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Promoting Interdisciplinarity in Primary School in the Framework of Science Education

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Abstract. The promotion of interdisciplinarity has been gaining prominence all around the world to better prepare students for the real-life challenges of an increasingly demanding society. This study aims to investigate how to promote interdisciplinarity in primary school in the framework of science education. With a qualitative methodology and an interpretative approach, participants are primary school teachers who participated in a collaborative continuing professional development program. Findings of our research show that teachers gained the skills to design and implement interdisciplinary tasks adequate to primary school syllabus.

Keywords: *interdisciplinarity, science education, professional development, hands-on, primary school.*

Introduction

Interdisciplinarity is present in our day to day lives. In fact, when we interpret nature or solve diary problems most of the time we don’t notice if we are using Mathematics, History, Biology, Physics, Chemistry, or any other curricular topic. This is one of the reasons the promotion of interdisciplinarity has been gaining prominence in international school curricular programs all around the world, in order to better prepare the students to the increasingly scientific and technological challenges of our society (Abell & McDonald, 2006; Kim & Bolger, 2017; Rocard et al., 2007).

Education is the cornerstone of society and Science is considered an enabler of economic development and scientific literacy, being the motive, it is a compulsory curricular unit in primary and middle school in most countries (Harlen & Qualter, 2014). Also, Mathematics is part of our real world and it is a very important curricular unit being compulsory in primary and middle school, all around the world. Because Science and Mathematics are crucial subject matters, they are both subject of several international assessments such as PISA (Programme for International Student Assessment) or TIMSS (Trends in International Mathematics and Science Study). PISA measures 15-year-old student skills in Science and Mathematics. TIMSS evaluates Mathematics and science literacy of students of the 4th-grade and 8th-grade of primary school (about 9 to 10 and 13 to 14 years old, respectively) and 12th-grade of secondary school(about 17 to 18 years old).

Technology is also gaining prominence and considered essential to future careers. There is a growing number of acronyms that result from interdisciplinary among several subject matters such as ICT (Information and Communication Technologies), STEM (Science, Technology, Engineering and Mathematics) and STEAM by adding A from Arts (Weaver, 2016). Long, Robert and Davis (2017) sustain that benefits of this integration are related to scientific and economic development of countries. Costa and Domingos (2018b) propose the acronym STEAMH, by adding H of Heritage to STEAM, arguing that Heritage is a very important feature of the real world since its beginning.

These recommendations have impact in the school curriculum of a growing number of countries and lead to the need to innovate teachers' practices, in order to adapt them according to school syllabus. However, although many authors are arguing the importance of promoting interdisciplinarity, namely STEAM and ICT integration, there are also many studies diagnosing difficulties of STEAM implementation in the classroom, especially at the primary school level (e.g., English, 2017; Kim & Bolger, 2017).

Suggestions to overcome these difficulties are related to teachers' Continuing Professional Development (CPD). In this sense, it is crucial to support them, being necessary to accompany them in class, in order to promote Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK) (Shulman, 1986; Ball, Thames, & Phelps, 2008), that may conduce to the innovation and sustainability of their practices (e.g., Zehetmeier & Krainer, 2011).

In this paper, we aim to investigate how to promote interdisciplinarity in science education, in the framework of a collaborative teachers' CPD program. Our main goal is to research if teachers who participated in this CPD program, gained the skills to design and implement interdisciplinary tasks adequate to primary school syllabus. Also, in the context of the CPD program, we intend to find strategies that motivate teachers and make them able to innovate their practices in the classroom. These strategies may be useful to teacher educators, who are interested in promoting teachers' professional development related to interdisciplinarity subject matters.

Framework of this study

Lately, calls to implement new pedagogical approaches, student-centred and based on real problems solving, have been gaining prominence in the literature. Also, recommendations to promote interdisciplinarity among several subject matters, namely STEAM integration are increasing in many studies (Kim & Bolger, 2017).

In Portugal, the first cycle of primary school consists of four school years, with students aged 6 years old (1st grade) to nine years old (4th grade). In this cycle, there are three main curricular units lectured/supervised by the same teacher: Portuguese, Mathematics and Study of the Environment. The first two curricular units are considered crucial for students and are the subject of national assessments to gauge students' knowledge. The Study of the Environment curricular unity has about 3 hours a week and integrates contents such as Astronomy, Physics, Chemistry, Natural Sciences, Geography, History, Heritage, Human Body, amongst others.

Interdisciplinarity is present in the general objectives of primary school syllabus, in Portugal, where it is emphasised that the "Study of the Environment is at the intersection of all other curricular units of the school syllabus and can be a driving force for learning in these areas" (Ministério da Educação [Ministry of Education], n.d., p. 101). Concerning Mathematics, the analysis of the real world is one of the three goals of methodological orientations, where it is recommended that Mathematics "is indispensable to an adequate understanding of most of the phenomenon that occurs in the world around us (…)" and it"reveals essential to the study of phenomenon that is object of attention of other disciplines from school syllabus of elementary education" (Ministério da Educação [Ministry of Education], 2013, p. 2).

Also, in the school year 2018/2019, there will be implemented in elementary and middle school the autonomy and flexibility curricular project (Diário da República [Republic Diary], 2017), which also emphasises interdisciplinarity among curricular units. To achieve the project' goals, teachers may change the order of the contents in the curricular units in order to solve the tasks related to the project.

But, in Portugal, as in many other countries all around the world (e.g., Abd-El-Khalick, 2013), the reality of many classrooms is still the traditional teaching, using textbooks and giving priority to disciplines such as mathematics or the native language without promoting interdisciplinarity (Carvalho, Silva, Lima, Coquet, & Clement, 2004; Rocard et al., 2007).

This reality and the above recommendations lead to a change of paradigm conducting to the need of innovating teachers' practices to correspond to the methodological suggestions of school syllabus and the challenges of autonomy and flexibility curricular project (Costa & Domingos, 2018a). This observation raises the following questions: How to promote interdisciplinarity in primary school? What knowledge is necessary to change the paradigm? How to design and implement interdisciplinary tasks in the classroom?

Teachers are the cornerstone of any renewal of science education (Rocard et al., 2007) and no pedagogical intervention is possible without their professional development (Hewson, 2007). It is expected that teachers re-design the curriculum, to adapt it to the students and the school surrounding reality. In Portugal, Martins (2006) claims to be a priority to strengthen investment in scientific research in the field of science education in the early years of schooling and continuing teacher training. Also, Hewson (2007) sustains the importance of updating teachers' Subject Matter Knowledge and Pedagogical Content Knowledge.

CPD of in-service teachers is mandatory in several countries, as in the case of Portugal (OECD; 2014). In our country, CPD of in-service teachers needs to be approved by the *Conselho Científico Pedagógico da Formação Contínua* [Pedagogical Scientific Council of Continuing Education], who also follow the evaluation process of the continuous training system (http://www.ccpfc.uminho.pt/).

This study is part of a broader pedagogical project entitled "Academy of Science, Art and Heritage" (AcademySAH) designed and supervised by the first author of this paper (Costa & Loureiro, 2016). Created in 2013 at the Instituto Politécnico of Tomar (IPT), it receives children aged 8 to 14 years old, during their school holidays, at the IPT laboratories to develop several STEAMH hands-on workshops in order to promote their interest by these subject matters (Costa & Domingos, 2018b). Since 2015, the AcademySAH also promotes teachers' professional development related to STEAMH.

In 2015, with a partnership of universities, a local training centre and elementary schools, it was designed and approved by the Pedagogical Scientific Council of Continuing Education a CPD training course targeted to primary school teachers. The CPD course consists of 26 hours of a face-to-face session with university educators. In 2016 a second CPD course was approved with 13 hours of face-to-face workshops with university educators and another 13 hours of autonomous work by the primary teachers at the classroom with their students. The CPD courses consist of several STEAMH workshops, with a duration of two to four hours, directed by university educators. University educators are teachers and researchers in the areas of science education, electrical and computer engineering, mathematics, biology, physics and chemistry. Besides directing the workshops, university educators also design laboratory experiments and prototypes, according to the school syllabus, to be implemented with primary school students. An essential characteristic of this program is the support given to the participant teachers, namely accompanying them in the classroom with their students.

The main objective of this CPD program is to provide teachers with Content and Pedagogical Knowledge that may lead them to gain motivation, autonomy and skills to design and implement STEAMH interdisciplinary tasks in the classroom.

Literature Review

To face an alarming decline in students' interest for STEM (Rocard et al., 2007), several authors sustain the need to intervene in the first years of school in order to motivate students to learn these subjects (DeJarnette, 2012; Hallstrom, Hulten, & Lovheim, 2014). Also, it is crucial to perform hands-on and minds-on experiments in the classroom to lead students to achieve significant improvements in performance and to produce positive attitudes towards Science (Mathers, Goktogen, Rankin, & Anderson, 2012; Mody, 2015; Varley, Murphy, & Veale, 2013).

Abell and McDonald (2006) argue that Science should be used to promote interdisciplinarity because it contributes to learning about other curricular units. STEM integration should be implemented in the first years of school by designing adequate curricular material to develop hands-on experimental activities and by promoting teachers' professional development. Also, Kim and Bolger (2017) sustain the creation of a curriculum that integrates STEAM, being crucial to involve teachers into interdisciplinarity lessons adequate to this approach.

Young (2007), argues that schools are responsible for making students achieve powerful knowledge and, for this purpose, it is necessary to develop a collaborative work among local, national and international groups of teachers and researchers. Young (2010) sustains that it is crucial to learn how to reflect about the interaction between education and sociology, which means to learn not only about all that is going on in our institution (micro-cosmos), since curriculum to teaching diary activities, teachers and students; but, also, to understand the society where we live in, to understand the reality of the several educational institutions (macro-cosmos).

In this regard, to improve teaching and learning, it is crucial to develop a partnership between researchers and designers that promotes appropriate pedagogical approaches to provide the integration of tasks in the classroom (Geiger, Goos, Dole, Forgasz, & Bennison, 2014). Also, being part of a network motivates them, contributes to improving the quality of teaching and promotes the sustainability of their professional development (Hewson, 2007; Rocard et al., 2007; Zehetmeier & Krainer, 2011). Another essential CPD design aspect is to stimulate cooperation among the participants, and between the participants and the professional developer (Kuzle, & Biehler, 2015).

Teachers are the key to any model to improve learning and teaching (Rocard et al., 2007). Teachers' professional development is a very complex task, and there is a need to develop research about this subject, namely by presenting empirical studies that contribute to the literature (Hewson, 2007). Ríordáin, Johnston and Walshe (2016) refer to lack of research about science and mathematics, concerning in-service teachers and sustains the importance of supporting the teachers at school and a community of practice levels.

To improve students' learning, it is fundamental to give learning opportunities to teachers by designing adequate training courses and workshops (Ball, 2003), where teachers can practice what they are expected to implement in the classroom in a collaborative learning environment (Afonso, Neves, & Morais, 2005).

A CPD program will only be successfully achieved if teachers gain the skills to implement what they learned in the classroom (Buczynski & Hansen, 2010). To achieve even better results, it is essential to develop a robust Subject Matter Knowledge and to support the teachers in their classroom (Abd-El-Khalick, 2013).

In Portugal, Science experiments at the first cycle of primary school are integrated into the curricular unit of Study of the Environment. But to reinforce the importance of implementing science hands-on experiments there has been created the curricular unit "Experimental teaching of Sciences" (http://www.dge.mec.pt/disciplinas), making compulsory the implementation of several experiments related to astronomy, sound, electricity and magnetism, light and shadows, air and water, among others, in the classroom (Ministério da Educação [Ministry of Education], 2007).

Based on a preliminary study, during the school year 2015/2016, Costa and Domingos (2017) conclude about the importance of developing teachers' Subject Matter Knowledge about Science, in order to lead them to design and develop interdisciplinary tasks in the classroom. Also, they recommend the need to keep promoting teachers' CPD in order to achieve better results in the future, making them gain confidence and autonomy to innovate their practices. In another paper, based on two school years of research (2015/2016 and 2016/2017), Costa and Domingos (2018c) developed a study to investigate what knowledge is necessary to implement Science hands-on experiments at primary school. In this study, they conclude about the importance of several knowledge categories such as Curricular Knowledge, Subject Matter Knowledge to teach, Technological Knowledge, or Pedagogical Knowledge, amongst others. Concerning Science Education, they highlight Subject Matter Knowledge as crucial to motivate teachers to innovate their practices and, also, they sustain the importance of Pedagogical Knowledge to perform Science hands-on experiments in the classroom.

In summary, to promote interdisciplinarity in science education, there is the need to develop a partnership and collaborative work, in order to promote adequate teachers' professional development. A collaborative CPD program that supports teachers is crucial to lead them to gain motivation, knowledge and skills to innovate their practices.

Methodology

This paper aims to investigate how to promote interdisciplinarity in Science education, in the framework of a collaborative teachers' CPD program. This CPD program is part of a broader pedagogical project that is based on a Teacher Design Research (TDR) methodology (Bannan-Ritland, 2000). This approach involves several cycles of design research, where the main objective is to promote teachers' professional development, improving their ability to adapt to the classroom environment and leading them to innovate their practices. In the broader project, each cycle consists of a whole school year. A total of three cycles of TDR have occurred until now during the school years 2015/2016, 2016/2017 and 2017/2018.

In this paper, we will use a qualitative methodology and an interpretative approach (Cohen, Lawrence, & Keith, 2007), in order to try to find out what strategies of the referred CPD program may lead teachers to gain motivation and skills to design and implement interdisciplinary tasks adequate to primary school syllabus. These strategies may be useful for teacher educators interested in promoting interdisciplinary CPD programs.

Also, we apply methodological instruments of content analysis (Bardin, 1997) to the written reports presented by the teachers during the CPD program. Bardin (1997) recommends methodological instruments of content analysis to achieve a rigorous and objectivity interpretation of data as possible.

Teachers in this study participated in a CPD program that consists of several workshops, with a duration of two to four hours, directed by university educators. At these workshops, teachers have the opportunity to learn, observe and work the laboratory experiments, that they are expected to implement in their classroom. It is provided with an informal learning environment where the teachers feel comfortable to ask questions, clarify any doubts and collaborate, to improve the experimental activities and the teaching approach. Teachers are asked to implement hands-on experiments with their students and to promote their autonomy by creating and proposing their STEM tasks. The last workshop is mainly directed to share with the participants' innovative practices, created and implemented by the teachers with their students. Also, there is performed a focus group discussion about the CPD program in order to find out what needs to be improved in the following cycles of TDR.

Data collection consists of portfolios presented by the teachers at the end of each cycle of TDR, with a critical account on the CPD context and about the impact of the training course in their practices, including their proposals and evidence of STEAMH tasks, implemented in the classroom with their students. Also, data collection includes observations during the teachers' workshops and during the visits to teachers' class, either to perform Science hands-on experiments either to observe the teachers in action when performing their experiments. The first author of this paper was present at all the workshops and during visits to the classroom. The second author is responsible for triangulation and validation of the collected data.

Participants

Participants in the teachers' CPD programme are 1st to 4th grade in-service teachers that made their inscription at least in one of the three cycles of TDR. The participants in the first cycle of TDR (school year 2015/2016) comprised 14 female teachers of 5 primary schools aged between 42 and 58 years old and more than twenty years of experience. These teachers participated in the training course beginning in September 2015 and ending in July 2016. Eleven teachers were lead teachers of 3rd and 4rd grade students, two of 2nd grade and the last one had no assigned class. At the second cycle (school year 2016/2917), participants were 37 female teachers aged 35 to 61 years old and one male teacher with 45 years old of 14 primary schools. All the teachers had more than ten years of service. In the third cycle of TDR, participated 20 teachers of the first cycle (6 to 9 years old) of primary school and 18 teachers of second (9 to 12 years old) and third cycle (11 to 15 years old) of primary school.

In this paper participants are first cycle primary teachers, who were involved at least in one of the three cycles of TDR. Special attention will be given to the teachers who were able to design and perform interdisciplinary tasks in the classroom, in order to find out what made them gain motivation and skills to achieve those results. To preserve the teachers' identity, all the following names are fictitious.

Data analysis and discussion

In this section, we start by analysing some teachers' perceptions about the CPD program. After, we use content analysis to interpret data from teachers' reports, in order to identify categories related to our research.

Teacher Aurea, 62 years old and responsible for a 2nd grade class with 22 students, participated in the second cycle of TDR (2016/2017 school year). In her final report, presented in June 2017, she refers that she chose this CPD program because she wanted to "improve my content knowledge about STEM subject matter" and "design a teaching/learning trajectory for my class, with more quality and enhancer of the success of my students" (Final report, June 2017). Concerning the CPD context, she reports that "there is a decentralization of the teacher's action from the result to the process of teaching", meaning the action is centred in the students instead in the teachers. She also refers to the Educator' method "I register with great appreciation the clairvoyant approach of the Educator who promoted the dialogue between teaching methodologies and the sciences" (Reflection, January 2017). In her first reflection, concerning the impact of the first workshops, teacher Aurea refers that:

> Three transversal ideas were behind: constructing mental models that make sense; instilling in students the "empowerment" that is, leading them to believe that they can build their learning and finally designing an education based on experiences, manipulations and experiments (as was the case in this session, where we had several demonstrative practical moments). (Reflection, January 2017).

In her final report (June 2017), she concludes saying that: "I am sure that I have reinforced the knowledge and the sensitivity necessary to improve my performance in the classroom, using the variations and modulations that had offered me".

Teacher Anita (52 years old and responsible for a 3rd grade class with 24 students), also refers to the importance of developing hands-on experiments with her students:

> During the workshops it became to me evident the importance of performing with my students a set of activities that permits to build their own knowledge, in a constructive way, involving the manipulation of materials and the realization of tasks that they can observe, question, reflect, experiment and finally conclude (Anita, June de 2017).

Both teachers recognise the importance of developing this kind of approach and how the practical workshops gave them strategies to perform hands-on experiments with their students. Like teacher Aurea and Anita, the other teachers' reports reflect the CPD context and give an account of the impact in their perceptions, practices and in their students' interest and learning about STEAMH.

Based on methodological instruments of content analysis, applied to the reports (to which correspond the above reflections) and other individual reflections, presented by the teachers, several categories were identified and organized in Table 1. Concerning the focus of this paper, we selected the following categories: Teachers' motivation; Innovation of teachers' practices; Impact on the students; Visits to teachers' classrooms; Interdisciplinarity; Collaborative work; Sharing of practices. In Table 1, (Name, 2016) means reflection or final report presented by teacher Name.

Table1

Categories identified in teachers' reports.

Categories	Report's excerpts
Teachers' motivation	I recognise the importance of performing hands-on experiments (...). This CPD gave me confidence to innovate and, also, Knowledge and tasks proposals to apply in the classroom (Pilar final report, June 2016).
	I emphasise that the training course has contributed to the acquisition of new knowledge that will allow me to improve the professional performance and to have a positive impact in the classroom, providing to the students diversified experiences of learning and the development of scientific competences (Micaela's final report, June 2017).
	I believe that this training will bring to my learner practice a wider range of possibilities for new activities, to be carried out in the context of the classroom. The most interesting thing is that these new approaches, which we have been trained in are mostly practical approaches, which is very good (Anacleto's final report, June 2017).
	In this training course, I expand my horizons and face experimental sciences in a more motivating and straightforward way, which will improve my pedagogical performance. (…) I gained a more significant capacity of developing experimental sciences in my class because I learned several categories of knowledge enriched by the fact that it was a very hands-on training in the framework of a classroom (Cristiana, June 2018).

Categories	Report's excerpts
Innovation of teachers' practices	The math activities performed in the class gained new meaning as it was applied to practical real-life situations (Teacher Luísa final report, June 2016).
	This training course gave me the acquisition of knowledge, skills and competencies. My teaching practice will undoubtedly undergo some changes, including the introduction of experiments and the so important regularly discuss/question in my lessons (Anabela's final report, June 2016).
	The participation in this training course was very enriched and contributed […] to improve my pedagogical practice (Goreti, June 2017).
	[…] This course made me perform another kind of experiments that are not usual in the school books (Josefina, June 2017).
	Undoubtedly, this action allowed other types of experiments to be carried out, in addition to those in the school books, enabling students to be active agents in the learning process (Maria's final report, June 2017).
Impact on students	The class appeared to be very engaged when completing the tasks proposed by the instructors. The students adopted a cooperative, experimental attitude in which failure was regarded as a part of the scientific process (Luisa Final report, June 2016).
	[…] after performing the electricity handson experiments (which happened at September/October), at the end of the school year (about June) children still remembered what they learned at that time (Luisa Final report, June 2016).
	[…] it arouses greater curiosity in children allowing them to discover and question what they are observing […] students are encouraged to raise questions and seek answers through simple experiments and research […] also it should always be made the formulation of hypotheses, results, prediction, observation and explanation of results (Marta, June 2017).
	With practical approaches, students become more attentive and interested, collaborating in a more active and committed way, which is then noticed in their learning (Anacleto, June 2017).
	[…] the pupils show an extraordinary interest and they are very determined for the accomplishment of the proposed tasks (Lígia, June 2017).
	The classes where the experiments take place are very lively and participative classes by the students. They like classes much more when they perform practical experiments. For this reason, it is notorious how they learn by playing, experimenting and doing (Paulina, June 2017).
	Students manipulated diverse materials, observed, experimented, reflected and recorded the various moments, always with a lot of commitment and enthusiasm which was reflected in the way they evaluated the activity (Mariana, June 2017).

Categories	Report's excerpts
Visits to classrooms	One of the highest points is the educators' visits because it is a unique moment in the classroom. Students will be able to learn/experiment with the help of accredited technicians equipped with all the necessary materials (Anacleto's final report, June 2017). I highlight the visits of the university students to our school to perform science experiments because they develop the interest of the students, making them more participative and committed with the tasks (Silvina, June 2018). I must begin by mentioning that the "Goings of the Trainers" to my classroom were excellent contributions to create in the students a more entrepreneurial and creative spirit. The activities developed were easily understood because they proved to be exciting, since they seemed to be playful and were very pedagogical (Cristiana, June 2018). The fact that trainers go to school […] to develop with the students, experimental activities and to approach contents, using diverse and very concretizing materials in a very motivating and rewarding way, demonstrated the great interest that should be given to the practice of experimental activities and to the importance they have for the development of knowledge and the opening of scientific horizons (Manuela, June 2018).
Interdisciplinarity	In the action in which the astronomy was approached, I had many ideas to develop with my students at the classroom, being able to articulate between the different curricular areas (Carla's report, February2017). The application of new ideas to address specific contents related to experimental sciences and mathematics has provided interdisciplinary practice in different areas (Mathematics, Portuguese, Plastic Arts, Study of the Environment) (Maria's final report, June 2017). […] contributed to broaden my horizons and the performed experiments permit to implement interdisciplinarity and work differently way several subject matters, which is fundamental and enriching to my pedagogical practice (Andrina, June 2018). Another capacity that I developed with the learning activities carried out in the training action was to provide my students with more diversified knowledge in mathematics, geography, natural sciences, meeting what has now been defined as goals to be achieved in the Student Profile (Cristiana, June 2018).
Collaborative work	I appreciate all the support that the educators gave us during the workshops and the opportunity to practice the experiments with my peers (Micaela, June 2017). We also found out that in a collaborative environment it is not difficult to promote this kind of activities (Silvina, June 2018). I highlight all the interest and support of the trainers during classroom implementations (Manuela, June 2018).

Categories	Report's excerpts
Sharing of practices	Undoubtedly, this action allowed other types of experiments to be carried out (...) encouraged the application of new methodologies in the classroom and enabled the sharing of activities among all the trainees(Maria's final report, June 2017). The sharing of good practices among the teachers, with the presentation of the work done in class, by my colleagues, was very enriching (Teacher Ilda final report, June 2017). In this training, there was a sharing of acquired knowledge and practices, diversity of opinions, doubts, in a notable way (Manuela, June 2018). Sharing practices was centred in vibrant discussions about how to perform the experiments individually or how to organise the groups (Micaela, June 2018).

Teachers' motivation is very critical because without it they will not change their practices. We highlight the following observations: "I recognise the importance of performing hands-on experiments" and "gave me the confidence to innovate"(Pilar, June 2016); "this training will bring to my learner practice a wider range of possibilities" (Anacleto, June 2017); "I enlarge my horizons and face experimental sciences in a more simple and constructively way, which will improve my pedagogical performance" (Cristiana, June 2018). These observations show that teachers gained motivation because they recognise the importance of performing this approach and that they acquired knowledge to implement it.

The motivation is the first step to innovate teachers' practices. In this regard, several teachers recognised changes in their practices: "This course made me perform another kind of experiments that are not usual in the school books" (Josefina, 2017); "My teaching practice, will certainly undergo some changes, including the introduction of experiments" (Anabela, June 2016).

Also, we verify that teachers recognised that this approach has an impact in their students, contributing to improve their interest to learn these subject matters. Even though the students are not the focus of this paper, it is not possible to ignore them because all the teachers referred to their students in their reports. Among several mentions of the students, we highlight the following: "we promoted students' interest for science" (Margarida, June 2016); "it developed students' scientific knowledge" (Marta, 2017); "we reinforced students learning" (Goreti, June 2017). These mentions to their students show the importance that teachers give to the impact of this approach in their students and how it contributes to their motivation to perform this kind of experiments.

The promotion of interdisciplinarity is very present in teachers' reports and is related to the innovative practices. Some references are the following: "being able to articulate between the different curricular areas" (Carla, June 2017); "provided interdisciplinary practice in different areas (Mathematics, Portuguese, Plastic Arts, Study of the

Environment)" (Maria, June 2017); "the performed experiments permit to implement interdisciplinarity and work in a different way several subject matters" (Andrina, June 2018).

Finally, collaboration and sharing of good practices is strongly emphasised in the reports because it helps them to innovate their practices, gives them ideas to implement new practices in the classroom and makes them confident to perform the science experiments promoting interdisciplinarity.

Many teachers referred that this CPD program gave them new ideas to develop and perform interdisciplinary tasks in the classroom, relating contents from several curricular units. All teachers recognised that this kind of approach is very important and should continue in the future. Also, teachers referred that the CPD context gave them knowledge and skills to be able to innovate their practices by designing and implementing STEAM hands-on experiments with their students. The support of the educators, namely the visits to teachers' classroom, was highlighted by the teachers as crucial to help them develop this kind of approach with their students. Also, the sharing of good practices was considered very enriching, contributing with more strategies to be used in the classroom.

Final considerations and conclusions

This study investigates how to promote interdisciplinarity in science education, in the framework of a collaborative teachers' CPD program. With a qualitative methodology and an interpretative approach, participants are primary school teachers who participated in a collaborative CPD program. This research is based on data collected during three school years: 2015/2016, 2016/2017 and 2017/2018.

Based on content analysis (Table 1), we verified that teachers gained motivation about the importance of developing science experiments with their students. Also, they referred that the CPD program gave them knowledge and ideas to design new tasks adequate to be implemented in the classroom. All the teachers referred impact of this approach in their students and defended that it is important to keep developing this approach, because it promotes students' interest and motivation to learn. We argue that the fact that teachers have recognized the impact in students' motivation and learning, contributes to their motivation about the importance of keeping developing this kind of approach in the classroom.

Other important strategies that contribute to innovate teachers' practices are related to the CPD context, namely the exemplificative practices with the teachers and the support that university educators give to the teachers. A very frequently mentioned aspect in the reports is the visits to the teachers' classroom. These visits, either to exemplify science experiments or to support teachers in their proposals of interdisciplinary tasks, have turned out to be very important in promoting the effectiveness of this CPD program. We argue that this strategy motivates teachers to implement this approach and contributes to teachers gaining more SMK and PCK making them confident to innovate their practices.

This collaborative strategy that supports teachers is in line with authors such as Capps and Crawford (2013) who sustain the importance of supporting teachers in how to teach science, leading them to achieve greater gains in SMK and PCK. The sharing of good practices was also very highlighted by the teachers because it gave them good examples of tasks they could also use in their classroom. This is another strategy that the authors of this paper consider important to contribute to change teachers' practices. In fact, the opportunity to see tasks that their peers performed in the classroom is very inspiring for them, making them believe it is possible to innovate their practices.

We believe that we developed a partnership and a collaborative work between teachers, educators and researchers, as recommended by several authors (e.g., Geiger, Goos, Dole, Forgasz, & Bennison, 2014; Hewson, 2007; Rocard et al., 2007; Young, 2007).

Finally, we verified that teachers who participated in this collaborative CPD program, gained skills to design and implement interdisciplinary tasks adequate to primary school syllabus and related to Science Education. We highlight the supporting strategies that lead the teachers to achieve the referred results, namely visits to teachers' classroom and the sharing of good practices as crucial to contribute to innovate teachers' practices.

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Tarpdiscipliniškumo skatinimas pradinėje mokykloje mokslinio ugdymo kontekste

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Santrauka

Tarpdiscipliniškumo skatinimas vis labiau pastebimas viso pasaulio tarptautinėse ugdymo programose – tuo siekiama geriau parengti mokinius realaus gyvenimo iššūkiams, kylantiems iš vis reiklesnės visuomenės (Abell, Mcdonald, 2006; Costa, Domingos, 2018b; Kim, Bolger, 2017; Rocard et al., 2007). Šios rekomendacijos didina mokytojų motyvaciją atnaujinti praktinio darbo klasėje įgūdžius, siekiant profesinio tobulėjimo (Hewson, 2007; Rocard et al., 2007; Zehetmeie, Krainer, 2011).

Šiame straipsnyje siekiama rasti būdus, kaip skatinti tarpdiscipliniškumą mokslinio ugdymo kontekste, remiantis bendradarbiavimu paremta nuolatinio mokytojų profesinio tobulėjimo (angl. CPD) programa. Pagrindinis mūsų tikslas buvo ištirti, ar mokytojai, kurie dalyvavo įgyvendinant šią CPD programą, įgijo įgūdžių kurti ir atlikti tarpdalykines užduotis, tinkamas pradinės mokyklos ugdymo programai. Be to, remdamiesi CPD programa, mes bandėme rasti strategijas, kurios motyvuotų mokytojus atnaujinti praktinius darbo klasėje įgūdžius.

Buvo taikoma kokybinė metodologija ir interpretacinis požiūris, o dalyviai buvo pradinės mokyklos mokytojai, kurie dalyvavo įgyvendinant minėtą CPD programą. Tyrimo rezultatai patvirtino, kad mokytojai, kurie dalyvavo įgyvendinant programą, įgijo įgūdžių kurti ir atlikti tarpdisciplinines užduotis, tinkamas pradinės mokyklos ugdymo programoms ir susijusias su moksliniu ugdymu. Strategijos, kurios padeda mokytojams tai pasiekti, yra sietinos su lankymusi kitų mokytojų pamokose ir dalijimusi gerąja patirtimi. Dėl to mokytojų darbas tampa inovatyvesnis.

Esminiai žodžiai: *tarpdiscipliniškumas, mokslinis ugdymas, profesinis tobulėjimas, praktinė patirtis, pradinė mokykla.*

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