACY

This category analyses the potential of the "Experiencing Science" course to enrich the pedagogical practice of Basic Education teachers and its influences in Natural Science classes, attempts to interpret the aspects related to scientific knowledge and transpose this knowledge to the elaboration of an investigative approach. The units of record and context of this category are set out in Table 2:

Table 3 - Units of record and context present in the Category Literacy Environment

Participant	Unit of Records	Unit of Context	Category
P4	Didactic	“the course is very **didactic**”	Literacy Environment
P1	Reality	“the experiments are simple according to the **reality** of the school”	
P7	Experimentation	“Surely the world of the child is the world of **experimentation**”	
PU	Motivation	“when you introduce experiment you **motivate** the child to learn any concept”	
PRU	University	“The country has put this on the **university** priority agenda for a long time so that it can address it”	

Source: Self-Authored (2019).

The category Literacy Environment describes the learning made possible by the course "Experiencing Science". In the unit of record **security** the influences of this training in the planning of natural science classes become evident, as the following reports: P1 - "In fact, in practice it gives you more security". P3 - "The course is very didactic, the teacher gets sometimes, with a question that we have, he can bring several others that the student will have". Therefore, it is perceived that there is legitimacy of the ideas propagated in this teaching training in relation to the objective of the course. According to the teachers participating in the training under analysis, the course proposes security and support for the pedagogical practice, using them to carry out experiments. However, we understand that these experiments still need to be restructured for a problematizing aspect of reality.

According to Campos and Campos (2016), it is important to instrumentalize teachers of Natural Sciences through continuing education, since they have the task of teaching content that was probably not part of their academic scientific training, as reported by P9 - "Lack of knowledge of the discipline. Moreover, the context in which scientific concepts and theories are constituted should also be investigated as a way to attribute meaning to students' learning. After all, reflecting on science as a cultural production of humanity can be a way to improve students' understanding of the very construction of science that is constituted of many other knowledges besides scientific contents, due to its collective and cooperative character, that is, it emerges from social relationships.

Thus, at the unit of record **university**, the Pro-Rector of the UFPR deals with the current context of initial training of chemistry teachers by reporting the degree as a "priority agenda of the university", aiming to improve the quality of teacher training from its undergraduate basis. It is clear from his statement that there is a proposition of ideas aimed at overcoming the gaps in initial teacher training. In this sense, "Experimenting Science" has indirectly contributed to raise discussions in the academic environment and also in Basic Education about the existence of a relevant social problem not only for the area of Natural Sciences, but for the whole society. Thus, although briefly, it was possible to perceive the presence of epistemic practices in this training, by identifying problems that permeate the process of teaching and learning and teacher training (SASSERON, 2018).

Such statements prove the importance of the "Experimenting Science" course for the improvement of didactics aimed at science teaching, since the initial training of teachers themselves has presented gaps in the understanding of the process of scientific knowledge elaboration, its continuities and discontinuities, as well as controversies and scientific theories. Thus, "doubt, contradiction and questioning must be privileged; diversity and divergence must be valued, and certainties and uncertainties must be questioned, stripping the contents of their neutralized form" (CAMPOS and CAMPOS, 2016, p.138).

ANALYSIS AND DISCUSSION OF TEACHERS' ASSESSMENT OF CONTINUING EDUCATION "EXPERIMENTING SCIENCE"

Table 1 – Summary of the evaluation of the 21 participants of the course "Experimenting Science"

Academic Background	Pedagogy 52,38%	Biological Sciences 9,52%	Letters 4,76%	Chemistry 4,76%
	Physiotherapy 4,76%	Not Specified		
Time of activity in science teaching	4 months 4,76%	2 years 33,32%	3 years 14,28%	4 years 9,52%
	5 years 9,52%	10 years 4,76%	12 years 4,76%	15 years 4,76%
	18 years %	Not specified 9,52%	Average 5 years and 11 months	
Year/Cycle of operation	Kindergarten Education	Early Years of Elementary School 1st to 5th grade	Youth and Adult Education (EJA phase I)	Pedagogical Coordination
Is there a Lab?	No 71,43%	Yes 19,05%	There is a Science Room 9,52%	
Feel comfortable exploring the experiments	Yes 95,24%	Oscillates according to content 4,76%		
Would you take the course again?	Yes 47,62%	Sure 42,86%	No 9,52%	
Main difficulties for Teaching Natural Sciences	Lack of physical environment and adequate materials to work with experiments.			47,62%
	Lack of specific knowledge of the area.			23,81%
	Lack of awareness of the "management team" of the importance of the Natural Science discipline.			9,52%
	Continuing Education.			9,52%
	Do the didactic transposition of scientific contents and plan classes involving CTS.			4,76%
	Lack of adequate time for further exploration of the experiments.			4,76%
	Combine theory with practice according to the established content.			4,76%
Characteristics attributed to the course "Experimenting Science	Rich, important, innovative, excellent, necessary, clear, wonderful, very good, enlightening, provides great confidence and great interaction, has accessible practices, besides being an excellent opportunity to acquire and improve both theoretical and practical knowledge.			

Source: Self-Authored (2019).

As described in Table 1 above, in the group of teachers who participated in this formation there is a predominance of graduation in pedagogy. The time spent by female teachers in the area of science varies from 4 months to 18 years, totaling an average time of 5 years and 11 months. The Teaching of Science developed by

teachers participating in Early Childhood Education is directed towards Natural Relations. In Elementary School - cycles I and II cover from 1st to 5th grade and also serves Youth and Adult Education (phase I), in addition to the pedagogical coordination (responsible for guiding and monitoring the pedagogical work).

It was possible to verify in the teachers' statement that of the twenty-one school units, only 19.05% have a science laboratory and 9.52% have science rooms. In other words, most of the school units, 71.43% do not have a specific space for natural science classes, which take place in conventional classrooms. We found that according to 47.62% of the course participants, this is one of the greatest difficulties for the development of pedagogical practices specific to Science classes. According to their reports: P4 - "Lack of laboratory material and proper space". P5 - "Lack of materials needed to work with experiments". P6 - "Lack of laboratory". P9 - "Lack of knowledge of the discipline and laboratory that we do not have yet". P14 - "Lack of physical space, in the classroom limits a lot".

When reporting on the difficulties encountered in working with Science Teaching, 47.62% of teachers reinforce that the lack of an adequate physical environment and the absence of materials for the experiments becomes an obstacle to enriching the classes. The results of the evaluations show that this is one of the group's greatest concerns, as reported below: P6 - "There is a lack of materials needed to work with experiments". P 16 - "Have an adequate place and appropriate material". P20 - "Material and appropriate room". However, 95.24% of the teachers considered that the course "Experimenting Science" provides security for experimenting and only 4.76% said it oscillated according to the content worked on, feeling secure at some times and not at others.

Thus, Campos and Campos, (2016) report that the uncertainty of the generalist teacher makes teachers in the early years reduce their classes to mere expositions of concepts described in textbooks, without the application of experiences and cognitive conflicts that result in new knowledge.

As for the continuity of the course "Experimenting Science" 90.48% of the teachers showed interest in participating in the training again. That is, 47.62% answered that they would participate again or would give continuity, 42.86% answered that they would certainly participate and only 9.25% considered it unnecessary to continue participating in the course.

In the sequence 9.52% of the teachers pointed out as a difficulty, the lack of awareness of the directive team about the importance of the discipline of Natural Sciences for the students. However, they leave doubts about which are the members of this directive team. It was not clear from the teachers' assessment whether the directive team was the school's pedagogical team or the Municipal Department of Education's team, given that currently, in the vast majority of schools, natural science teachers perform related functions: Regency of Science and Coregency. In some cases, in parallel with the discipline of Natural Sciences, they teach other subjects such as Art, Religious Education, Literature and so forth.

In this way, when thinking about the continuing formation of teachers one has to initially consider the formative needs inherent to these professionals, since they are not homogeneous, as they differ according to the academic formation, time of teaching experience, personal interest, experiences lived by the subjects, etc. Although this is a complex problem, only 9.52% of the teachers point out

continuing education as a problem for Science Teaching. The following statements confirm this: P11 - "I believe that this year the difficulties decreased due to the formations focused on Science Teaching, in others the difficulty was the lack of formation. This is the second formation of this year. Excellent by the way".

Fabrício and Martins (2019), when investigating municipal teachers' conceptions of continuing education report that "when asked how they evaluate the continuing education courses offered by the SME, predominantly teachers evaluate positively" (p.12). Teachers who "consider that fewer improvements are needed" (p.12) argue that such training turns out to be repetitive and/or weak.

This fact leads us to reflect on the need to broaden discussions about Continuing Education for Natural Science teachers so that it, in addition to disseminating the potentialities of experimental investigative teaching, can also provide discussions about the gaps that exist between pedagogical practice and the reality in which it is constituted. It is perceived that the scarcity of continuing education for natural science teachers may contribute to further aggravate the lack of quality in teaching in this area. In fact, the initial training of teachers is a weakened process in relation to the acquisition of specific knowledge due to the existence of gaps in undergraduate courses. This situation becomes even more serious when we reflect on the proposition of positivist conceptions in teaching. After all, the science conceptions that permeate the continuing education process are also worrying as they may accentuate stereotyped and dogmatic views of science.

By disseminating an exclusively bookish profile, one runs the risk of spreading illusory ideas that simple interaction with materials and experiments results in an innovative practice for Science Teaching. This may cause teachers' didactical approaches to be transposed from the two-dimensional support of textbooks to the three-dimensional support of experiments, but without reaching the depth of the reflections needed for the expected cognitive developments. By pointing out their difficulties in relating theory to practice, the teachers demonstrate this problem: P12 - "I found it difficult to get the ideas and experiments into the classroom because of the area". P15 - "Link theory with practice according to the established curriculum". Thus, 4.76% of the teachers reported didactic transposition as a complex challenge. Therefore, the main focus of the teachers is on the offer and possibility of participating in continuing education and not on reflections on its quality. In this way, such reflections end up in the background. In addition, the training under analysis itself, even though it is requested by teachers, offers a considerably limited number of places (20 registrations per edition) if we consider the percentage of professionals in the municipal network.

Additional difficulties were the lack of adequate time for further exploration of the experiments (4.76%). Do the didactic transposition of the scientific contents in the planning of classes that involve CTS - Science Technology and Society (4,76%).

Regarding the qualities attributed to the course "Experiencing Science" the teachers describe in a positive way the characteristics of this training, as described in the evaluations: P7: "Rich and important for the formulation of innovative classes"; P2: "Excellent for continuing and permanent formation"; P5: "Necessary for the teacher, as it is a practical and viable course to be worked on with our

students"; P4: "Excellent course, many very practical suggestions, simple activities but with optimum student feedback". Other qualities were also pointed out: "feasible, clear, wonderful, very good, enlightening, provides safety and great interaction, has accessible practices, besides being an excellent opportunity to acquire and improve knowledge, both theoretical and practical".

During his training, the UFPR (PU) Chemistry teacher brought reflections on the real economic conditions of the public school. Taking into consideration the few resources that schools have for the purchase of materials that allow experiments, it becomes important to work with alternative materials. From this perspective, the course "Experimenting Science" proposes to instrumentalize the scientific knowledge of teachers to develop experiments with accessible, low-cost materials that can be manipulated in any environment without offering risk to students. The course materials (experiment booklet) presents some models of accessible experiments. The teacher in charge of the course has also pointed out some suggestions for working with low-cost alternative materials to replace some specific laboratory materials. An example of this is the use of the natural indicator of base acid made with purple cabbage and the production of litmus paper, through the filter used to strain coffee.

In view of the above, we consider that the applied course has the potential to encourage problematizing experimental research and investigative experimentation in addition to qualifying teachers' pedagogical practice more consistently. Besides deepening the discussions on the importance of initial teacher training as a basis for structuring and qualifying the Teaching of Sciences. It was also realized that "Experimenting Science" makes it possible to increase the level of Scientific Literacy of teachers through continuing education. As argued by Gonçalves, et al., (2019) that training proposals focusing on teaching action and its professional progression can potentially be favorable to the exchange of educational experiences.

CONCLUDING REMARKS

This study aimed to analyze whether and how - the course "Experimenting Science" aimed at the continuing education of science teachers of the early years - can support them theoretically and methodologically for the development of experiments in natural science classes.

It was possible to perceive that the referred continuing education course has brought innumerable contributions to the direction of pedagogical practices destined to the Teaching of Natural Sciences. By arousing the interest of teachers to innovate their classes through experimentation, it was possible to clarify that there are different possibilities to constitute didactic strategies that enable the improvement of the quality of Education at all teaching levels.

Furthermore, it is important to create spaces for dialogue between the university and Basic Education as a way of contextualizing teaching and establishing relationship links at different educational levels. Although the course " Experimenting Science " is directed towards the continuing education of (the) teachers of Natural Sciences, the reports of the undergraduate students in Chemistry, who taught the course under the guidance of the teacher (UP), revealed that there was a significant advance in the interest of the undergraduate students in Basic Education as a possibility of professional action, such interest was aroused during the training. If we consider that the lack of specific education in the area of Science was pointed out by teachers as one of the great difficulties in the planning of classes, then it is important to emphasize that it is important to have teachers with academic background in this area also acting in the initial years, since most (of the) teachers have education in Pedagogy or even in distinct areas of the Natural Sciences field. Thus, there was a significant percentage of teachers who mentioned having difficulty working with this subject due to the lack of specific knowledge of the area.

This is undoubtedly a necessary discussion in the field of Education, after all, as we have seen in the reports of the teachers participating in the course, it is a gap still far from being overcome. Since both the initial and continuing education of Natural Science teachers have shown that they have not yet been a cause for concern in educational policies aimed at teaching. The very format of Natural Science Teaching in the municipal network reveals this, because the way in which the municipal curricular proposal structures the didactic planning for Science Teaching in parallel with the development of correlated functions as coregency and/or associated regency of other subjects, shows that there is still a need to overcome the traditionalist curricular proposals, focused on the teaching of Portuguese Language and Mathematics as a priority in the initial years. After all, even if it is an interdisciplinary area, each area of knowledge has its own specificities that should be contemplated both in the pedagogical proposals of the Teaching Systems and in the didactic planning of the classes. In addition, there is a lack of support for the teaching activity such as the absence of an adequate educational environment and the unavailability of resources also interfere in the quality of teaching.

Another factor mentioned by teachers related to this traditional profile of Education is the need to theoretically base the pedagogical practice of teachers in the initial years so that it is not restricted to book teaching or just expository. In

this sense, "Experiencing Science" was considered by teachers as a possibility of overcoming superficial teaching by a theoretically grounded teaching capable of materializing scientific theories into meaningful pedagogical practices. After all, for a quality pedagogical action it is important that teachers have clarity of their objectives in the planning of the classes and also in the evaluation strategies adopted by them.

If we consider the persistence of the difficulties currently encountered by teachers, from the lack of structure for the development of classes to the frustrations related to the professional teaching career, which has intensified in recent years, providing training that motivates teachers to seek innovations for their classes, can be a positive way to enhance their professional identity.

We can also highlight in this training the possibility of using technology as a didactic tool for teaching, constituting an ally in encouraging a researcher teaching profile. We consider that the understanding of Science and Technology as a human practice is indispensable for a quality teaching action. As for the Teaching by experiments, it was possible to perceive in this study that experimentation is a methodology highly appreciated by students and teachers. Therefore, it is recommended to work with investigative experimentation and/or problematizing experimentation to qualify the Teaching of Science, making it potentially critical and democratic.

We then understand that activities that promote investigative experimental teaching can be considered innovative practices for science teaching. Thus, by analyzing simple phenomena such as chemical reactions, transformations of matter, different textures, among other experiences, it was possible to realize that even when dealing with children still in an initial period of schooling, students demonstrated to build knowledge about complex scientific concepts. In addition to broadening their vocabulary, they were able to discuss scientific issues and propose hypotheses regarding the phenomena investigated in a coherent manner. This shows that closer relations between the university and Basic Education can directly interfere in the quality of teaching. In other words, it makes it possible to broaden the discussions on the importance of investigative teaching as a way of problematizing reality, since the course has also favored the perception of science in society in different ways and not only in the restricted space of the laboratory.

However, there is still a need to add discussions aimed at reflecting on the Nature of Science and on CTS approaches, as a way to guide the work with local issues. In order to have the understanding of students and teachers about scientific production as a collective and collaborative human practice, interfering in society, which transforms it at the same time (SASSERON, 2018; BARBOSA; AIRES, 2018).

For this reason, the training offered by the Department of Chemistry of the Federal University of Paraná - PET Química (Tutorial Chemistry Education Program), has become an ally to the pedagogical practice of teachers, since it arouses their interest in investigative teaching. We consider that courses like this can be a reference for the qualification of teachers' educational action, with potential for the introduction of reflections pertinent to the discussions of the CTS approach.

Although the course "Experimenting Science" has provided important evolutions in the planning of Natural Science classes, through the attempt to

propose an investigative experimental teaching, this formation still has traditional traits. When reporting the interferences of teaching by experimentation for the improvement of learning, "Experimenting Science" presents experiments that do not always propose the investigation of scientific phenomena, being based only on the observation of experiments. There is also a need to relate the experiments suggested in the booklet to the daily lives of students in a more direct way. After all, the reflections on the influences and benefits of Science Teaching for the understanding of science as a social activity were presented in a succinct and indirect manner in the course.

Moreover, in the training offered there was no reflection on the function of scientific activity in society in an explicit way. Nor was there any mention of the possibility of using technology to enrich the methodologies intended for the Teaching of Sciences as a tool for mediating the teaching and learning process and not only as a didactic resource. Although the virtual environment "Google Room" is a good example of the educational potential of technology in the educational environment. Thus, only seven out of the twenty-one participants in the course have posted the application of the experiments worked in their classes, this shows that there is a need to direct such experiments to an investigative teaching and problematizing reality.

Currently, the area of Teaching Sciences has become a potentially effective instrument in the emancipation of society. It proposes reflections on issues related to the environment and its interactions with living beings, sustainability, scientific and technological advances, planned obsolescence, exploitation of natural resources and their depletion, pollution among other issues that need to be discussed in the public sphere. That is, besides contributing to the improvement of people's quality of life, it must also be focused on overcoming the positivist ideas of the traditional teaching of the Natural Sciences, which was directed only to the contemplation of the beauties of the natural world and the propagation of "scientific discoveries". Opposing this conception, the current pedagogical proposals for Science Teaching already demonstrate the concern to awaken the critical sense of individuals to better understand the reality in which they are inserted, being this one of the greatest challenges of Science Teaching in the modern and globalized world.

ACKNOWLEDGEMENTS

We thank the Postgraduate Program in Science and Mathematics Education of the Federal University of Paraná (PPGECM/UFPR) and its valuable faculty that makes discussions like this effective. To the colleagues of the research group in History, Philosophy and Sociology of Science and also to the colleagues of Pedagogy for their contributions in the reading of this material.

English Version: Tom Simões - traduko@tradukotranslators.com - https://tradukotranslators.com

REFERENCES

BARDAIN, L. **Análise de Conteúdo**. São Paulo: Editions 70, 2004, 229p.

BARBOSA, F. T.; AIRES, J. A. A natureza da ciência e a formação de professores: um diálogo necessário. **ACTIO**, Curitiba, v. 3, n. 1, p. 115-130, Jan/Apr, 2018.

CAMPOS, R. S. P., CAMPOS, L. M. L. A formação do professor de ciências para os anos iniciais do Ensino Fundamental e a compreensão de saberes científicos. **Amazônia – Revista em Educação em Ciências e Matemática**. V. 13 (25) Jul/Dec, 2016, p.135-146.

CHEVALLARD, Y. Sobre a Teoria da Transposição Didática: algumas considerações introdutórias. Traduzido por Cleonice Puggian. **Revista de Educação, Ciência e Matemática**, Rio de Janeiro, v. 3, n. 2. May/Aug, 2013.

FABRICIO, L.; MARTINS, A. A. Alfabetização científica no ensino de ciências nos anos iniciais do ensino fundamental: percepções dos professores da rede municipal de ensino de Curitiba. **ACTIO**, Curitiba, v. 4, n. 2, p. 594-609, May/Aug, 2019.

FRANCISCO, Jr., W. E.; FERREIRA, L. H.; HARTWIG, D. R. Experimentação Experimentação Problematizadora: Fundamentos Teóricos e Práticos para a Aplicação em Salas de Aula de Ciências. **Química Nova na Escola**, São Paulo, n. 30, Nov, 2008.

FREITAS, W. R.S.; JABBOUR, C. J. C. Utilizando estudo de caso (s) como estratégia de pesquisa qualitativa: Boas práticas e sugestões. **Estudo & Debate**, Lajeado, v. 18, n. 2, p. 07-22, 2011.

GONÇALVES, N. C. G.; COMPIANI, M.; MAGALHÃES, Jr., C. A. O. O ensino de ciências e a formação continuada de professores alfabetizadores: reconhecendo o campo da pesquisa. **ACTIO**, Curitiba, v. 4, n. 3, p. 270-291, Sep/Dec, 2019.

LONGINO H. Valores, heurística e Política do conhecimento. **Scientiae: Studia**, São Paulo, v. 15, n.1, p. 39-57, 2017.

LORENZETTI, L.; DELIZOICOV D. Alfabetização Científica no Contexto das Series Iniciais. **Ensaio - Pesquisa em Educação e Ciência**, Belo Horizonte, v. 3, n.1, Jun, 2001.

RODRIGUES, C. S. C.; RODRIGUES, M. A. Refletindo sobre o ensino de ciências com professores dos anos iniciais por meio de uma sequência se ensino investigativo. **ACTIO**, Curitiba, v. 3, n. 2, p. 58-79, May/Aug, 2019.

SASSERON, L. H. Ensino de Ciências por Investigação e o Desenvolvimento de Práticas: Uma Mirada para a Base Nacional Comum Curricular**. Revista Brasileira de Pesquisa em Educação em Ciências**, v.18, n. 3, p. 1061-1085, 15 Dec, 2018.

SOLINO, A. P.; FERRAZ, A. T.; SASSERON, L. H. Ensino por investigação como abordagem didática: Desenvolvimento de práticas científicas escolares. **XXI Simpósio Nacional de Ensino de Física** – SNEF 2015.

Received: 20 set. 2019
Approved: 07 dec. 2019
DOI: 10.3895/actio. v5n1.10755
How to quote:
OLIVEIRA, A.R. de.; AIRES, J. A. Experimentando Ciência: análise de um curso de formação continuada para professores do Ensino Fundamental. **ACTIO**, Curitiba, v. 5, n. 1, p. 1-22, Jan/Apr, 2020. Available at: <https://periodicos.utfpr.edu.br/actio>. Access: XXX
Contact:
Alesandra Rafael de Oliveira.
Rua: Valdomiro Rodrigues, n. 541, Tatuquara, Curitiba, Paraná, Brasil.