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Experiences of mediation in a Science Center: implications for the initial training of physics teachers

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Abstract: This work investigated the implications that mediation in a Science Center can promote in initial education of future physics teachers. The qualitative research was carried out with undergraduate who act as mediators in a Science Center integrated with the formative activities of a Federal University in the State of Minas Gerais, and semi-structured interviews were used as a data collection instrument. The interviews were analyzed qualitatively, and it was possible to notice that the performance in the non-formal teaching space has direct implications in the performance of the undergraduates in the classroom, either during the internship period or during their training, in addition to contributing to a broader understanding of teaching and learning processes.

Keywords*:* Mediator. Science Teaching. Science Museums. Non-Formal Education. Teacher Training.

Experiencias de mediación en un Centro de Ciencias: implicaciones para la formación inicial de profesores de Física

Resumen**:** Este trabajo investigó las implicaciones que la mediación en un Centro de Ciencias puede tener en la formación inicial de los futuros profesores de Física. La investigación cualitativa fue realizada con estudiantes de grado que actúan como mediadores en un Centro de Ciencias que está integrado a las actividades de formación de una Universidad Federal del Estado de Minas Gerais, y se utilizó como instrumento de producción de datos entrevistas semiestructuradas. Las entrevistas fueron analizadas de forma cualitativa y se pudo percibir que el desempeño en el espacio de enseñanza no formal tiene implicaciones directas en el desempeño de los estudiantes de grado en el aula, ya sea durante el internado o a lo largo de su formación, además de contribuir a una comprensión más amplia de los procesos de enseñanza y aprendizaje.

Palabras clave: Mediador. Enseñanza de las Ciencias. Museos de Ciências. Formación del Profesorado. Educación no Formal.

Experiências de mediação em um Centro de Ciências: implicações para a formação inicial de professores de Física

Resumo: Este trabalho investigou as implicações que a mediação em um Centro de Ciências pode provocar na formação inicial de futuros professores de Física. A pesquisa qualitativa foi realizada com licenciandos que atuam como mediadores em um Centro de Ciências que está integrado às atividades formativas de uma Universidade Federal no Estado de Minas Gerais, e utilizou-se de entrevistas semiestruturadas como instrumento de produção de dados. As entrevistas foram

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analisadas de forma qualitativa e foi possível perceber que a atuação no espaço de ensino não-formal acarreta implicações diretas na atuação dos licenciandos em sala de aula, seja no período do estágio ou ao longo de sua formação, além de contribuir para uma compreensão mais ampla sobre os processos de ensino e de aprendizagem.

Palavras-chave: Mediador. Ensino de Ciências. Museus de Ciências. Formação de Professores. Educação Não-Formal.

1 Introduction

Training teachers to face the difficulties and unpredictability that the educational environment imposes requires trainers and graduates to recognize the complexity of the teaching activity. As Brito (2011) points out, it is in the initial education that the articulation theory/practice can be effective to train critical and, above all, creative teachers, to overcome proposals centered on instrumental and technocratic rationality. Supervised internship is one of the mandatory curricular components that provides the future teacher with an approximation with the reality of teaching practices, with the social conditions of the exercise of the profession and with being a teacher (BRITO, 2011). However, although it is an important period to experience the practical knowledge of the profession, it is still considered insufficient (MILANESI, 2012; TEMPESTA and GOMES, 2017).

Vieira, Bianconi and Dias (2005) point out that preparing teachers throughout graduation to teach different types of classes can be a strategy to minimize future difficulties and conflicts they will encounter in the classroom. Thus, as the Museums and Science Centers are recognized as intrinsically educational institutions (MARANDINO, 2008), mediation in these spaces can be one of the ways to promote the integration between theory and practice in the training of graduates, in addition to allowing future teachers to build a list of knowledge and experiences to seek support in professional practice (OVIGLI, FREITAS and CALUZI, 2010).

In Museums and Science Centers, the intervention of mediators, also called guides, monitors, educators, science communicators or helpers, can promote better interaction of visitors with the collections (BERDNIKOFF and SILVA, 2020). The mediators are people who work in direct contact with visitors and, according to Marandino (2008), they implement communication between institutions and the public through a dialogue that allows giving new meanings to exhibitions and bring the public closer to scientific knowledge (TEMPESTA and GOMES, 2017). These professionals live with unforeseen situations that require the systematization of problems, reflection,

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and improvisation (MARANDINO, 2008). Because they are in contact with scientific knowledge, exhibition and the visitor, they must go beyond the simple repetition of decorated texts and open spaces for visitors to get involved with what is being experienced in the space (TEMPESTA and GOMES, 2017).

In this context, education characterized as non-formal[3], which sometimes has well-defined educational objectives, but operates outside the formal system (MARANDINO, 2008; VIEIRA, BIANCONI and DIAS, 2005), has pointed out positive aspects for the training of graduates who work in these spaces. Among these aspects, contact with the school public can bring the licensing-mediators closer to situations experienced in the classroom, teach them how to talk to different audiences and deal with unexpected and complex situations, develop different teaching methodologies, besides having an additional tool to use in their didactic planning (TEMPESTA and GOMES, 2014).

Lau and Sikorski (2018) present that in Museums, teachers can develop knowledge of content, learn new approaches to teaching, gain confidence in Science Teaching, and develop ideas on how to use the resources in the classroom. According to Ibáñez (2021), museums can expand the margins of action in the school context, allowing the use of innovative strategies.

In physics education, the activities carried out in the non-formal scope can contribute to the training of undergraduates given the need to train professionals for specific didactics and so that they can "approach physics in order to arouse interest, intentionality, predisposition of students" (MOREIRA, 2018, p. 76). As presented by Delizoicov, Angotti and Pernambuco (2018), the professional performance of science teachers is not reduced to the mastery of procedures, conceptualizations, models, and theories, but requires considering specificities of the area. As Science Teaching is not done exclusively in the school space (BACK et al., 2017), training teachers in different contexts and with different experiences still in initial training can bring significant relationships in the general scope, and in Physics in particular.

Freitas and Pacific (2015) also highlight that teaching knowledge is plural and is not reduced to a content knowledge, being necessary a solidified formation in

[3] Although the definition of non-formal education is complex and polysemic (MARANDINO, 2017), we will adopt in this work the literature review that considers museums and science centers as non-formal spaces of education (BONATTO, SEIBEL and MENDES, 2007; MARANDINO, 2008).

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concepts and practices that will serve as the basis for the necessary adaptations in the face of changes and transformations of society. For Tardif (2010), teaching knowledge is not limited to the transmission of knowledge produced by others, but integrate plural knowledge from professional training, disciplinary, curricular and experiential knowledge. Ovigli, Freitas and Caluzi (2010) point out that the knowledge of mediation, as well as the teaching knowledge, are constructed over time and are constituted by knowledge of content, skills and values that allow professionals to act in teaching.

However, although most often the mediators of the Museums and Science Centers are university students from the courses of Biology, Sciences, Physics, Mathematics and Chemistry (OVIGLI, 2009), which enables them to bring the knowledge constructed throughout the course to act in these spaces, the knowledge of mediation is predominantly experiential, since there is no specific training for the work of mediator (OVIGLI, FREITAS and CALUZI, 2010). According to Tardif (2010), the knowledge experiential emerges as a vital nucleus of the teaching knowledge and it is formed by all the other. They are not knowledge systematized in doctrines or theories, they are practical knowledge by which teachers interpret, understand and guide their profession and daily practice (TARDIF, 2010).

Thus, considering both the importance of articulating theory and practice in the initial formation and the educational aspect of Museums and Science Centers, Ovigli (2009), Ovigli, Freitas and Caluzi (2010), Tempesta and Gomes (2014) point out that associating undergraduate students with non-formal education spaces can bring significant contributions to the training of these future teachers. However, the same authors highlight that the number of studies that seek to understand the contributions of these spaces to teacher education is still reduced. Thus, we wonder what implications can acting in a Science Center bring to the initial training of Physics graduates? How can the role of mediator broaden the understanding of teaching work? Mediation at the Science Center interferes with the performance of undergraduates in the supervised internship period when students can articulate the knowledge acquired throughout graduation and experience the professional activity of teaching?

Based on these issues, the present work sought to investigate what implications the performance in a Science Center can bring to the initial training and pedagogical performance of undergraduates in Physics.

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2 Methodological Procedures

This research is configured as qualitative because it adopts strategies and procedures that allow the researcher to take into account experiences and points of view of the informant, in addition to having the natural environment as a direct source of data, being descriptive, be more interested in the research process than the final product and perform the analysis inductively, in which abstractions are constructed from the data produced, giving to the built meanings a vital importance (BOGDAN and BIKLEN, 1994). To investigate what implications, the performance in a Science Center can bring to the initial training and pedagogical performance of undergraduates in Physics, the research was carried out on the *campus* of a Federal University of the State of Minas Gerais, which has a Science Center integrated to training activities.

The participants of this research work in this Science Center consisting of a space of approximately 500 m², with five Physics-themed rooms and one of Mathematics. In the space work graduates of Physics and Mathematics who participate in one of the university's Tutorial Education Program (TEP) groups. Law no. 11,180, established on September 23, 2005 (BRASIL, 2005), and Ordinance no. 343, of April 24, 2013, which updates Ordinance no. 976, of July 27, 2010 (BRASIL, 2010; BRAZIL, 2013), govern this program and establish that it be developed in groups of undergraduate courses of higher education institutions in the country with the tutoring of a professor, to work inseparably on teaching, research, and extension activities.

The choice of graduates in Physics took place as a criterion for this research and by the fact that researchers understand that, as the space addresses a larger number of themes in the area, the implications in the formation of this group may be greater. Thus, given the objectives of the research, five subjects were chosen by the area of formation, for acting as mediators of a Science Center, and for having completed the mandatory internship period of the course.

The interview was used as an instrument for data production, which is a technique of social interaction with asymmetric dialogue in which one of the parties seeks to obtain data from another, which is the source of information (GERHARDT and SILVEIRA, 2009), and by allowing the investigator to interpret the way those investigated understand a phenomenon and the reasons that lead them to assume a certain point of view from their languages (BOGDAN and BIKLEN, 1994). We opted for the semi-structured interview to obtain comparable data and the various subjects

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(BOGDAN and BIKLEN, 1994), and because this type of interview admits that the researcher encourages the interviewee to speak freely about subjects that are unfolding from the main theme (GERHARDT and SILVEIRA, 2009).

The questions of the interview were formulated from the objective of investigating the implications that the performance in a Science Center can bring to the initial training and for the future performance of the undergraduates in Physics, seeking to identify why the graduates decided to act as mediators of the Science Center, the time of action in space, the difficulties encountered to mediate the visits, how mediation interferes in the training of undergraduates, considering the supervised internship period and the compressions that this performance promoted on the teaching work.

Data analysis was performed through a qualitative proposal that, according to Yin (2016), it is composed of a cycle of five phases that do not fit into a linear sequence but have recursive and iterative relationships. The first phase of the cycle is *compilation*, in which, through the exploration of the material, the researcher will classify field notes thus creating a database. The second phase is the *decomposition* of the data compiled into smaller elements and may or may not be accompanied by the assignment of new labels. In the third phase, in a process of *re-composition*, it is the time to think more broadly about the meanings presented in the data, seeking new understandings and patterns. In the fourth phase of the cycle, the decomposed material is used to create a narrative and *interpret* the recomposed data and, finally in the fifth phase, the researcher *concludes* his study by reevaluating the previous phases.

Preceding the interviews, the undergraduates signed a Free and Informed Consent Form giving consent to carry out the research and stated that they were informed about the objectives of the study. After the interviews, the statements were fully transcribed and from the proposed analysis procedure we identified three emerging clusters according to Chart 1.

Table 1: Emerging groupings

Grouping	Description
Performance of the undergraduates	Implications that mediation in the Science Center brought to the performance of undergraduates in the classroom
Understanding the teaching	Influence of the performance in the Science Center for the

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and learning processes	understanding of the teaching and learning process s
Contributions throughout initial training	Contributions of the performance in the Science Center throughout the training of undergraduates in Physics

Source: Prepared by the Authors

The details of the groupings and the analyses carried out from the reports of the licensee-mediators will be presented later. To preserve their respective identities, the five subjects of the research will be identified as M1, M2, M3, M4 and M5, and in the excerpts the name of the space investigated was replaced by Science Center.

3 Analysis Results

The analysis was performed after the transcription of the interviews and, before starting the questions that guided the investigation and unfolded in the clusters that emerged from the analysis, we sought to identify the time of action of the mediators and why they chose to participate in the TEP group that operates in the Science Center.

The interviewed undergraduates joined the TEP group to act as mediators of space in the second (M1, M2, M3), third (M5) and fourth (M4) semester of their graduations. They have been working at the Science Center for three and a half years (M1, M2, M3, M4) and three years (M5). As for the reason why they joined the TEP group and, consequently, became mediators of the Science Center, M1 and M3 report that the main reason was financial aid granted through a scholarship; M2 had an interest in acting in the space before even entering the course, in a visit he made with high school teachers; M4 realized that colleagues who were acting in space had "[...] a better resourcefulness, who were being able to speak without fear" (M4) in classes in which they had to present work. The mediator also reports that

> *[...] I've always worked with the public, so I have an ease to talk, only when it's a more formal thing I stop, so I was always afraid to say some wrong term, something like that, then I'd lock it. And not here, because you have audiences of all ages, of all grades, so you have to adapt, and here we learn that. (M4)*

M5 reported that he wanted to join the TEP group for the possibility of conducting a scientific initiation research and he learned the group's activities, as well as the mediation work carried out by the undergraduates at the Science Center. It should be reported that conducting research, with teacher guidance, is mandatory for the scholarship holders and optional for TEP volunteers.

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The reasons for working in the Science Center appear to be varied and not necessarily the undergraduates seek the activity to improve the knowledge acquired in the undergraduate course. In the space investigated, undergraduates can work with themes close to their training (Physics and Mathematics); however, in many cases the mediators of museums and Science Centers have a diversified background, either in the specific areas of sciences or humanities, or in more technical areas (MARANDINO, 2008).

With regard to emerging groupings, we identified the security to speak, the appropriation of content, the search for different resources and ways of teaching, and the development of a more contextualized teaching with the *implications that mediation in a Science Center can bring to the performance of undergraduates in the classroom.*

In the report of the five mediators, it was possible to perceive that the performance in the space allows the students to acquire security to speak, which contributes to the performance in the space and in the classroom.

> *[...] at first, I was kind of, kind of shy, right? with the visits, I saw the staff explaining and the staff explaining super well, speaking of things, but I think already, right on the first visit I tried to risk an experiment that I had more security, and then I was developing from that first contact, and I started to open up more to explain physics and talk about physics more naturally. (M1)*
>
> *[...] on several visits I had the opportunity to err many times and bet on different explanations, and I felt very free to do that, and I think it was very important because I can take an experiment and talk quietly about its physics, and I think this is largely due to the activities I've developed here. (M2)*

M3, M4 and M5 report that in addition to learning about the experiments, they learned to "not stutter" (M3) in the explanations, that "you're going to lose the fear of explaining something you never explained [...]" (M4), and that space helps in communication because "at the beginning we always arrive a little shy, with a little shame and this, with time, we lose" (M5). About having acted as a mediator in a Science Center still in the initial formation, M3 reports that

> *[...] it was more like basic preparation, to have more security to work on the concepts, for example, it was a good chance to err and go correcting myself, shaping my explanation of what was being discussed, then I realized that when I got to supervised stage III, which is the first one we really do regency, I didn't already have, I wasn't nervous to teach, I had already contacted classes of different age groups all the time, so when I got there, I gave the class. So, I think the Science Center serves to build a security in the teacher, mainly in undergraduate students, and to act really, for him to go there and teach a class about it, to go there and talk about this concept, talk about that issue. (M3).*

As Ovigli (2009) points out, mediation activities may mirror future actions of

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Basic Education teachers. The author identified that the mediation of the science exhibitions contributed to the development of communicative skills in the undergraduates, reflected even in the undergraduate course, and considers this to be one of the professional knowledge areas that the future teacher can develop in studies and internships in centers of scientific dissemination. For Tardif (2000), professional knowledge is appropriate knowledge, incorporated and subjective by people according to their experiences and, as the excerpts show, this "preparation" that the mediators say they have in the space made them feel safer to communicate and to deal with physical concepts in their classes.

Regarding the appropriation of content, M1, M2 and M3 report that the context of space challenge, that encourages you to think of the best words, terms and how to get closer to visitors, makes them think more about what and how they are teaching.

> *[...] depending on how I felt a little about the class, whether it was more or less shy, or else I made successions with those things they could get, whether they were more playful things or not, so that helped me talk about physics more naturally. (M1)*
>
> *[...] I believe that the fact that we are put in different situations, because one thing is you explaining to a child, another is you explaining to a teacher, another thing is you explaining to a disabled person, which cases have happened, these are challenges that are posed and this prepares us to face the school context, for example, with very diverse people, and allows us to acquire a slightly greater domain over what we are talking about. (M2)*

There is a consensus in the literature that knowing the content to be taught is one of the main formatives needs of the Sciences teacher and, as Carvalho and Gil-Pérez (2011) highlight, the lack of this knowledge can cause teachers to have difficulties in innovating in their practices, becoming mere transmitters of content. Lopes and Lima (2019) agree that a good physics teacher needs to know deeply his area of knowledge to satisfactorily fulfill the teaching function.

Another consequence of the work in the Science Center was the search for different resources and teaching methodologies within the classroom. M1, M2, M3, M4 and M5 report that they learned to speak of Physics in different ways, whether with sophisticated experiments, in a more theoretical and mathematical or more conceptual way, in addition to being encouraged to use different features when possible.

> *[...] regarding the Science Center, I think the biggest contribution in my teaching practice was actually trying to bring something more experimental into the classroom, always trying to bring something that would show the physical phenomenon itself, to them, not to get too abstract on what physics we were working on, so, for example, in the instrumentation disciplines for the Physics Teaching I brought, I tried to bring experiments; in the internship I frequently brought*

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> *them or, if they were not experiments, they were technological devices that spoke of the experiment which, then, helped such as simulators, or applications or whatever it was that dealt with the issue. (M1).*
>
> *[...] whether one wanted it or not, the Science Center was like a sample, even though it wasn't a classroom, it is a sample of how to deal with students and everything else, more focused on that; despite the fact that I wasn't there to teach a class, I wasn't giving a class, which is content that is tabulated, neat, but the physical contents and everything else we could learn with a different language. (M5).*

In the research of Tempesta and Gomes (2017), which seeks to identify the contributions of the performance in Science Museums after training in the Physics degree course, one perceives the need to redefine the knowledge acquired in the course, including historical and technological aspects that they would not have learned in another situation. Ovigli (2009) highlights that the mediator must develop skills and abilities to guide his daily practice, as well as the teacher in the classroom. The author recalls that teachers teach classes to people of different social, cultural, age and school levels and they also need to adapt the content to the groups and individuals with which they work.

The ability to interact and act through conflict situations that request interpretations and decisions of teachers are knowledge developed in experience and not knowledge about an object or practice (TARDIF, 2010). In this research, we identified that exploring different explanations and reflecting on the effects of visits to the Science Center caused undergraduates to seek new resources and improve their pedagogical practices when conducting classes.

Furthermore, M2 and M3 recall that there is limited access to resources in the Brazilian school context, especially in public schools, and that these spaces can fill this gap by more sophisticated experiments that, for example, low-cost experiments cannot supply, showing the need of the teacher to seek different sources to prepare the class when their reality is limited.

The development of a more contextualized and articulated teaching to the reality of the students was another aspect that M1, M2, M3 and M4 pointed out as necessary in the Physics Teaching, highlighting that the performance in the space makes them realize its absence and want to take it to the classroom.

> *[...] in the Science Center they are tangible things, these are things that we always try to associate with everyday things, and these known associations have always made me also take this to the classroom in my practices within the internship or at other times, even in private lessons it was also evident. (M1)*

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> *[...] but the idea that the teacher's practice should not be exclusively of content, that you can talk about physics without getting stuck in equations, you can talk about cool phenomena, of interesting things that are part of people's lives and this, mainly, I was able to learn here in the space; although teaching practices bring some elements in this sense, they cannot handle it on their own. I think the program, the space, the visits, they all contribute invaluably in this sense. (M2)*
>
> *[...] students, especially high school students, want to see what happens so, when there's something playful, whether it is an analogy, who knows, like a ballerina dancing on ice, they can assimilate better. (M4)*

For Ovigli (2009), contextualization is a recurring resource in the didactic transpositions carried out in the Museums and Science Centers to bring the exhibitions closer to the visitors. Although there is no consensus definition of what contextualized Physics Teaching is, one of the approaches is to consider that the school has the "[..] role of providing students with the capacity to abstraction and to understand the relationship between a theoretical model and the reaction" (RICARDO, 2010, p. 33). For Ricardo (2010), it is necessary to understand that Physical Science and School Physics are not the same thing, being necessary that the future teacher to develop the ability to insert Science and its technologies in a historical, social and cultural process and recognize practical and ethical aspects of science and then, relate it to the real world.

Thus, the moments of interaction in the Science Center articulated to the training in the Physics course make the licensing-mediators understand that "[...] Science builds models and, therefore, modifies the real" (RICARDO, 2010, p. 35). As Bonadiman and Nonenmacher (2007) point out, the student's perception of the importance of content for their education and life can provide favorable conditions for learning. Thus, from the excerpts, it is perceived that the frequency with which they exercise the ability to relate Science to reality in the Science Center makes them identify the benefits of this articulation and want to take it to the classroom. For Delizoicov and Angotti (1992), the discussion of everyday situations is favorable, not only from the point of view of effective learning, but also to develop interest in Physics, because the use only of sometimes disconnected concepts, exercises and tests can cause conflicts between the students' previous knowledge and what is presented by the teacher to prevail.

In this research it was possible to realize that acting in a Science Center contributes to *the understanding of teaching and learning processes*. Mediators report the complexity of the teaching process when pointed out that

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> *[...] one cannot delve into the explanation because time is short, there are several experiments, but at least show them that certain phenomena exist, they're going to stick with that and go through a process of appropriation of these things that happen in nature and, later when dealt with in the classroom, they will resume these issues. (M2)*

In this excerpt it is possible to identify that the undergraduate understands that the teaching process occurs gradually, at various times, and the Science space is one of the places where students can have contact with the scientific concept. Para Ovigli (2009), Museums and Science Centers do not build concepts with a high degree of complexity but enable contact with mechanisms and processes of science with different languages and forms of human thinking, besides the concepts relevant to exhibition apparatus (OVIGLI, 2009).

Another element that indicates this understanding of teaching is to recognize that teaching requires more than disciplinary knowledge.

> *[...] you trying to use the physics approach that we learned within the university is not enough, because even if you know how to do the math, it's important to know how to do the math, for you to know how to demonstrate it all the concept behind, but to teach the concept it is necessary more than just mathematical language. (M3)*

As indicated in the works of Ovigli (2009) and Tempesta and Gomes (2017), it was in the mediation work at the Science Center that the undergraduates had the possibility to realize, before the beginning of the internship, the complexity and difficulty of their function as future teachers. As pointed out by Tardif (2010), the limiting conditions of the experience allow teachers to develop a critical look at disciplinary, curricular, and professional knowledge to evaluate, filter and build new knowledge in daily practice. As described in the previous excerpt, the limitations encountered by the Science Center's licensing-mediators make them realize the need to develop skills that the initial training course in general does not provide. M3 still adds that space played a key role in his formation because

> *[...] there are the teaching practices, but I think remaining limited to that teaching practice is not enough either, because in teaching practice you end up limiting yourself to a specific method to each of them, while at the Science Center you have the freedom to treat, address the way you feel best and the way you have, that students are demonstrating better understanding, let's say so. So, you end up changing, each visit you speak in a different way, you explain the concept in various ways. (M3)*

Furthermore, the M5 mediator understands that the learning process is characteristic of each student and requires different methods and resources.

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> *[...] when learning each person will have a way that he will learn better. There's going to be that student who can understand everything just by looking at the equations and having a totally formal teaching; now there's going to be another student who won't understand in any way those formulas, which for him will be meaningless and when he sees an experiment, a space different from the one at school, the fact that he's not sitting in desks, not being in the classroom is going to give him a freedom to be able to, a greater freedom for him to reflect things, then ends up assisting for this type of student and even for the one who likes more a formal education, him being in a different space will open his horizons so he can think of other possibilities. (M5)*

For Bonadiman and Nonenmacher (2007), for directly influencing the pedagogical practice of the teacher, the methodological question is a relevant means to circumvent aversion to Physics and improve students' learning. Ovigli, Freitas and Caluzi (2010) highlight that graduates who have the experience of acting as mediators in Museums and Science Centers still in the initial formation, they will occupy a privileged position when visiting these spaces with their students, being able to better articulate the knowledge of the Museums with the knowledge developed in the classroom. It is worth mentioning that, although the choice of pedagogical actions appropriate to the teaching of Physics can favor the student's learning, this also depends on other factors, such as teacher competence and student willingness to want to learn (BONADIMAN and NONENMACHER, 2007).

When asked why and for what purpose they would make a school visit to a Science Center, the five interviewees show that they understand the educational role of the school when they point out that they would make visits at different times, but always with objectives relating the collections of Museums and Science Centers with the contents worked or doing articulation with the mediators.

> *[...] When the teacher brings students to a non-formal space, this non-formal space must have an educational goal [...] on their own the experiments, the students when they are there, they engage with the experiments, so they are learning something, and that is already quite beneficial, but I think this can be enhanced if students are aware of the educational objectives of that space. (M3)*
>
> *[...] I would try to bring them or bring them when I had seen some content or something that could be added [...] the teacher, in my opinion, must ask something on top of that, he has to have something like this to make the student assimilate, see the importance. (M4)*

According to Jacobucci (2006), the relations between teachers and the Museums and Science Centers can enable numerous transformations in schoolwork, either through a more critical interpretation of specific curricular contents or by different ways of approaching a scientific concept with students. In an investigation conducted by Pereira and Silva (2015), the authors also indicate that the collaboration between schools and Science Centers can cause the visits to exceed the expectation of showing

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in a more playful way the physical phenomena so to articulate them with the learning of scientific concepts.

Finally, the reports of mediators M1 and M2: "[...] We are also interested to see the theoretical study that we see in the classroom here at the *Science Center*" (M1), which suggest that mediation in the space also brings contributions *throughout the training of undergraduates*, sharpening curiosity and contributing to develop a broader understanding of physics.

> *[...] at first, I was still touching, as I was trying to understand what was going on, a kind of investigative activity even to see what was in that experiment; then, more to the end of the course when the theoretical knowledge was already more consolidated, I could perceive the relationships that, especially in the electrical room which is a room that requires a lot of theoretical knowledge, I was able to understand some things. (M2)*

It is noticed that the training that mediators receive in the space, through the observation of colleagues in visits and discussions in the group contributes to understand the objectives of each space, expand their knowledge throughout the graduation and have different experiences on which they can be based and apply in their classes.

> *[...] there was a process of sharing even with the "Tepians" who already had contact, who already knew and they were then transferring this information, this knowledge, and then, it was a process to improve my explanation, the way I led people, which experiment to choose first, because when I make the visit, I do not choose a random experiment, there is a sequence, it has a logic, so that students see that physics interconnects all the phenomena that happen, which can be understood by physics. (M2)*
>
> *[...] if you're going to work within a non-formal or formal space, you have different tools, you have different approaches, you have different visual instruments to use, so everything you do depends a lot on the space you are working on. [...] and you working in a non-formal space that provides you freedom for different instruments in different approaches will make it easier for you to have some planning to use these activities within the classroom, within the formal space. (M3)*
>
> *[...] one of the classes we went to talk about the physics of the storms, and we made a small project, so there was a whole sequence of classes and we wanted to bring some experiment, which was me and another colleague who is not from the Science Center, so I oversaw this class. I wanted to associate with the Van der Graaf generator because it was something I saw that worked very well, whether they wanted it, the students could understand when they went there because they saw the phenomena, so I wanted to take this to the classroom. (M5)*

Ovigli (2009) points out that the training of mediators escapes from the technical rationality in which they are often put in contact with theory and then apply knowledge in teaching practices and supervised internships. In the reports presented it is possible to perceive that the experiences in the space lead the undergraduates to improve their knowledge throughout the graduation, so they can understand their role in each space

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as mediators and teachers, as well as use the knowledge developed in their classes.

Regarding the performance of mediators still in graduation, M3 reports that:

> *[...] when I joined TEP and I saw, for example, the difficulty that was trying to explain to a child the concept simply knowing physics, I realized I could not. So, working at the Science Center made me have a different view of teaching practices as well as education subjects, so much so that my engagement in these subjects increased after I got into the project. (M3)*

By the excerpt, M3 demonstrates that the exercise of mediating visits in a Science Center brings a new view of the role of disciplines throughout graduation. Regarding the specific disciplines in Physics, M1 and M3reportfinding difficulty in transposing the content.

> *[...] when you see the matter the way we see it in college I think it becomes even more difficult in this period for you to make a contextualization, for you to articulate that knowledge in a more conceptual way but, perhaps, because we get very attached to the formalism part, of the matter itself, and this ends up being evidenced in our speech. (M1)*

For Ovigli (2009), as mediators do not have a specific training to work in Museums and Science Centers, it is natural that they apply the disciplinary and pedagogical knowledge they are acquiring in graduation. The author points out that the mediators who will be future teachers are building a qualification in the daily life of these spaces that, even with different objectives from teachers at school institutions, have convergent characteristics.

M2 and M5 also reported that the components of the graduation solidify the initial knowledge they had, facilitating adaptations and new understandings of the phenomena.

> *[...] after we study it gets easier because you have a domain to be able to modify and adapt to the public; when you don't have it, you don't know how to modify because you don't know, you faithfully say it but, sometimes you don't even know what you're talking about. And when you know, you look and see that you can make such an analogy that the teacher never spoke to me, but with me knowing it, I know how to make this analogy different. (M4)*

As highlighted by M4, the appropriation of content is a fundamental element to perform new approaches and seek other understandings of phenomena. However, studying the content for a period in graduation does not mean mastering it and being prepared to make coherent and scientifically correct adaptations. In addition, building knowledge and enriching the approaches of the contents in these spaces requires effort and dedication of mediators in relation to the demands of visitors, because if they

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work in these spaces only for the scholarship or for the hours of extracurricular activities it is very likely that they will leave the month in the form they entered (TEMPESTA and GOMES, 2017).

Another contribution throughout the training is the interaction with colleagues who work in space. M4 points out that fellow mediators play a fundamental role in this transposition of the content seen in the course for what is taught in the Sciences Center.

> *[...] so the colleagues had a big role to play in getting the experiment into the discipline, and some teachers too; if I were alone, I might have had more difficulty. [...] The mediators themselves helped to make this relationship between content and the experiment. (M5)*

The exchange of knowledge that happens between the mediators is a common process in the Museums and Science Centers and is often due to the lack of specific training for the performance in these spaces. Thus, in a permanent and shared process of experiences and knowledge, mediators are simultaneously someone who teaches and learns in their daily work (OVIGLI, 2009).

Finally, based on the analysis carried out here, we understand that mediation in a Science Center has significant implications for the training of undergraduates and, although the subjects investigated acted formally only during the internship period, they present reflections that show how the activities carried out in a non-formal space contributed and can contribute to their future teaching practices.

4 Final Considerations

To investigate the implications that acting in a Science Center can bring to the initial training of undergraduates in Physics, this research was carried out with undergraduates who are mediators of a Science Center that has their formative activities integrated to a Federal University of the State of Minas Gerais. The research subjects were chosen by their link with the space, by the training area and for having completed the four mandatory stages of the course, aiming to find elements that could have contributed to the training and pedagogical practices of the undergraduates.

Through semi-structured interviews it was possible to identify that the choice to work in the Science Center is for different reasons such as: for the possibility of conducting scientific initiation research, financial assistance, identification with the space and the activities of mediators, as well as the possibility of developing essential

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skills for the teaching activity. Even not knowing the mediation activity and initially choosing to work in a Science Center without reflecting on the skills they can develop as future teachers in this context, in the analyses, three groupings were identified that show that throughout the undergraduate course the undergraduate programs have significant implications in their training and performance in the classroom resulting from mediation activities in the Center.

The first emerging grouping identified in this research refers to the implications that mediation in a Science Center causes in the performance of the undergraduates. In this group, we identified that the performance in this space seems to bring security to speak in classes and to mediate visits, promoting the development of communicative skills in the undergraduates.

Adaptations and reflections to mediate visits also cause Physics students to appropriate the contents and rethink how they are teaching, besides interfering in their actions when they make them search for different resources and methodologies to teach Physics. As presented, one of the factors that makes it difficult for teachers to adapt and innovate in the classroom is the lack of in-depth knowledge of content, and the mediation activity in non-formal spaces seems to contribute not only to this more in-depth appropriation, but also to show the need to use different resources in classes.

Another implication that the undergraduates reported was the need for a teaching with a more contextualized bias, that brings more meaning to the learning of students and brings them closer and to reality. As we identified in the research, the interaction in the Science Center articulated to the training in the course provides a broader understanding of Physics and the needs of Physics Teaching, showing that Physical Science needs to go through transpositions to bring more meaning to the student's world.

The second grouping identified was the understanding of the teaching and learning process that the performance in the space develops in the undergraduates. The undergraduate course brings many elements to understand these processes, however, there are knowledges that only experience can bring. As Silva and Felício (2018) point out, the act of teaching is not reduced to the transmission of knowledge, but incorporates different expertise, knowledge, skills, abilities, and attitudes that are integrated in pedagogical practice. The excerpts show that working as mediators in a Science Center allowed undergraduates to understand the complexity of the teaching

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activity even before them going to the supervised internship, in addition to expanding the possibilities of acting in the classroom and making them reflect more on the role of the disciplines in the course.

The undergraduates also showed a broader understanding of the teaching processes by emphasizing that, as teachers, they would visit a museum or Science Center with their classes, articulating the curricular activities to the exhibitions. The spaces of popularization of science alone already encourage and arouse curiosity, but to articulate them to the curriculum is a way to bring students closer to the study of Science and enrich the processes of teaching and learning. From the excerpts, the undergraduates-mediators demonstrated to recognize these possibilities and to be willing to rethink pedagogical practice from an activity that could be restricted to the day of visitation and to the space of Museums or Science Centers.

As for the contributions over the training of undergraduates, working as a mediator makes them close to equipment and have the experience of teaching Physics more often than they would have in the course alone. This contact seems to bring a list of knowledge to be used in the classroom, besides favoring the learning process itself throughout the Physics course. As presented by Abib *et al*. (2012) , p. 5174), in partnership with undergraduate courses, non-formal spaces can help "[...] in the construction of a teacher with a teacher-researcher profile and concerned with the issue of his/her self-formation". With the mediation of activities in the space, the undergraduates teach Physics while learning from their colleagues in the course, and this implies mobilizing and constructing new understandings of the phenomena and the teaching activity.

Although this research has found elements that indicate that mediation in a Science Center contributed to the formation of undergraduates and may contribute in the future in their practices, it cannot be affirmed that the same influences highlighted in the performance of the supervised internship will remain when the undergraduates become Physics teachers. We agree with Tempesta and Gomes (2017) that, although the experiences carried out in Museums and Science Centers are very rich and can help in the future actions of mediators, these have limitations.

It is worth noting that this research was conducted before the pandemic caused by the SARS-CoV-2 virus, and as studies involving the training of teachers and mediators in non-formal spaces of Sciences are scarce (ABIB *et al.* , 2012; IBÁÑEZ,

2021; TEMPESTA and GOMES, 2017), therefore, it is important that other research be conducted with undergraduates and teachers who have gone through this experience — of mediating activities in Museums and Science Centers — in the field of Physics and other Sciences, to find other elements and contributions of this activity in their teaching activities and practices, even in times of social distancing, in which teachers had to reinvent themselves in order to continue their pedagogical practices.

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