
The effectiveness of the Sirius School for high school teachers

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Abstract: The Sirius School for High School Teachers (ESPEM) is an in-service program for high school science teachers. It is held at the National Center for Research in Energy and Materials in Campinas, in partnership with the Brazilian Society of Physics. The program aims to enhance the skills of science teachers in high schools, facilitate the exchange of knowledge between teachers from all over Brazil, and produce updated teaching materials that promote Brazilian science and technology. To investigate how ESPEM contributes to the training of basic education teachers, and to assess the effectiveness of the program, we employed various data collection methodologies in a qualitative research study. Our objectives were: i) to identify the expectations of the participating teachers, ii) to evaluate the products generated during the program, and iii) to measure the achievement of the main goals of ESPEM. To achieve these objectives, we analyzed the letters of intent submitted by the selected participants before the program began. During the program, we conducted participant observation. After the program, we conducted semi-structured individual interviews, and a focus group, and distributed questionnaires to the participants.

Keywords: synchrotron light; in-service training; professional-Development Schools; high school teachers

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Introduction

It is widely agreed that every professional should strive to improve their skills and knowledge, regardless of their area of expertise. However, when it comes to teachers, this need is particularly emphasized and supported by various national and international studies (Day, 2001; Villegas-Reimers, 2003; Pacca and Villani, 2018). Continuing education or professional development courses for teachers can take on various forms and have multiple interpretations. One such interpretation is: training initiatives in the period that accompanies the subjects' professional time. It has a different format and duration, assuming the perspective of training as a process. It can either originate from the initiative of the interested parties or can be inserted into institutional programs. In the latter, education systems, universities and schools are the main agencies for such types of training (Cunha, 2003).

ESPEM (Acioly, 2020, 2021, 2022) is an in-service teacher training course to foster partnerships between teachers and universities (in this case, a research center) to enhance the teaching and learning process in the classroom (Villegas-Reimers, 2003).

The Sirius School aims to provide high-quality teacher training by promoting interactions between leading Brazilian science researchers working at the Brazilian Center for Research in Energy and Materials (CNPEM) and participating teachers. This approach emphasizes the importance of establishing links between research laboratories and basic education schools (Acioly, 2020, 2021, 2022). However, communication between academic research and teaching practice remains a significant challenge.

This article is structured as follows: the following section provides an overview of the theoretical concepts that were used. Then, one outlines the methodologies that were employed. Next, we describe how the data was collected and analyzed. In the penultimate section, we present the primary findings along with a discussion. Finally, we conclude with our final remarks.

Theoretical contributions for an evaluation of ESPEM

When analyzing a continuing education course and exploring the relationship between different types of knowledge, several approaches have been proposed in the literature that focus on "teacher thinking." These include Tardif (2002), Shulman (1986 and 1987), Oliver and Park (2008), who address the concept of Pedagogical Content Knowledge (PCK), as well as Pimenta (1997) and Pessoa de Carvalho, who conducted research with Daniel Gil-Perez (2011), among others.

Regarding the evaluation of these courses, the reference chosen was Thomas Guskey (2000), who discusses the processes involved in evaluating professional development courses. In this case, his model was adapted for the evaluation of continuing education courses.

In designing ESPEM as a professional development course for teachers, there was a strong emphasis on promoting dialogue between the research center, schools, and society. Conceptual strategies were developed through discussions with experts, providing teachers with opportunities to update their scientific and pedagogical knowledge. The selection of teachers for the program also considered their prior experience and knowledge of pedagogy. ESPEM focused on updating teachers' knowledge of science and equipping them with the necessary skills for teaching (Villegas-Reimers, 2003; Tardif, 2002; Shulman, 1987).

Through the integration of cutting-edge research in science and technology with basic education, ESPEM allowed participating teachers to expand their scientific and pedagogical knowledge. According to Tardif (2002), teaching practice is formed by different types of knowledge: professional training knowledge, disciplinary knowledge, curricular knowledge, and experiential knowledge. For Shulman (1986), there is a minimum repertoire of knowledge necessary for teaching practice, a concept that combines content with pedagogy. In 1987, Shulman explained PCK, which for him involves understanding, transformation, teaching, evaluation, reflection, and new understanding, and is the content planned and delivered in the teaching action. Park and Oliver (2008) contribute by adding new components to the PCK, including knowledge of teaching guidelines, knowledge about student understanding, knowledge of the curriculum, knowledge of instructional strategies for teaching, knowledge of learning assessment, and teaching effectiveness. These different conceptualizations of knowledge and teaching practice were considered in the development of ESPEM, to provide teachers with a comprehensive and up-to-date understanding of the field.

Some authors tend to agree on the types of knowledge necessary for the teaching profession. According to Pimenta (1997), three types of knowledge are interrelated: subject matter knowledge (a teacher's knowledge of the subject they teach), pedagogical knowledge (a combination of subject matter knowledge with knowledge of education and teaching), and experiential knowledge (the teacher's experiences in their context). The ideas of Carvalho and Gil-Perez (2011) contribute to the necessary knowledge repertoire in science. The authors suggest what science teachers should "know" and "know how to do" in their teaching practice, based on the idea of learning as knowledge construction and the need to transform a teacher's spontaneous thinking (Carvalho and Gil-Pérez, 2011).

According to Guskey (2000), evaluation of professional development courses can be divided into five levels. As ESPEM is a field of research, these levels would be: i) Initial reaction of teachers immediately after the completion of ESPEM; ii) Learning of the participants on the topics covered in the course directly (only with the classes) or indirectly (with the study of the topics according to the sources presented by the organization); iii) Organizational support and transformation of the environment in which the participant is professionally immersed (the school where the teacher works) after participation, to encourage the application of the concepts learned in the course; iv) Use of new knowledge and skills by participants from the information acquired in the course. v) Learning outcomes

of students who took classes after the teacher participated in ESPEM, recognizing the change in the teacher's attitude.

In the discussion between the different authors and approaches, it can be concluded that Guskey's (2000) perspective aligns with the views of Park and Oliver (2008) and Shulman (1987) on Pedagogical Content Knowledge (PCK). The first two levels identified by Guskey, are the initial reaction of the teachers and the learning of the participants either directly or indirectly, along with the fourth level that pertains to the learning of new methodologies and skills acquired during the course, associated with the pedagogical experience of the teachers, provide a positive assessment of professional development courses from the perspective of the participants.

The aim of this paper is to answer the following question: "How did ESPEM contribute to the training of basic education teachers, in the dialogue between teachers from all over Brazil and in the production of updated teaching materials that value Brazilian science and technology?"

Method

The collection of data was carried out in three steps. The first step in data collection took place before the ESPEM course and involved a documentary analysis of the letters of intent submitted by the selected teachers. In November 2018, after selecting the participants from over 200 candidates, the 20 letters of those chosen for the January 2019 course were analyzed. In November 2019, out of 109 candidates, 35 were selected and their letters of intent were analyzed.

This section of the research involved document analysis, which followed the methodology outlined by Bardin (2011). After reviewing the letters of intent of the selected candidates, the researcher identified common and relevant points for the study and grouped them into categories (GARNICA, 1997).

The second phase of data collection occurred during the course and involved comprehensive and participant observation. The researcher was fully immersed in the field of study, which was not an easy process, as human relationships and behaviors were intertwined with data collection. According to Marconi and Lakatos (2011), the researcher needs to participate fully in the community or group being studied, to the extent that they become a member of it, experiencing everything the group experiences.

Participatory observation, as a methodological procedure for data collection in this part of the research, follows an ethnographic approach, which involves a detailed description of the routines of the group being studied (Bogdan and Biklen, 2006). Ethnographic qualitative research, which employs participant observation, allows for interaction between the research subjects and the researcher, enabling the subjects to voice their perspectives while generating reflections and actions about the group during data collection (Mattos and Castro, 2011).

The third stage of data collection was carried out after ESPEM in four ways: the first with the response to an online form immediately in the week following the course; a second with a small questionnaire, months after the course, with some participants chosen at random, by a cell phone application; the third with semi-structured individual interviews with four randomly chosen teachers, two from the 2019 course and two from the 2020 course; the fourth was a remote focus group with eleven teachers (who did not participate in the semi-structured interviews), also randomly chosen, five from 2019 and six from 2020. The focus group was mediated by the three authors, lasting about 1.5 hours, in which eleven teachers participated, those who did not participate in the semi-structured interviews, five from the 2019 edition and six from the 2020 edition and took place remotely due to the COVID-19 pandemic.

Application of different data collection modalities

Data collection before ESPEM: an analysis of letters of intent

Document analysis is a set of operations aimed at representing the content of a document in a different form from the original to facilitate its consultation (Bardin, 2011). After reading all the letters

of intent from the selected teachers, some categories, which were most cited and which are related to continuing education courses, were created inductively.

The first category addressed reports on the “opportunity to exchange experiences with teachers from all over the country”, while the second category was about the “opportunity for training on more advanced topics such as Brazilian cutting-edge science and technology”, as well as Modern and Contemporary Physics. This training aimed to improve physics teaching and make it more interesting for its target audience.

To analyze and evaluate the results of ESPEM for the teachers, and to understand if the ESPEM objectives were achieved, we needed to analyze the expectations of the selected teachers before starting the course and compare them with the data collected during and after ESPEM. The surveyed teachers were not named by the decision of the research group and were identified by the region of their state and the year they participated in ESPEM.

Data collection during ESPEM: a participant observation

Participant observation can be defined as a process in which there is a multilateral relationship between the researcher and the researched, allowing for scientific understanding of the analyzed group (MAY, 2001). This methodology represents an excellent resource for deep immersion in the continuing education course, allowing the researcher to naturally understand the participants' questions.

The large number of teachers from different states and cultures gathered from 8 am to 6 pm for five days, all with the same objective, bringing a climate of unity and cooperation to ESPEM. During the classes and lectures, the participating teachers took on the role of students and, in addition to taking notes on theoretical classes and experimental visits, asked high-quality questions about the application of certain phenomena, generating rich conversations between cutting-edge research and basic education.

The first author was a member of the ESPEM organization, and a teacher of basic education, he was able to be part of the universe of participants and better understand their vision. The first author participated in social relationships and the moments "backstage". At the same time, it was possible to understand the demands of the organization and sought to improve dialogue between the parties.

There are significant advantages to participant observation since the observer's prolonged contact with the analyzed group increases the likelihood of attaining more accurate interpretations. This higher degree of personal involvement and identification with issues of professional affinities results in increased credibility.

Several types of records can be utilized in participant observation, and for this research, the researcher was able to take notes and make recordings throughout the course using a cell phone. The researcher recorded the speeches of the participants that pertained to questions about completing the continuing education school using writing and audio applications. Some of these excerpts were chosen for analysis and compared to the letters of intent before the course and the interviews conducted after the course to evaluate the ESPEM results.

The programming for the two versions of ESPEM in 2019 and 2020 aimed to immerse the participating teachers in the laboratory complex. The week-long course consisted of lectures, theoretical classes, visits to experimental stations, and time for informal conversations between researchers and ESPEM participants. The day concluded with presentations of the research conducted there and group meetings of teachers to develop pedagogical proposals for the implementation of the material covered in their respective schools.

Data collection after ESPEM: an evaluation of the participating professor and the organizing institutions

After ESPEM, one of the objectives was to understand the results generated and evaluate them. This evaluation was conducted in two ways. The first involved examining the aspirations of the participating teachers, which was in line with the references of authors who follow the conceptions of Pedagogical Content Knowledge (PCK), and the knowledge necessary for the teaching profession (Tardif, 2002; Shulman, 1986, 1987; Park and Oliver, 2008; Pimenta, 1997; Carvalho and Gil-Pérez, 2011). The second path followed the line of Guskey (2000), in which we analyzed the collected data to identify whether ESPEM reached the five levels categorized by the author through the participants' statements.

Since there were 55 participants in the two editions of ESPEM, the research group decided to use a strategy with different data collections to increase the field of response after the course. Four semi-structured interviews (Manzini, 1991) were conducted, focused on subjects that go according to the script of questions, but also contemplating other questions momentarily during the interview. This type of interview allows for freer information gathering than standardization of alternatives (Manzini, 1991).

A remote focus group was also conducted with 11 participants who did not participate in the semi-structured interviews to collect different information from the previous ones. This focus group was conducted on a virtual platform in a meeting that lasted 1 hour and 40 minutes, with all participants having their cameras on. Six teachers from the 2020 edition and five from 2019 participated, in addition to the authors of this work. The meeting was recorded, and all data were transcribed for later analysis.

Research with a focus group aims to detect information, concepts, attitudes, experiences, and reactions through the exchange of ideas and group discussions in a more complete and faster way than in observations, interviews, or questionnaires (Morgan and Krueger, 1993).

In addition to the interviews and focus group, a survey was conducted through a form for all 55 participants immediately after the completion of the course, and a questionnaire with open questions for 10 other participants months after the completion of each edition. Open-ended questionnaires have advantages as they are conducted individually, allowing respondents the freedom to express themselves and provide meaningful comments and explanations that help in data collection (Mattar, 1994).

The data collected from the interviews, a focus group, and questionnaires were transcribed and analyzed and categorized (Garnica, 1997). These categories were divided according to the course evaluations in the teachers' view and the view of the course organization for this part of the research.

Results and Discussion

Table 1 presents the results of the analysis of the letters of intent of the candidates before ESPEM. It was identified two main categories: 1) opportunity to exchange experiences with teachers from all over the country; 2) opportunity for training on more advanced topics such as Brazilian cutting-edge science and technology.

Table 1. Analysis of the letter of intent of the candidates before ESPEM

Edition	Region	Report	Category
2019	North East	<i>"The event aroused my interest in having the opportunity to exchange with high school experiences from various parts of the country, thus being able to seek new resources and alternatives to introduce teachers to the high school of Modern Physics in Education and the EJA modality in the future."</i>	1 and 2
2019	Southeast	"Participating in a school like this is a unique opportunity because, in addition to getting to know a modern research center, there is an	1 and 2

Edition	Region	Report	Category
2020	North East	important space for exchanging experiences with researchers and other physics teachers." "Training at ESPEM is a unique opportunity for learning, networking, and motivation for a teaching career. We, teachers in the Northeast region, experience structural problems in the educational system and have limited chances for professional development in physics teaching."	1
2020	Southeast	"Develop activities and/or projects together with the new network of teachers who graduated from ESPEM 2020, enhancing interactive learning through the use of communities via the internet, exploring the relationship between classes from different schools"	1
2019	Midwest	"I propose to gather proposals on how to make the classroom more interesting for students and how to work on more advanced topics with practical approaches to these concepts."	2
2020	North East	"My professional objective is to bring to high school classrooms a scientific discussion of current Modern Physics, with rigor and theoretical criticism in a language accessible to students to assist them in the teaching and learning process, as well as in the process of development of a critical and participatory spirit focused on the new demands of the 21st century."	2
2019	North	"...the opportunity to participate in the Synchrotron School and learn about the activities developed in the laboratory as well as the countless applications of synchrotron light (...) allows us to show students that Physics is everywhere, given that One of the many difficulties of students is precisely in "seeing" and understanding its application."	2
2019	South	"Making complex concepts of Modern Physics familiar to teenagers requires a professional qualification of another order of magnitude."	2

During the event, some observations were recorded and then compared with interviews carried out by the same teachers, in which the influence of ESPEM is obvious in teacher training. Table 2 presents a comparison between the reports of the participants during ESPEM and afterward interviews.

Table 2. Comparison between the reports of the participating teachers during the course, and afterward interviews.

ESPEM	Report during ESPEM	Report after ESPEM
2020	"I was very discouraged with the career of a physics teacher, in which I did not see many prospects for professional development, but here at ESPEM, the topics discussed here, encouraged me to seek a new career path, as soon as I return to my city I will look for something in my area."	"I was discouraged and didn't want to do my master's last year. Then, I got motivated with ESPEM, I'm doing my Master's, and the educational product will be Modern Physics! She already has an embryo, and by December everything will be fine."
2019	"Man, I urgently need to download and print these cards, as I'm sure my students will be very interested in this. This virtual reality and augmented reality that Régis showed us will bring my students closer to science, students who may never be able to leave their cities."	"...I took that Accelerate app with a student who is a scholarship holder here at the planetarium, and as soon as we returned I did a study with him on what Sirius was, and we created that institutional video inside the planetarium. So, in all the sessions we hold at the planetarium, we talk about Sirius. In 2019, we made a lot of movement regarding schools. We attended more or less 19 schools, and we also went to the countryside, in the state of Rondônia. We went to Ariquemes, Guajará-Mirim, and the mall in Porto Velho. We set up the planetarium... But at the Porto Velho mall, we couldn't set up the accelerator system because of their scheme"

ESPEN	Report during ESPEM	Report after ESPEM
		<i>inside. So we just showed Sirius' movie. Then we had another lecture. So, at UniNorte, it was for a group, it was very crowded and it was nice because it generated a lot of curiosity from electrical engineering students from various periods. And then, there in Guajar-Mirim and Ji-Paran, with Higher Education and High School students, it was also quite interesting."</i>

Regarding the initial reaction of the participants after completing ESPEM, there was almost unanimity in their positive evaluation of both the perspectives of this research - the evaluation of the participating teachers and the evaluation of the course. Below, we present an example of each relationship between the reports of the participating teachers that correspond to the research objectives. Table 3 presents the teachers' reports after completing ESPEM.

Table 3. Reports from teachers after ESPEM

Category	Reports
Participants' initial reaction	<i>"...the school served as a watershed for most of all teachers there. Because most had a very clear experience in the classroom with High School. We had an experience of dealing with this public, but this enrichment of what we lived there (at ESPEM) helped us a lot daily. Our bond with Sirius School was very positive."</i>
Theoretical concepts covered in the course related to the teacher's experience and future pedagogical strategies	<i>"...we participate in some moments of pedagogical enrichment throughout the week. So, we observed those who taught us, bringing theoretical content and an approach to the topic. And then, we had the chance to talk among ourselves to think about the best way to apply these contents. What happened? We managed to organize this in our daily lives, because this set of experiences, both of those who gave the lectures and of the colleagues who exchanged ideas, certainly gave us conditions to expand our thinking, think about new concepts, how to better organize the concepts, what we should present at first, what to present at the end of the class. How to apply this? When and how do you talk to students? So, it helped us a lot to make this strategy more focused, and more coherent. Gives us one more plan. It allows us a more detailed, more qualified planning. So, it was very productive in that sense, yes, for sure!"</i>
personal and attitudinal development	<i>"On my return, as soon as possible, I got in touch with the Regional Management of Education in my city to develop the training project for physics teachers: Developing proposals for Teaching Physics using SIRI."</i>
the learning of new knowledge among the participants	<i>"The "new knowledge" I used was when I went to deal with the radiation process of synchrotron light for studies and research development in Brazil. For evaluation, I used Plickers, which was presented by one of the ESPEM participants."</i>

A participant from the 2020 edition comments on the importance of teachers understanding the cutting-edge and quality research carried out by Brazilians:

"Before ESPEM, I had already participated in the Astronomy Olympiad... Space Journey! I went with a student of mine who qualified, and I went to INPE (National Institute for Space Research). Then, I had this impact... I said: "Wow! Brazil does quality research!" And I get very upset, very sad when people say "Ah! Brazil, right?" as if they were belittling the capacity of our people. That completely changed my mind. And ESPEM came and finished changing, you know? Now I have the clarity that, as a teacher, one of my missions is also to open the eyes of our students that we need to stop having this bad view of our people, and our ability. We must show that we have the capacity, like any other people in the world, don't we? And then, just as I saw in another research center, I also saw in Sirius that fantastic world that we all had the opportunity to know, and to see the work of those super, ultra-competent, wonderful people! So, it was this impact and this change in Education that I

think is very necessary! We must take this view of the colonized and become the protagonists of our history. Stop just admiring others and admiring our achievements too. We must tell you what our Brazilians do and that it is of the highest quality!”

The participating of both editions kept in touch through a group on a mobile application. In addition to using this medium to exchange information and content with experiences that worked or not, they have access to a storage cloud space created by the organization, which places the presentations and information that took place at ESPEM. A participating teacher in 2020 comments on the importance of consulting this online space:

“Of all the content seen, there was always something I already knew, but I confess that most of the techniques presented were new, when dealing with CNPEM I had to review materials. This year, in February, when the classes started, I already started talking about physics based on modern physics and it was very interesting to see the enthusiasm of the students.”

Some participants followed the proposals suggested by their letters of intent, and some actions such as the creation of courses for teachers and students in their institutes, the elaboration of lectures with CNPEM researchers, and the participation in scientific events to present methodological proposals for the use of the synchrotron radiation in high school.

Thanks to social networks and face-to-face interactions with researchers, the ESPEM teachers were able to disseminate cutting-edge research to various cities. Researchers from CNPEM, particularly from the National Synchrotron Light Laboratory (LNLS), were available to teachers to conduct activities at their institutions. These researchers actively participated in activities proposed by teachers from different regions of Brazil who participated in ESPEM and visited schools in various parts of the country.

It would be impractical to include all the information provided by the 55 teachers who participated in the 2019 and 2020 editions in this paper. Therefore, the research group decided to select a relevant project in each region of Brazil to showcase some of the activities that were carried out after ESPEM. Table 4 presents some of the activities carried out by the teachers after ESPEM.

Table 4. Relevant work carried out by teachers after ESPEM

Region	Examples of teacher actions after ESPEM
North East	Two teachers who participated in ESPEM in 2020 created a continuing education course that worked remotely, called <i>AmpliaCiência</i> (SOUZA and CAL, 2020a). It was a 40-hour course for 17 physics, chemistry, and biology teachers, which aimed to discuss modern science through synchrotron radiation with a focus on the classroom. In this activity, five researchers from the LNLS were invited to present their research to the participating teachers.
Midwest	A participating of the year 2020 created an online program of scientific lectures called <i>Talk with Science</i> (DUARTE, 2020), where she invited several researchers and some of them talked about topics that dialogue with those studied at ESPEM. The target audience included high school students, elementary school teachers, and science curious.
Southeast	A teacher participating in the 2020 ESPEM, who is one of the organizers of the Center for Learning in Experimental Physics (CAFE) (RIZZATO, 2020). She carried out several activities on synchrotron radiation, inviting researchers from CNPEM to present their activities. This cycle of lectures aims to present scientific subjects to high school, technical, and higher education students, in addition to having invited teachers.
South	A teacher at the Instituto Federal Catarinense, a participant in ESPEM in 2020, developed several activities for students, teachers, and administrative staff at her institute. These activities relate to the concepts of modern and contemporary physics, in addition to valuing Brazilian science and women in scientific research for their students and presentations for teachers. A researcher from the LNLS participated by giving a lecture to the entire school community.
North	A teacher from the Instituto Federal do Acre, a participant in the 2019 ESPEM, prepared several activities for his state and neighboring states. He already has extensive experience in the dissemination and popularization of science, and went to the countryside of Acre, Rondônia, and the state of Amazonas, by car, to take science to several schools and universities.

The scope of each of the five examples highlighted above is incalculable. However, it is relevant to conclude that when a continuing education course reaches and motivates certain teachers, and these teachers can apply these significant changes in their spaces of action, the teaching-learning process can happen fluidly. According to Acioly (2015):

“Student motivation is fundamental for teaching and learning processes, not just for Science, but for any knowledge. It is necessary to capture and hold the attention of the student, so that teaching is more effective, as well as more pleasant, both for those who learn and for those who teach. The concept of motivation is linked to the human need for survival.”

One of the researchers who participated in one of these presentations for teachers commented to the group of teachers during a lunch day in the 2019 edition:

“We are concerned with putting together didactic presentations that, at the same time, must go deeper into the content, but must be accessible to teachers, as not all of them had the same training. We were surprised several times with very interesting questions, and we realized that we could delve deeper into a certain concept without any problem. We see that you (the participating teachers) manage to transform that content that was sometimes difficult to understand, into super didactic classes for students in your cities.”

During the XVIII Research Meeting in Physics Teaching, two teachers from the Northeast region who attended ESPEM 2020 presented their work "Synchrotron Radiation in Brazil and Technology in Physics Teaching: Some Proposals" in an oral communication session (Souza and Cal, 2020b). This work was also presented at the Physics Journey at the Federal Institute of Bahia.

The Brazilian Society of Physics (SBF) has proposed the creation of an event room at main scientific events for Physics teaching to disseminate ESPEM to other researchers in Physics education. The event room aims to gather ESPEM participants and present their activities to others.

Thus, the ESPEM organizing committee is committed to bringing cutting-edge science and researchers closer to participating teachers. This commitment was highlighted by a participant at the 1st edition in 2019 who stated:

“I find it very difficult to describe the scenario of a continuing education course for a professional educator. I think the teacher must be constantly willing to update himself and, eventually, sometimes, we don't know the ways to do that, do we? I think we don't know which courses or professionals in the field of physics teaching may contribute to us being constantly updated and informed.”

It was also ratified in the speech of a participant of the 2nd edition, in 2020, when he said:

“...the Sirius School is an opportunity for us teachers to have access to a research center of excellence. And what do we understand about ESPEM and this relationship with SBF, the Brazilian Society of Physics? This is an opportunity for us teachers in the area to have a continuous, targeted education, and to make links with the practical world of cutting-edge research. So, for us, it's a great opportunity. Nobody would want to let this opportunity pass, would they? I think that any teacher who has access to a week immersed there, learning about content that we spend in the day-to-day in the classroom and that we explain, but we would love to see practical applications and in-depth research on the subject.”

Some teachers in both editions reported that due to the pandemic and their school's lack of remote classes, they were unable to apply any activities from March 2020 onwards.

One problem found was that some participants did not comply with the proposals of their letters of intent. After ESPEM, some teachers reported that they were only interested in getting to know the laboratories' complex and were not interested in applying the concepts in their classrooms or sharing the research with their peers and institutions. The organizing committee's main interest is not just to present a scientific space but to look for teachers interested in being partners in bringing state-of-the-art Brazilian scientific research closer to basic education and society.

Another issue was that some schools did not provide any space for teachers to carry out any activities, whether to present to other teachers or to organize events for students. Some teachers reported that the classroom was the only space they had to talk about the knowledge gained from ESPEM and that if they had no connection with the planned content of their discipline, they would not be able to discuss it. Some even shared the feeling of frustration with institutions that do not recognize, or value teacher training and state-of-the-art science and technology developed in Brazil.

This third problem goes against the third level of evaluation of a continuing education course (Gkey, 2000). These external factors often do not depend on the course's organization or the participating teacher but are linked to a structural problem of belief in science or education, particularly in Brazilian quality production.

Conclusions and final considerations

After conducting research on the information collected before, during, and after the two editions of ESPEM in 2019 and 2020, to answer the question "How does ESPEM impact the training of basic education teachers, the dialogue between teachers from all over Brazil, and the production of updated teaching materials that value Brazilian science and technology?", several conclusions can be drawn.

Firstly, the teachers' expectations were exceeded. The concepts learned at ESPEM were beyond what was planned by the teachers. Not only did the teachers get to visit an international reference laboratory and learn about cutting-edge research carried out by Brazilians, but they also had access to institutional materials prepared by the researchers, direct contact with people at the forefront of this cutting-edge Brazilian research, and access to methodologies that facilitated the approach of the contents worked there to present in basic education in their cities of origin. This was more than just a visit to a complex of laboratories but was a continuing education course that contributed to the teacher's professional experience, facilitated dialogue between teachers from different states, and led to the development of different pedagogical proposals in line with the conceptions of PCK and the knowledge necessary for teacher training. (Tardif, 2002; Shulman, 1986 and 1987; Park and Oliver, 2008; Pimenta, 1997; Carvalho and Gil-Pérez. 2011).

From the ESPEM organization's perspective, a professional development course can be evaluated based on five assessment levels (Guskey, 2000). However, there is currently no method of evaluating all these levels. Follow-up work is necessary to evaluate all teachers and the students who had classes related to the contents covered in ESPEM.

Finally, we present a conclusion on each level categorized by Guskey (2000):

1st) Teachers' initial reaction immediately after ESPEM: Practically 100% of the teachers were fully satisfied with the course structure, the covered contents, the technical visits to experimental stations, the contact with researchers and their research, the contact with teachers from all over Brazil, and the understanding that Brazil produces cutting-edge research with a quality to compete with large international laboratories.

2nd) Participants' learning about the topics covered in the course directly (only with the classes) or indirectly (with the study of the topics according to the sources presented by the organization): 55 participating teachers from 22 states plus the Federal District, with varying backgrounds, attended ESPEM. Some had just graduated, while others had postdoctoral degrees. Some teachers had 40 years of experience in basic education, while others were at the beginning of their teaching careers. Despite their differences, they all shared a desire to learn and share the innovations of science and technology produced there. As the topics covered in ESPEM were outside the traditional curricula, virtually all reported learning new concepts and new approaches to these concepts. They also had access to the material used throughout the course, which enabled them to continue their training and study.

3rd) Organizational support and transformation of the environment in which the participant is professionally immersed (the school where the teacher works) after participation, to encourage the application of the concepts learned in the course:

This is perhaps the most difficult category, as it depends on many variables. Each educational institution has its action plans defined by decisions made by people or bodies. Whether an organization defines the importance of changing attitudes or opening a space for teachers to carry out projects or actions of dissemination and teaching depends on the relationships between these bodies and people.

We can divide the organizational support provided to participating teachers into three types:

The first group reported that they received full support from their educational institutions to conduct activities for other teachers, students, and administrative staff, and even to disseminate in

other educational institutions and academic events. Some of these teachers also mentioned that their institution provided a space to develop long-term projects for the dissemination of Brazilian science.

A second group of teachers had partial support from their educational institution. This partial support was limited to one presentation only, or the non-receipt of absence from work due to the presentation of a certificate of participation. Some reported having a certain freedom to talk about the topics covered in ESPEM, but only within the class time and content of their disciplines.

In the third group, teachers had no support from their institution. Some of these teachers reported not having any space to present any type of activity seen in ESPEM, either to their students or to their peers. Some commented that they faced oppressive pedagogical coordination that did not even allow them to talk about the contents seen in the course within their disciplines. Others commented that they did subversive work, where they managed to work on the themes seen in ESPEM within their contents, but without the pedagogical coordination knowledge.

After analyzing this third category, there is an urgent need for greater dissemination of Brazilian research in a language that is accessible to all and through various media platforms. Additionally, didactic materials that relate the contents of science to Brazilian research should be made available to support teachers.

4th) Use of new knowledge and skills by participants from the information acquired in the course:

This category was highly regarded by most participating teachers, as during the course, they participated in pedagogical workshops to discuss proposals for applying the course content in the classroom. Additionally, some researchers presented alternative methods for use in the classroom, such as free mobile applications for virtual and augmented reality or for conducting virtual visits, while others presented educational games to aid in understanding certain content. The exchange of ideas was rich, and after the course, teachers continued to discuss these methodologies in group communication applications on their phones.

The fifth level involves assessing the learning outcomes of students who took classes from teachers after they participated in ESPEM, considering changes in the teachers' attitudes. This level depends on a relationship that can be established between the organizing committee of ESPEM and the educational institutions of the participating teachers, as it would involve analyzing what students learned after their teachers participated in the course and the activities that they carried out. This category can also be analyzed in terms of changes in students' attitudes towards the information provided by the participating teachers.

Evaluating a continuing education course can take years and requires partnerships from various institutions. However, we were able to answer the research question, confirming that ESPEM significantly contributes to the training of basic education teachers, promotes dialogue between teachers from different regions, aids in the production of pedagogical methodologies for classroom use, and contributes to the dissemination of cutting-edge Brazilian science and technology produced by Brazilians.

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