Change of the ideas of science teachers after participation in a training program on the use of non-formal educational places

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Absract: The objective of this study is to understand how the perception of teachers might change after they participate in a training program on the use of non-formal educational places (NFEP). The design of the study is ethnographic and its methodology is qualitative. The study comprehends the analysis of three multiple cases according to the disciplinary area, including teachers of primary education, biology, and physics. The analysis was focused on the discourse of the participants, establishing eight categories which were previously validated through triangulation by time and by instruments. The study concludes that the participants were able to restructure their ideas about the use of NFEP for teaching, showing mainly ontological and epistemological changes, which are discussed in the paper.

Keywords: educational places, non-formal education, teaching of science, teacher training

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DOI: https://doi.org/10.31129/LUMAT.6.2.314

1 Introduction

In the last few years, experts have reflected upon how students' learning occurs, both inside and outside the classroom. The learning process tends to be much more significant when it takes place in real, everyday contexts, usually outside the school facilities (Ibáñez & Vincent, 2012). The school is no longer the only place where the learning process happens and it cannot assume the educational role in society on its own.

Similarly, and according to the socioconstuctivist and cultural approaches in education coming from psychology, learning can be understood as a situated and distributed social process (Melgar & Donolo, 2011). Vygotsky recognizes the existence of a zone of proximal development that acts as an area of interaction between the individual, the collective, and the artifacts that are part of the environment, emphasizing the roles of dialogue and joint development of knowledge (Franco-Avellaneda, 2013). In this sense, to consider learning from this broad viewpoint allows

to distinguish a variety of contexts for learning and to expand the boundaries of formal education (Melgar & Donolo, 2011).

Melgar and Donolo (2011) identify three types of educational contexts: formal, informal, and non-formal. Non-formal contexts include all those institutions, activities, media, and educational aspects that, while not being part of the educational system, have been created to fulfill particular educational objectives. The Ministry of Education of Chile (MINEDUC, 2009) defines non-formal teaching as every formative process carried out through a systematic program, not necessarily evaluated, which can be recognized and verified as a valuable learning opportunity, with the possibility of obtaining a participant certification.

Therefore, there are different contexts that might contribute to the formation of scientific culture in students (Gerber, 2001). For this reason, the settings in which non-formal learning can be built are diverse, according to the cultural diversity offered by the social context. Some examples of non-formal places of learning are museums, parks, zoos, farms, natural reservoirs, and science and technology centers (Vanegas et al., 2013).

On that basis, the importance of integrating different learning contexts into the school curriculum arises, so that the incorporation of non-formal contexts as part of scientific education is seen as an alternative. This has become a challenge for teachers (Dierking et al., 2003; Guisasola & Morentin, 2007; Pedretti, 2002; Guisasola & Morentin, 2010).

2 Antecedents

The activities in museums play a significant role in the teaching of science, becoming convenient tools for teachers in science education (Sanchez & Marin, 2014). However, the difficulties begin with the type of activities that teachers propose when visiting non-formal educational places, not only because the activities are unconnected from the school curriculum, but also because many times the teachers simply lose track of the pedagogical purpose of the visits and turn them into just a “trip”.

In this sense, the study conducted by Guisasola and Morentin (2010) suggests that the science teacher places a high educational value on the visits, getting involved in the organization of the visits but not in the definition of objectives nor in the preparation of the activities prior, during and after the visits. Griffin (2004) points

out different reasons why teachers are not involved in the outings. These reasons include lack of time, logistics, students' needs, and mostly, the little or no training of the teachers in methodological elements that allow them to build bridges between what the museums offer and the school curriculum.

Therefore, the use of non-formal learning contexts should be included in the curriculum, and the activities must be prepared by the teachers, not only paying attention to the organizational aspects but also focusing on the tasks that students will have to carry out before, during, and after the outings (Guisasola & Morentín, 2005, Melgar & Donolo, 2011).

On an international level, several research projects suggest that the ideas teachers have about the use of NFEP for the teaching of science focus on generating motivation and interest in the students, who should be able to enjoy these new learning experiences and to ignore the connection established between the outing and the curriculum (Eshach, 2006). For example, Kisiel (2003) detected that only 50% of the surveyed teachers were able to describe the objectives of a visit to a NFEP, and although most of them stated that going out was a "valuable experience," they did not know exactly where the value lay.

The present study was conducted in Chile because, unlike other South American countries, there is not much research done on the perceptions that teachers have about the use of non-formal educational places and the methodologies they use to work in those places (Bustamante et. al., 2012).

Despite the fact that there are no indexed publications regarding informal educational spaces in Chile, an increased interest on the topic has been seen in the recent Chilean Society of Scientific Education (SChEC) congresses. The papers presented in these instances highlighted clear attempts to use the NFEP for the teaching of science. Although the studies are still incipient, they allow to see the weak points in the preparation of activities for non-formal settings, exposing the fact that Chilean teachers are not prepared to use these places for pedagogical purposes.

For this reason, it is interesting to see the discourse of science teachers as an indicator of the preconceptions that they had of museums and their pedagogical use, according to their personal life stories, teaching subject, and teaching style.

Based on the above, the research problem detected is that teachers do not possess a clear idea of how to use non-formal educational places, and that they are not able to link the non-formal setting with the school program or curriculum. The aim of this

study is that teachers, with a continuous training program on using non-formal educational spaces, give different meanings and senses to the use of these spaces, which will allow them to develop strategies and instruments to mediate between the museums and the school curriculum.

3 Theoretical Framework

Different international organizations, such as the National Association of Research in Science (NARST) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), recognize the importance of the experiences of learning in non-formal contexts like museums, since these contexts stimulate positive attitudes toward the sciences and encourage scientific education (Melgar & Donolo, 2011). Likewise, there is evidence that learning is a limited social phenomenon which is boosted when other scientific and cultural scenarios, such as visiting museums, are incorporated to the curriculum. This encourages new learning experiences and methods (Falk & Dierking, 1992; Vanegas & Fonseca, 2010).

In this way, learning becomes an individual process in which the museum provides the student with an active role, offering the opportunity not only to learn individually but by their own choice. This is seen as a non-linear process, whose success increases with the freedom of choice and the personalized pace of each student (Bustamante, 2016; Xanthoudaki, 2003; Bustamante et al., 2012). It is relevant to mention that the use of museums and other similar places establishes a direct relationship between leisure time and education. These places constitute then a scenario in which the reality of the curricular contents related to environmental education, the natural sciences, ethical and civic formation, and the social sciences can be explored (Melgar & Donolo, 2011).

The sociocultural theory of learning of Falk and Dierking (1992; 2010) states that learning is built through personal, sociocultural, and physical contexts that influence the process of negotiation between the ideas presented in the physical context of the museum and the personal ideas of each visitor (Figure 1). The personal context refers to the motivations and expectations of the visitors, and therefore, it is the visitors themselves who control and select what they want to learn and how they want to learn it. This is where previous knowledge, beliefs, and interests interact. Similarly, the sociocultural context has an impact on the intervention or mediation that occurs in the museums, whether it is elicited by a peer, a guide, or a teacher. This creates a bond

between the environment and the visitor. Finally, the physical context refers to the museum *per se*, so that the environment, the organization, and the orientation of the space and content presented by the museum affect the visitor's learning.

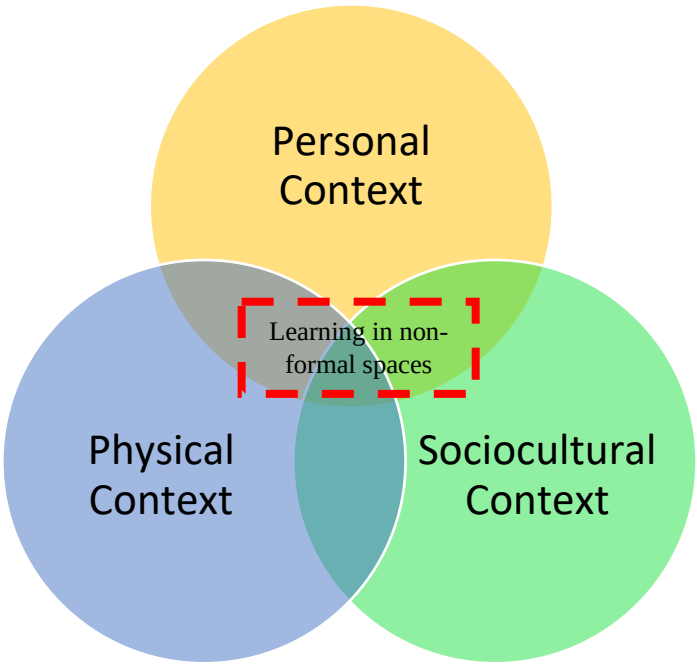

Figure 1. Contexts that intervene when learning in museums (Falk & Dierking, 2010)

The systematic review by Guisasola and Morentein (2010) proposes that the majority of teachers place a great value on the pedagogical outings and the visits to museums, but they are not really involved in the formulation of objectives or the activities done prior, during, and after the visits. This turns the visits into a mere "field trip", since teachers do not usually establish effective teaching strategies and do not connect the outings with the experiences of the students. This prevent the teachers from generating learning processes in non-formal education places, thus delegating that responsibility to the museum (Bustamante et al., 2012). Moreover, Griffin and Symington (1997) claim that teachers often feel intimidated by the visits to museums because in many occasions they do not have a clear learning objective to achieve in said spaces.

This scenario comes along with the need for teachers to understand their role as an agent of change, boosting the learning of each and every student through educational activities within and outside the educational institutions, applying their autonomy to

develop scientific competence in their students, and reflecting upon their own performance (Bustamante et al., 2012). Consequently, teachers must design activities based on the criteria of accessibility for everyone, and in particular, for those with special educational needs (Reynoso, 2013.) This makes the teacher a fundamental piece in the communication between the museum and the school (Falk & Adelman, 2003). The role of the teacher is transcendental in the success of the educational outing (Camareo-Izquierdo et al., 2009).

It may be noted that whatever the non-formal educational place the teacher chooses, it is important that they examine and keep in mind some considerations (Chen & Krechevsky, 2000):

- To explore the places beforehand
- To take the students there more than once
- To use the outing as a place to observe the behavior of the students

In the same way, when planning a visit to a non-formal educational place, the teacher must define at least three moments (before, during, and after the visit) to use the NFEP with educational purposes (Table 1). It is also important that prior to the visit, the teacher discusses the experience with the students, encouraging them and problematizing the topic that will be explored at the NFEP. Later during the visit, the activities proposed must be collaborative and based on the observation and manipulation of objects, promoting the collection of evidence and data to be analyzed, and opening the discussion of scientific contents according to what students experienced in the NFEP and the theoretical bases they had learned (Aguirre & Vásquez, 2004). Finally, and after the visit, the experience must be extended and deepened, talking about it, promoting students' metacognition by means of the analysis and reflection upon the activities done, and also verifying the appropriation of the topic discussed in the two previous instances.

Table 1. Use of non-formal educational places. Table adapted from the preparation of a visit to a museum by Aguirre and Vázquez (2004)

Moments	Spaces	Stages	Focus	Processes
Before	School	Preparation	Interrogation	Questioning the topic
During	Non formal educational space	Realization	Collection and analysis of data	Observation and manipulation of the object
After	School	Extension	Analysis and summary	Appropriation of the topic

Aguirre and Vasquez (2004) state that when using a non-formal educational place, three main factors intervene: the student (visitor), the topic (scientific notion to be discussed), and the teacher (intervener). The scientific notion is called the "unifying topic". This unifying topic comprises the objects found in the museum or science center which have research, exposition, and education purposes. The museum then must have features that are relevant to the content to be discussed. The intervener, or the role the teacher must adopt, should be preferably the role of a mediator between the topic and the students. In this way, the students get involved with the objectives of the visit (Bustamante et al., 2012) and therefore the didactic transposition required to teach the scientific notion is achieved. Figure 2 shows the Legendre triangle applied to NFEP. The figure shows the relationship among the agents involved in the teaching of science in museums: student-visitor, intervener, and topic, all of which constitute the "educational program".

It is relevant to integrate the class topics with the experiences in the non-formal educational place, connecting the tasks in the classroom with what is studied in the museum. Similarly, the student must participate in the design of problems that could be solved in said space. Therefore, the curriculum should be aligned with the contents of the NFEP in a way that the activities in the museum allow for and stimulate the learning on several cognitive levels, not only of the content as such, but also on affective and imaginative levels, promoting critical thinking, etc. (Griffin, 2004).

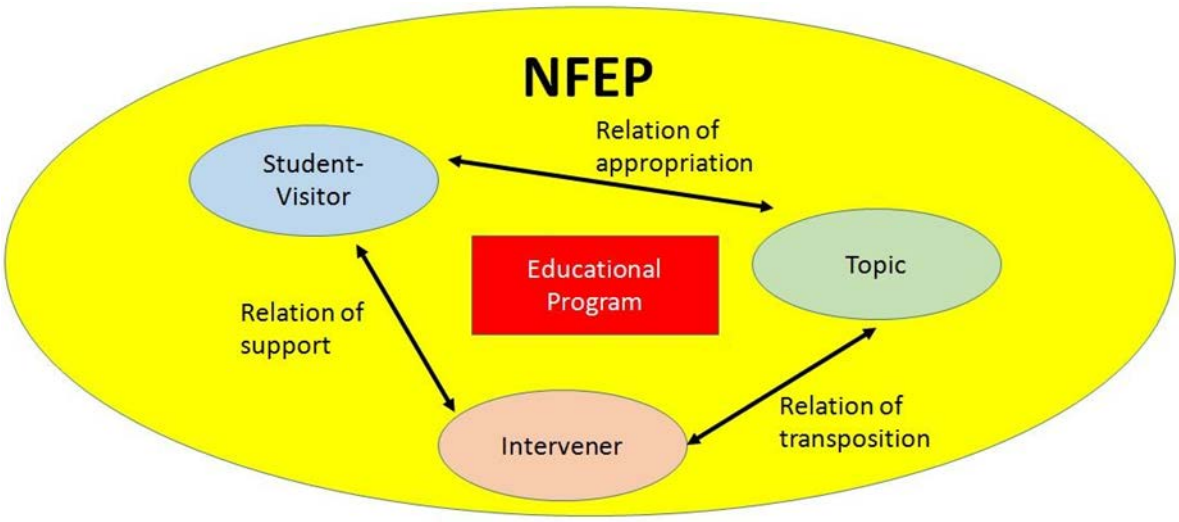

Figure 2. Adaptation of the Legendre triangle applied to museums (Aguirre & Vásquez, 2004)

4 Research objectives

The general objective of this study is to understand how the ideas that science teachers have might change when they participate in a training program on the use of non-formal educational places. Three specific objectives have been identified:

- To identify science teachers' previous knowledge about the use of non-formal educational places.
- To describe possible changes in science teachers' ideas about the use of non-formal educational places.
- To compare science teachers' ideas before and after their participation in a training program on the use of non-formal educational places.

5 Research design

The methodology used was conceived from a qualitative research, with a comprehensive scope, since it not only identifies and describes the preconceptions that teachers have of the use of non-formal educational places for the teaching of science, but also intends to find out how these ideas change before, during, and after the training program (Denzin & Lincoln, 2005; Sandín Esteban, 2003; Yilmaz, 2013). The design is also conceived from educational ethnography, and it particularly corresponds to the study of three multiple cases (Neiman & Quaranta, 2006). The procedures that guarantee the rights established in the ethical framework of educational research were carried out with each of the teachers in all cases.

Case 1: Three primary education teachers. Two of them work in state-subsidized schools, and the other works in a public school. They have been teaching for five, fifteen, and twenty years, respectively.

Case 2: Mixed group composed of three biology teachers, two women and a man. One of the female teachers works in a private school, and the other two teachers work in state-subsidized schools. They have been working for two, seven, and twenty-one years, respectively.

Case 3: Group constituted by three physics teachers. Two of them work in state-subsidized schools and the other works in a public school. This is the least experienced

of the three groups, since its members have between two and four years of teaching experience.

This research focuses on the study of the discourse of teachers who participated in a training program on the use of non-formal educational places and how the experiences brought by the program might boost, reconfigure, or change the teachers' previous ideas on the use of NFEP. The selection of the participants was made through an open call to all science teachers in Santiago, the capital city of Chile.

Three phases were considered for the production and collection of the information, which are included in the sessions of the training program the teachers participated in (Table 2).

Table 2. Sessions of the Training Program on the Use of Non-Formal Educational Spaces (26 hours in class and 14 hours of autonomous learning)

Session	Objective	Activities	Class Periods	Place
1 (Phase 1)	To identify previous ideas about the use of non-formal educational spaces.	Questionnaire. Discussion of key concepts based on previous knowledge.	4	University
2 (Phase 2)	To analyze the non-formal educational places from the theory and personal experiences to establish a connection with the classroom.	Definition of concepts. Sharing personal experiences. Discussion of articles.	4	National Museum of Natural History (Quinta Normal Park)
3 (Phase 2)	To build sequenced activities under the constructivist cycle of learning by Jorba and Sanmartí for a non-formal educational place.	Designing activities under the constructivist cycle of Jorba and Sanmartí. Sharing the designed activities.	4	Museum of Science and Technology (Quinta Normal Park)
4 (Phase 2)	To use the non-formal educational place for science teaching.	Outing to a non-formal educational space according to the area of interest of the teacher. Designing a sequence of activities.	6	Case 1: Pochoco Hill. Case 2: Bosque Santiago Park. Case 3: Fantasilandia theme park.
5 (Phase 2)	To discuss the tasks done in the non-formal learning place for science teaching.	Showing the didactic units constructed. Reflecting about the work done by the teachers.	4	Nuestra Señora de Gabriela Park, Puente Alto

6 (Phase 3)	To debate about the importance of using non-formal educational places for science teaching.	Handing in final versions of the didactic units. Lectures and debate about the information among teachers.	4	University

It is worth mentioning that the instruments used to analyze the discourse of the teachers were the products derived from the application of the didactic unit during the whole training program as well as the video recordings of the sessions. In this way, the study was centered in the content of the science teachers' discourse before and after the training program (Tójar Hurtado, 2006). In order to perform the analysis, the following eight categories were established, as shown on Table 3.

Table 3. Description of the categories of the analysis of the teachers' discourse.

Category	Description	Indicators
Epistemological Commitments	Refers to implicit suppositions shown in the subject's discourse about the relationship between his own knowledge and the environment (Pozo & Gómez, 2006).	- Ingenuous Realism - Interpretative Realism - Constructivism
Ontological Commitments	Refers to the understanding of the world in three categories (states, processes and systems) through the sensitive and experiencing perception of the individual about material and non-material things (Vanegas & Fonseca, 2010).	- States - Processes - Systems
Physical Context	The physical context becomes relevant in the investigation of the scientific area because individuals' preconceptions depend on this space to base their answers and build learning in relation to a specific scientific notion (Flores & Gallegos, 1999; Falk & Dierking, 2010).	- Memory or imagination - Experience - Use
Prior experience	Prior experience is built around aspects that are part of life, therefore, it is important to broaden students' experience to enhance their creativity, recreation, and inventiveness, elements that constitute something new in the subject. This implies combining the old with the new and sets the basis of creation. Besides, the acquisition of new experiences rearranges the previous experiences, so "the new conception takes places and appears to contradict the past experience" (Vanegas & Fonseca, 2010). According to this, the conceptions not only confront but also complement each other.	- Preconceptions - Exemplary situations - Immediate intervention
Teacher's Role	Refers to the role of the teacher when visiting and using the NFEP for science teaching. (Aguirre & Vázquez, 2004).	- Passive - Administrative - Focused on the learning process

		- Focused on teaching
Perception of the Students	Ideas and beliefs that a teacher has about their students when using and visiting the NFEP. (Guisasola & Morentin, 2010).	- Socio-economic status - Behavior - Learning
School-Museum Relation	Role of both institutions (museum and school) with the intention of reviewing the strengths and weaknesses, as well as the complexities and needs of their relationship (Sánchez, 2013).	- Individual - Comparison - Collaboration
Choosing a non-formal learning space (NFEP)	Reasons that the teachers have to choose and use a NFEP for the teaching of science (Meglar & Donolo, 2011).	- Appearance - Playful and entertaining - Attributes that are coherent to the objective - Space of learning

Two types of qualitative triangulation were used in the analysis: triangulation by time and triangulation by instruments (Benavente, 2009). The triangulation by time consisted in comparing the results obtained before, during, and after the continuous training program. For the triangulation by instruments, the transcription of the sessions (discourse) was contrasted with what the teachers wrote in the different activities of the training course. In addition, the KAPPA reliability analysis was made (Benavente, 2009) which indicated a good index of reliability (0,64) and 81,76% of agreement among researchers.

6 Results

The results of each of the cases are summarized below:

6.1 Case: Primary Education Teachers

In the first session, the ideas referring to the teacher's role in the use of NFEP were identified. These ideas mainly correspond to the administrative aspect and the planning of the activities. This is why their discourses are based on previous experiences they had with students, giving more than once examples of "educational outings" that turned out to be effective for them. The teachers also emphasized that the educational outings are important to their students because the students have a low cultural level and are socioeconomically vulnerable, and claimed that these non-

formal contexts are “more entertaining”. Likewise, the teachers highlighted that an important part of planning a visit to a NFEP is the previous motivation given to the students. In consequence, epistemological commitments of an ingenuous and interpretative nature as well as ontological commitments of state appear.

By the end of the course, the teachers kept the idea that NFEP are playful and entertaining, but that their attributes should be coherent with the Chilean school curriculum in order to perform specific tasks with their students. Moreover, the teachers identified their role as mediators in the learning process, emphasizing that they must “dare” to use the NFEP with previously planned activities, without fearing their students’ behavior. Additionally, they warned that the museum must not become a school, since their students need to “change the context,” and also recognized that there is a need for a connection between the schools and the museums in order to generate a culture of visits to NFEP. In this sense, their discourse provides examples of experiences lived during the course and experiences lived during the making of the didactic units. Ultimately, the epistemic commitments move toward a constructivist and interpretative nature and toward ontological commitments of system.

6.2 Case: Biology Teachers

The biology teachers compared the school and the museums more than once, characterizing the latter as more playful and entertaining than the classroom. The teachers emphasized the poor behavior of the students, but at the same time, they mentioned how significant “field trips” can be for students’ learning. Similarly, the role of the teacher is regarded as organizational and administrative, giving a lot of importance to the legal aspects that visiting a NFEP involve.

Conversely, at the end of the training program, the biology teachers expressed that the role of the teacher lays on the creation of activities to be used in the NFEP, which should be connected to the curriculum.

> I mentioned that it was necessary to review the additional material, I mean, apart from what is in the museum, to incorporate a work guide with information we could better relate to what is exhibited in the museum. Sometimes we need to do a didactic adaptation and to modify a bit the contents that we want to teach. (Teacher 5)

In this respect, the teachers’ discourse contains personal experiences lived in the course, providing examples that allow to see the NFEP as places of learning, so the

choice of such space must be made by the teacher. They also recognized that schools are like “islands”, and that in agreement with the upcoming public policies, links between the schools and the museums and science centers should be fostered. Likewise, they highlighted that the NFEP should not only be used for the teaching of science, but also of other school subjects, thus making interdisciplinary visits to the museums. In conclusion, the initial epistemic commitments are ingenuous and tend to be interpretative. Similarly, the ontological commitments change from state to processes.

6.3 Case: Physics Teachers

The physics staff mentioned that the places to be visited with their students must be selected according to the contents taught in class. They warned that the role of the teacher is not only organizational but also pedagogical, and therefore they must generate activities with a defined learning objective, something that could only be done if the teachers know the place. The teachers gave examples of “educational outings” made by them. They also recognized that their students are socioeconomically vulnerable, and as a result, this type of spaces favors their learning. Additionally, they regarded these “outings” as an extracurricular resource and not as directly attached to the school curriculum or the annual planning, since they think that the visits should be presented as work projects. The teachers showed ontological commitments of process and epistemic commitments of an interpretative nature.

However, after participating in the training program, the discourse of the physics teachers is characterized by the identification of the lack of connection between the schools and the museums, highlighting the importance of a collaboration between the two.

> Maybe the visits I make are not very structured, then the option I got with this class is to develop a dynamic that truly promotes learning, because until now, the outings mostly distract the student, they get to leave the classroom for a moment, but we’re not guiding them exactly to the content we want them to learn. Now we have the tools to give a sense and a structure to the use of non-formal educational places. (Teacher 9)

Furthermore, the teachers exemplified the importance of the NFEP with situations lived during the course, situations where the teacher must have a “technical” approach to the creation of activities, always connecting them to the Chilean school curriculum. However, they mentioned that the museums and science centers should not be turned

into schools, but remain as another type of “resource” or “didactic approach” to teaching science. Therefore, every visit to a museum or similar place must focus on the “pedagogical sense”. In consequence, constructivist epistemological commitments and ontological commitments of system are shown.

7 Conclusions

Consistent with the objective of this study, it was evident how the teachers of science in each discipline managed to restructure their perceptions after the training program on the use of NFEP for science teaching.

At first, the teachers, and just like Guisasola and Morentin (2010) mention, attached a high formative value on the outings, getting involved in their organization but not in the definition of the objectives, let alone the activities before, during, and after the visits. This is explained mainly because none of the participating teachers had training in teaching science in NFEP.

In the first session, the teachers talked about the use of NFEP for science teaching mainly with ingenuous epistemic commitments and ontological commitments of realism and reduction. The teachers mentioned that the visits to this type of spaces are beneficial for their students because they are playful and entertaining. However, the physics teachers established interpretative epistemological relations and ontological relations of process focusing the purpose of the visit to a NFEP on the school curriculum. In this sense, there is a diversity of interpretations in relation to the role that teachers have in the educational outings.

Likewise, the teachers talked at first about their own experiences of outings organized in their schools, basing their arguments mainly on the type of student they had and the behavior that the students showed. However, by the end of the study, the teachers justified their ideas from different theoretical bases, which can be attributed to the training program.

At the beginning of the study, the three groups acknowledged that the museums and schools are independent from each other, and that they are only linked when the schools visit the museums. After the training program, all the three groups recognized the importance of a collaborative relationship between museums and schools, discussing current educational public policies. It is worth mentioning that primary

science teachers and physics teachers highlighted the importance of not schooling the NFEP.

At the end of the training program, the teachers were more able to create didactic units which were coherent with the Chilean school curriculum, mentioning that it is necessary to take into account the individual attributes of the NFEP for science teaching. According to this, the role of the teachers goes from passive or administrative (at the beginning of the program) to mediator of learning and planner of the activities (at the end of the program). The teacher must be able to select the place to be visited according to their pedagogical purpose and the attributes of the NFEP.

Based on the previous point, and in relation to the objective of this investigation, we can state that science teachers were able to acquire some abilities and the knowledge needed to design outings to museums and science centers. Such visits might produce significant learning in the students, both in the affective, social, and procedural aspects (Guisasola & Morentin, 2007). Likewise, we can state that the participants' preconceptions were modified, linking their previous experience to the training program, becoming new ideas that can be used for future experiences on NFEP for science teaching.

This study has various limitations which prevent the generalization of the conclusions to all science teachers: The number of the teachers who participated was small, there were no chemist teachers involved, and elements like age, years of teaching experience, and the gender of the teachers were not taken into consideration. Nevertheless, the study provides enough evidence to pose challenges to the initial and continuous training of teachers in Chile: How to intend learning processes that allow science teachers to articulate the school curriculum with the possibilities offered by the NFEP? What abilities do training programs and teacher trainers have to provide learning opportunities in NFEP? How to generate articulation among the NFEP, the universities, and the schools to improve teacher training?

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