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Science Teachers' Perceptions of Professional Development via Environmental Education Programs

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ABSTRACT

The present research explores whether environmental education practices and methods can serve as a professional development tool and help science teachers to transform theory into educational practice. To answer this question, the perceptions of 40 experienced science teachers implementing environmental education programs were explored. Activity theory was used as an analytical tool to illuminate how teachers relate science teaching to environmental education and to highlight the contradictions and tensions that develop due to the conflict between the dominant positivist model of science teaching and the child-centered model of constructivism adopted by environmental education. The analysis showed that environmental education has the potential to lead to the desired transformation if implemented in a way that is consistent with its principles and objectives. It can also support horizontal professional development efforts as it utilizes the very strong intrinsic and personal motivations of teachers that drive them to engage in environmental education programs.

Keywords: environmental education, teaching, science teachers, professional development, activity theory

INTRODUCTION

Nowadays, the intense environmental crisis that humanity has been experiencing is characterized as an educational crisis, since there is a lack of literacy, critical thinking, and reflection on issues of science (Bascopé et al., 2019; Gough, 2020). The contemporary teaching of science seeks to ensure the learners' scientific literacy, the adoption of child-centered teaching, the use of exploratory learning, the need to respect the knowledge that learners bring into the classroom (Saka et al., 2013). Reformative efforts focus on changing the way science is taught rather than on content, and teachers' professional development is seen as a prerequisite for change (Postholm, 2018). The desired change for the science teaching in school depends on the teachers' ability to combine the reformative proposals of teaching practice with their beliefs and their existing practices (Mohan et al., 2017). Reformative interventions have rarely led to changes in teaching practice because it is difficult to design professional development experiences that focus on changes in teachers' beliefs about what "teaching" and "learning" mean, about the goals of teaching and their role in the classroom (Sannino & Nocon, 2008). What teachers describe as teaching practice is a reflection of their culture, a mirror through which they understand their lives and interpret the world around them. While accepting that new teaching methods promote the scientific thinking and learning autonomy of their students, their practice is guided by their cultural beliefs, which follow the traditional perception of knowledge transfer and effectiveness. Teachers' beliefs are mainly positivist (Lederman & Lederman, 2019) and follow the traditional (with some deviations) perception of teaching and learning science. These double contradictory sets of beliefs cause tension in teachers, who cannot transform their beliefs into teaching practice, due to the low level of awareness of their beliefs and the strong influence of the social context (Pang et al., 2016). Professional development programs cause tension in teachers because they ask teachers to take on new, unknown roles in the classroom. Changing perceptions presupposes that teachers understand and accept the constructive child-centered conception of teaching and learning, a difficult and complex process, because they do not realize the learning benefits. Few teachers have experienced this kind of learning environment as students themselves, so they struggle to understand and put their new role into practice (Kayi-Aydar, 2015; Korthagen, 2014).

Gough (2020) states that the adoption of environmental education's approaches may be a solution to the formation of a new science education which will be more attractive to learners, in accord with the need for scientific literacy. Teaching science in school needs the environmental education so as to be connected with contemporary culture and social becoming and gain interest and meaning among learners

(Bencze et al., 2020). Environmental education is developed in two contexts, in the pedagogical and in the environmental ones. The pedagogical framework is linked to education for sustainability, which is characterized as quality education (UNESCO, 2018) adopting a constructive approach to knowledge (Rannikmäe et al., 2020), helping learners to have a positive attitude towards learning, enhancing basic literacy skills, developing their communication skills, boosting their self-confidence through self-action (Murphy et al., 2021). In addition, the pedagogical framework of environmental education improves teachers' professional development as it supports their reflection on their pedagogical practices. Education for sustainability has disconnected environmental education from school science (Ghisloti-Lared et al., 2015) and the positivist pedagogy that it follows (Bencze et al., 2020). Science is not correlated with environmental education because it applies different philosophies and pedagogical methods. The gap between "theory and reality" of the two fields is due to the teachers' positivist traditional education model and the contemporary constructive model that seek to connect science with everyday life and scientific literacy. The formation of the appropriate pedagogical and teaching approach of science is a challenge and invitation for the capitalization of the methods and practices of the environmental education in science courses. Environmental education, in the way its methods and practices are developed, can function as a tool for professional use and help teachers to transform theory into educational practice (Krasny, 2020). The activity theory argues that the professional development of science teachers is enhanced by the adoption and evaluation of methods and practices of environmental education during their class (Sannino & Engeström, 2018). The way in which teachers relate the teaching of science to environmental education, the contradictions and tensions that are developed due to their epistemological background also shows the path to more efficient professional development programs.

Professional education programs must be developed in a meaningful and understandable way for teachers as a process of connecting theory with practice. This process should take into account the way teachers learn, their intrinsic motivations that determine their effort as well as their epistemological background. The nature of the professional development of teachers is a continuous, lifelong, complicated process that starts from what they consider as the most important thing in their work (Postholm, 2018) and occurs in the classroom, in the school community, in the official professional training programs and the various workshops in which they participate.

All the professional development types, even those whose value has been proven, are not suitable for all teachers and they often fail because they organize and implement professional development activities, without considering the teacher to be a unique personality, who applies his own practice (Attema-Noordewier et al., 2011; Avalos, 2011). A professional development program cannot follow a single approach or "one solution for all" strategy (Voerman et al., 2015). Postholm (2018) points out that teacher need a proposal for training and transformation that begins from the people who work at school and not from the desired practice. In any case, the school framework is so strong that it will offset any attempt at change. Since teachers do not consider academic knowledge (theory) to be appropriate and do not trust it for their everyday teaching, a professional development proposal will be successful when it manages to connect theory with teachers' strong points (Korthagen, 2014). The activity theory points out that teachers engage in professional development programs with specific goals: to put new teaching practices into practice, to collaborate with colleagues, to participate in innovative initiatives and to strengthen their curriculum vitae (Yamagata- Lynch & Hundenchild, 2009).

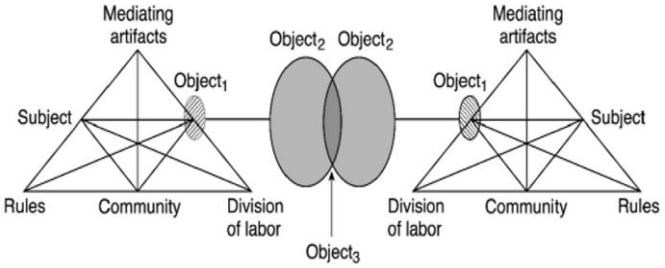

Figure 1. The interactive activity systems of the third generation of activity theory (Engeström, 1996)

The Activity theory

The activity theory emerged from the work of Vygotsky (1978), who tried to explain how human thought and its environment interact and how they are transformed through interaction. Engestrom (2001) describes the three generations of theory (**Figure 1**). The first generation presents human activity as a complete unit of analysis and investigation of how individuals interact with their environment. The second generation emphasizes the collective nature of human activity; the unit of analysis focuses on a collective system of activity and not on the individual. The third-generation unit of analysis focuses on at least two interacting systems of activity and on the relationships that are developed as they are considered to be sources of change and innovation. The structural elements of an activity system are: The *subject*, who can be an individual or a group of individuals and whose point of view dominates the activity and pursues a common goal. The *object* is the goal of the activity, precedes and motivates the activity and is formed or transformed into an outcome through the mediation of the tools. The object is simultaneously influenced by the rules, the community, and the division of labor, that is, by the social context of the activity. *Rules* are the explicit and implicit rules that regulate actions and interactions within the system. The *community* refers to the participants in an activity system, who share the same object. The *division of labor* includes the division of duties and roles among members of the community as well as the division of power and prestige.

Activity systems develop internal contradictions, caused by tensions among system elements. Tensions and contradictions within the elements of the activity system are called primary contradictions, while among elements, they are called secondary contradictions. Tertiary contradictions occur between a new mode of activity and the remnants of the previous mode of activity, whereas quaternary contradictions occur between a newly reorganized system of activity and the neighboring systems of activity (Engeström & Sannino, 2010).

METHODOLOGY AND METHOD

The aim of the research was to examine the way in which the implementation of environmental education programs functions as a process of quality professional development, demonstrating the contradictions and tensions within the epistemological and teaching systems of teachers. The objectives of the research are to highlight:

1. Teachers' perceptions, beliefs, and practices for teaching science.
2. The motivations that push teachers to implement environmental programs.
3. The contradictions of teachers' beliefs and practices that arise between the system of teaching science and the system of implementing an environmental program.
4. The educational framework that allows the connection between theory and practice.

The research questions refer to the capitalization of the environmental education as a tool to professional development of science teachers and, more specifically, they focus on teachers' perceptions, views, and practices for teaching science and implementing environmental programs. The activity theory, as a tool of analysis, shows the tensions and contradictions between the systems of teaching sciences and implementing environmental education programs. The research questions were formulated as follows:

1. What is the epistemological background and the teacher's personal theories that shape their teaching practice?
2. How do teachers perceive and implement environmental education programs? Do teachers' practices manage to link the goal of the activity with the outcomes?
3. What are the conditions that lead teachers to integrate the teaching strategies and practices of environmental education into science teaching and to develop professionally?

The research was conducted in Greece during the period 2016-2017 and 40 experienced science teachers participated in it (16 women and 24 men), having a considerable experience in the implementation of environmental education programs. The research was qualitative, and the method used for data collection was the semi-structured interview. The interview consisted of three sets of questions. The first group of questions explored the epistemological background and practices of teachers for teaching science in school. The second group investigated the epistemological background and the implementation of practices of the teachers' environmental education programs and the third group referred to their views on the concept and the necessity for professional development in general, and their personal professional development in particular.

The analysis of research data was based on the principles and procedures of qualitative research design and the principles of the activity theory (Engestrom, 1993). Each interview constituted a separate and autonomous field of analysis and the data formed two separate activity systems: the activity of teaching science and the activity of implementing the environmental program.

The content analysis of each system followed the systematic organization, description, identification, and categorization of the research questions. Initially, the data that answered the central research questions were consolidated and could appear in different parts of the interviews, followed by the integration of the data into groups. Then, the data of each group was divided into information units and those units that provided the same information were consolidated into categories. This was followed by the formation of the final thematic units and by their interpretation and understanding with the help of the activity theory which showed the personality of the teacher, his professional identity, and his level of self-efficacy. The internal contradictions of each activity system were recorded.

The connection of the two activity systems of each interview followed, as well as the tensions that are developed and the dynamics of change and development of the subject-participant in the activity emerged. The reliability and validity of the research was ensured through the clear and detailed description and interpretation of the findings, by checking the course of the analysis results, by doing the interviews at a time distance from each other, so that there is no effect of the findings of previous interviews on the following, by taking a representative sample, from the connection of the research findings with the bibliography (Forbes et al., 2009; Jones & Leagon, 2014; Korthagen, 2014; Mansour, 2013; Pedder & Opfer, 2013; Postholm, 2012, 2018; Reis & Roth, 2010; Savasci & Berlin, 2012; Voerman et al., 2015; Yamagata-Lynch & Haundenchild, 2009; Yoo & Carter, 2017).

RESULTS

Teachers' Perceptions of Science Teaching

Of the 40 teachers who participated in the research, 37 have a positivist background, use teacher-centered teaching, are interested mainly in completing the syllabus and the teaching tools they use are the book, the lecture, the blackboard and, in a satisfactory percentage, the ICT, which help teaching to be interesting and to develop a kind of dialogue with learners (**Table 1**). The use of images is necessary, especially in Biology, as it is about concepts of the microcosm that need imagination to be understood.

Teachers argue that the goals set by the curriculum are difficult to be achieved, as the curriculum lays emphasis on abstract theoretical problems that children do not care about and the textbooks are inappropriate and badly written. In addition, the educational goals must be in line with the unwritten goal of society, which suggests that students do well in exams, excel and enter university; a process based on memorization.

> "There is pressure from society (for students] to enter university. Thus, the main goal of teaching is for students to take part in the national exams and to practice in specialized exercises and in topics that most children will not encounter in their daily lives" (M7).

Table 1. The framework of achieving teaching objectives of teachers with a positivist background

Teaching methods	Objective	Result	Teaching tools
Teacher-centered frontal teaching 37	Connect lesson with learners' everyday life	Syllabus completion 31	Book 27
	Understand concepts	Understanding concepts 4	Lecture 23
	Love the teaching subject	Course connection with ecological issues 2	Blackboard 17
			ICT 15
			Worksheet 2

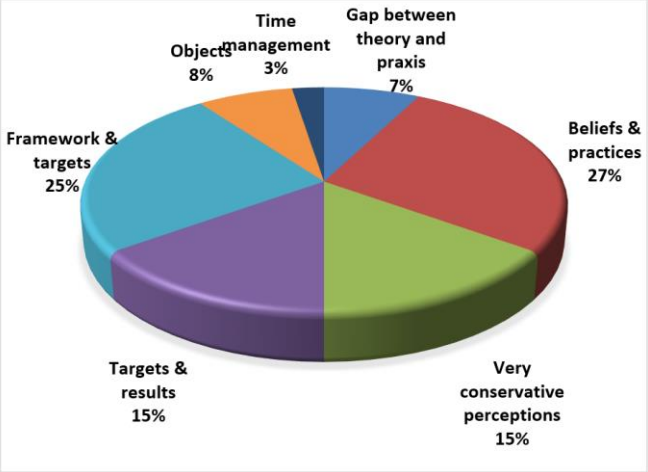

Figure 2. Science teaching contradictions

When the goal is to connect the lesson with everyday life, the activity seeks development of students but the teaching practice they apply does not support them. When the goal is the exams, then the activity seeks to successfully complete the syllabus and in this case student learning is a by-product. When the goal of the teaching activity is to complete the syllabus, then the learners are transformed from objects of the activity into mediation tools for implementation of activity.

The traditional teaching framework teachers accept and apply does not allow them to communicate with their students and this forces them to reconsider the ways in which they will improve their communication with the students in order to make their lesson more effective and get satisfaction from their work. For teachers, an obstacle to adopt new teaching practices for which they have been informed or trained is their inability to manage school time and the questioning of the value of these practices.

> "Students love the science lesson, if they love the science teacher, so you start to have a good relationship with them, to be sure that they will learn and be impressed" (M19).

Teachers put emphasis on the content of teaching because they believe that when something is taught, it is automatically learned by the children and consequently any failure is attributed to the learners and not to the way of their teaching. Teachers, while pointing out the problem (students' negative feelings, their inability to understand the knowledge provided, indifference), attribute it to the learners and their mental immaturity, laziness, and indifference. Teachers, who apply a formalistic positivist teaching model (five out of 37), argue that their duty is to impart the new knowledge to the learners, whereas the learners' feelings, which are shaped by their success or failure do not matter.

> "The majority of students do not love [Physics] because they do not understand it. The lesson becomes something unknown either because they are lazy or because they do not like it" (W3).

> "The aim of teaching science is cognitive, so when the lesson is difficult, most of the learners will not deal with it, but they will hate it, just as they hate mathematics. Only learners who are intelligent and want to do something better in their life have positive feelings" (M8).

The activity of teaching science develops contradictions due to the gap between theory and practice, to the teachers' beliefs and practice, especially to the very conservative beliefs, to their context of teaching that hinders the achievement of the goal, to the internal tensions in the object of the activity and to the time management (**Figure 2**).

Teachers do not manage to connect their teaching with the learners' everyday life because they lack pedagogical training. Content knowledge is not enough, thus putting teaching strategies into practice, which connect their teaching lesson with everyday life, is required. Their teaching schedule includes the lesson presentation with an outline that includes the points that, in their view, are important for learners to learn, or a summary of the lesson that students have to learn. In addition, they teach based on the teaching myth of the average student, a student model which, although it does not exist, facilitates a peculiar teaching uniformity.

> "Colleagues are very well-trained in their subject, but in the part of teaching they lag behind. They should teach us how to teach" (W22).

> "Unfortunately, not all children have the same abilities and unfortunately, we have to work with the average student, not with the very good student. I make a lot of notes on the board, explaining some things, and I insist that they copy them and study them at home. And I see that they learn the things which are written on the board" (W21).

Teachers who adopt student-centered teaching approaches are few (three out of 40). They have knowledge of pedagogical content, and have consciously changed their teaching framework, since they define themselves as learners' collaborators and form collaborative classroom rules. They recognize and take learners' cultural capital into account, change their teaching role, apply practices that connect science with the learners' everyday life and their interests and urge the learners to build their knowledge. For them, the most effective teaching practices are the emotionally charged, the experiential and the game-based ones.

Table 2. Objectives of environmental programs

Objectives of environmental education programs	References
Knowledge for learners to understand environmental issues and change attitudes	*It is a way to get learners to learn basic elements of the environment.* *To find information, to be concerned about environmental issues, to maintain a correct attitude towards the environment.*
Learners have fun or participate in an encyclopedic learning process outside of school	*I think children will learn things. It's something different from school.* *What is certain is that they will say "we had a great time", even if they see something that may not interest them, something they will not understand.*
Learners' connection with the environment to conserve the natural resources	*To love the environment–nature, in general.* *To acquire an emotional, environmentally friendly attitude.*
Learners' scientific literacy	"Basic knowledge on environmental issues, e.g., mercury, heavy metals […]. These things are not mentioned anywhere in any textbook."
Learners' environmental and social literacy	*It is an opportunity to connect economics and society with science.* *For me, E.E. programs must shape socially responsible citizens.*
Learners' environmental, personal, and professional empowerment	*E.E. is a journey of self-knowledge, recognition of one's place in the world and the effort of many people together to keep something for the next generations.* *For me, it is very important, it is a breath of fresh air in our school and our education system.*

The teaching practices may include brainstorming, lecturing and discussion, searching and presenting information, dramatization, and teamwork. The teaching tools they use are games, constructions, ICT, videos, textbooks, research, and discussion. The use of art and hands-on activities helps a lot in understanding the concepts. It's not the learners' responsibility, but teachers are the ones who are responsible for showing how the concept will be presented to them, so that it is understood. The main factor for understanding the concepts is the teachers' practices, which make a lesson interesting or boring.

> "Experience has influenced the way I teach, which is a two-way process. The students' feelings are positive, because the educational process is done in an experiential way and with the new technologies that they like. But the course is determined by my own practices. I use the Internet, some interactive experiments, experiential games, constructions like the classic soda volcano. Then, I tell them «Touch it, explore it" (W22).

> "The children, when they come to school, are concerned about several issues that have to do with their home, their family, their friendships and their problems, so we are more educators, more supportive of children" (M7).

Teachers' Perceptions of Environmental Education

The environmental education programs seek learners' declarative knowledge in order to understand the environmental issues and change their attitudes (**Table 2**).

Moreover, if learners understand the environmental issues and take actions, individually and collectively, then they will conserve natural resources and they will protect the environment. In case the development of an environmentally friendly attitude is sought, teachers emphasize the learners' emotional connection with nature. When environmental education is considered a process of scientific literacy, learners must learn to protect themselves against a dangerous technological world. If it is considered to be a process of environmental and social literacy, then the goal of humans is to redefine their role and their responsibility to other people and all living beings on the planet, a goal of a sustainable lifestyle. A program can also aim at empowering teachers in an environmental, personal, and professional way.

The research showed that most of the teachers (27 out of 40) develop environmental programs with a positivist and teacher-centered approach (**Table 3**).

They characterize all their environmental education programs as "project", having a general and a vague picture of the method. A common practice of their programs is the development of volunteer activities that include clean-up trash in local parks, reforestation, taking walks in nature, etc. In their environmental education programs, teachers use the traditional teaching framework, a fact that is conflicted to the principles of the environmental education such as the child-centered character of the programs and the learners' personal knowledge building, so, as a result, the learners become frustrated and gradually leave. The teachers' motivation for the implementation of environmental programs is usually the learners, but it can also be the environmental activity itself that acts as the most important thing, or their need to communicate with the learners, or the understanding of concepts. Teachers implement environmental education programs because they want to communicate with the learners, since the traditional way of teaching in their class keeps them at a distance, thus creating stressful conditions. Communicating with learners is a way to stay spiritually young and active, feel satisfied with their effort, as they receive positive emotions. The learners feel satisfaction and joy from their participation in the activity and the excursion they take, as well as from the connection they have with each other. The teaching practice applied by teachers is teamwork so as to find a predetermined topic with the help of technology, whereas they use brainstorming and the collaborative method less often. The obstacles to the implementation of environmental programs are external, such as the time pressure to complete the syllabus during the lesson, the school bureaucracy which acts as a block to the movement of students out of school, the lack of time and resources for the environmental program as well as the lack of collaborative culture in the school.

> "Honestly, I sometimes get frustrated. Colleagues are not willing to deal with the situation, to improve, I feel I'm the weird one" (M18).

Table 3. Teachers' epistemological background and the framework of the environmental education programs

EB	M/C	Activity object	Outcomes	References
Positivism 27/40	Teacher-centered methodology Traditional context	The learners communication environmental activity understanding concepts	Collection of information-knowledge Understanding of concepts Communication with students Empowerment of teachers Fuzzy results	*"Initially, the children showed an interest, then they start losing it very quickly. I wanted to know about the subject, the children would learn something out of it as well."* *"School can trap you. The motivation of programs refreshes teachers."* *"Every time I implemented a program, I was practical; we cleaned the schoolyard, which was full of papers, rubbish, leaves, branches."* *"I have the program in my mind, I assign an item to groups in order for them to bring me information about it and we discuss it in plenary. In the end, we make a presentation at school."*
	Vague		Vague	*"The last project I had done for the EE was a weather station, we had made its parts by hand."*
Constructivism 13/40	Child-centered methodology Collaborative framework	Learners	Critical thinking, understanding of concepts, students' self-action, & knowledge building	*"Be aware of who you are dealing with and adjust yourself to their needs, not vice versa. My goal is to get each child one step further than they already are."* *"We are a team, we think, we decide, we organize together, and we get improved."*

Note. EB: Epistemological background & M/C: Method/context

In case teachers use a child-centered framework (**Table 3**), teachers and learners set the rules together, respect each other, accept the diversity, the consistency, the discipline, and the acceptance of making errors. The teacher joins the group as a member, resulting in the empowerment of his image to the learners and the development of communication relationships, which facilitate his work. A key feature is the change in the role of the teacher who works collaboratively and does not consider himself as an expert. Environmental education does not follow a routine process as the course of the program is shaped by the learners, who are different every year. Therefore, each program offers the teachers experience and self-knowledge, enhancing their development. There are also cases where learners are involved in making short films, while others are involved in podcasts. Teachers seek the learners' emotional involvement in the learning process and adopt innovative teaching approaches.

DISCUSSION AND SUGGESTIONS

The analysis of the teaching systems of science and environmental education showed that in case the two systems do not have a common goal, then the activity system of environmental education enhances the emotional needs of the teacher without leading to substantial professional development and without achieving the environmental goal. In case the two systems have a common goal, then a field of expansive learning is formed, which is expressed along with the teachers' professional development.

Teachers with a positivist epistemological background do not reconsider their epistemological and pedagogical beliefs, therefore the development of a contradiction between beliefs and practice is unavoidable. Their inability to reconsider, in combination with their lack of internal motivation, creates a sense of distrust of any attempt at extroversion and change, which is reinforced when the school environment does not cooperate. This teaching framework cannot support the communication with their students, a situation that upsets most teachers and leads them to engage in environmental programs. The way in which the environmental education programs are implemented brings about tensions, which are mainly due to the disagreement between the principles and the philosophy of the environmental education as well as the method of projects, taking teachers' epistemological background and their incomplete pedagogical training in them into consideration. The contradiction between the teaching framework and the desired goal limits the outcome of the activity as far as the emotional empowerment of the teacher is concerned, while the students are not led to the building and internalization of knowledge, nor to the emotional involvement. The motivation for the students is external (excursion) and the process leads them to form a wrong impression on the environmental education since the context of the activity is similar to that of the school. The students, instead of being the object of the activity, act as a mediation tool for the achievement of the teachers' personal goals.

Teachers, with a constructive epistemological background, apply child-centered methods in their lesson and this enables them to develop and enhance communication and collaboration with their students. They enhance students' self-efficacy, and they are interested in the process and reflection on the issue of inquiry and are not limited to seeking information. In this case, the two systems of analysis, the science teaching, and the implementation of an environmental education program, have a common goal: the learners' active learning. Not only does this common goal led to better learning outcomes for learners but also to the professional development of teachers. The teachers argue that child-centered teaching practices in environmental education can be applied to the science lesson and improve the way learners learn science.

The research, based on the analysis of the activity theory, comes to add its qualitative findings to what the international literature has recorded; reinforcing the claim that child-centered pedagogy supported by environmental education can lead to the professional development of science teachers when applied in a way that is consistent with its principles and objectives. Since the main obstacle to change and development of science teachers is their positivist epistemological background, environmental education can support the efforts of horizontal forms of professional

development, as teachers' decision on getting involved in the process is personal. This position should be strengthened with further research concerning science teachers but also teachers of other scientific fields.

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