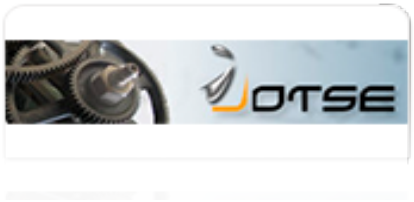

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EXPLORE: AN ACTION TO BRING SCIENCE AND TECHNOLOGY CLOSER TO SECONDARY SCHOOL

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Abstract

This paper presents the experience of an initiative, the EXPLORE courses, designed to bring science and technology closer to secondary school. The EXPLORE courses, organised by "EXPLORATORI: Natural Resources" project, are particularly addressed to secondary school teachers and are conducted at Catalonia (North East of Spain). The main objective is to provide secondary school teachers with the opportunity to explore the natural resources. Based on a combination of face-to-face and online learning, the programme of the courses uses an interdisciplinary approach, integrating Science, Technology, Engineering, and Mathematics (STEM) and STEAM (STEM + art) fields. Data presented in this paper correspond to the 2012 and 2013 editions. The results, which were obtained from a written questionnaire completed by teacher participants of EXPLORE courses, indicate that more than 70% of secondary school teachers were encouraged to introduce some course contents on their teaching classes after participating in an EXPLORE course.

Keywords – Teacher education, Secondary school, Natural resources, STEM education, STEAM education.

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1 INTRODUCTION

Over the past decade, the number of students in science and technology fields has increased in absolute terms in most European countries, but their proportion of the total student population has significantly decreased during the same period (ERT, 2009). Recognising that a highly qualified workforce in the areas of Science, Technology, Engineering, and Mathematics (STEM) is vital to the economic prosperity of Europe, the declining interest in these studies among young people has been a matter of international concern in several studies and policy reports (for example: EU, 2004; EU, 2007; OECD, 2008; Osborne, Simon & Tytler, 2009).

The situation in Catalonia, in the North East of Spain, is not different from the rest of Europe: the number of first-year enrolments on scientific, technological, and mathematics courses in Catalan universities is critical. In this sense, a recent study (Everis, 2012) revealed that the total number of students choosing to pursue studies in Information and Communication Technologies (ICT) field at the Catalan universities had declined by more than 50% from 2001 to 2010. This trend was even more pronounced in the case of technical engineering. Furthermore, the study also reported that the majority of Catalan students found the careers in science and technology fields attractive, to have high social prestige, and to offer good employment opportunities. Nevertheless, many of them do not choose them because they have low expectations for own success. Results

from the Programme for International Student Assessment (PISA) for 2006 (CSA, 2008) indicated a tendency for Catalan students to show relatively lower levels of interest in science than other OECD (Organisation for Economic Cooperation and Development) countries. In general, students expressed more interest in learning about health or safety issues that they perceive as being relevant to their lives than those that they perceive as being of little relevance to themselves (Bybee & McCrae, 2011).

To overcome this situation, scientific and educational organizations across the country have been working on developing and implementing activities and projects designed in part to increase young people's interest in STEM careers and grow the number of qualified workers with STEM skills and knowledge. This paper presents our own experience with one of these initiatives: the EXPLORE courses.

The EXPLORE courses are an action addressed particularly to current science and technology teachers in secondary level education, organized by the "EXPLORATORI: Natural Resources". The "EXPLORATORI: Natural Resources" is a project from the Barcelona Knowledge Campus (BKC), presented by the "Universitat Politècnica de Catalunya · BarcelonaTech" (UPC) together with the "Universitat de Barcelona" (UB), and the Berga Town Council. The main objective of the project is to bring science closer to secondary school students, their teachers and the society in general. To achieve this, the "EXPLORATORI: Natural Resources" organizes activities related to scientific and technological topics, with a common background: the use and exploitation of natural resources.

The specific purpose related to the EXPLORE courses is to provide tools for teachers to be used afterwards in their lectures with students. The program courses primarily focus on secondary school teachers as the main target of this initiative, but are also addressed to university students and environmental science professionals.

2 METHODOLOGY

2.1 The singularity of the EXPLORE courses

Although there are many training programs for educators, EXPLORE courses have an important distinctive feature compared with other courses: the theory lectures are combined with workshops and visits to sites of scientific and technological significance where samples can be taken for the workshops. For this reason, these activities are carried out in the "El Berguedà" region, given the value of its rich natural landscape. In fact, field-based learning is not new; it appears particularly in studies related to Earth sciences (biology, geology, environmental science...). However, it is also true that this methodology is not commonly applied in teacher training courses. Moreover, learning connected to the nature has the potential to decentralize knowledge that currently fulfils an important responsibility of the University. Table 1 shows the structure of an EXPLORE course.

Sessions	***Format***	***Duration***	***Contents***
Session 1	*Face-to-face*	*5 hours/day*	*Theory lessons*
		5 hours/day	*Practical lessons (visits and workshops)*
Session 2	*Face-to-face*	*5 hours/day*	*Theory lessons*
		5 hours/day	*Practical lessons (workshops and visits)*
Session 3	*Online*	*10 hours*	*Individual study and online self-learning*

Table 1. Structure of an EXPLORE course

In addition, the workshops provide teachers with a set of tools of easy implementation in the classrooms, as they attempt to use as much as possible accessible material and samples collected at the visits. For example, in the "Construction of simple meteorological equipment" workshop of the EXPLORE meteorology course, an anemometer and a thermometer were constructed using low-cost and easily available material in any school, such as plastic cups, drinking straws, rubber bands, pencils, etc.

The contents of the EXPLORE courses focus on the theme of natural resources, and the main topic of each course is chosen by the organizers of the "EXPLORATORI: Natural Resources" project according to the time of year. Appendix A collects the topics of the EXPLORE courses offered in the 2012 and 2013 editions. Each course covers different aspects of the topic selected, from different disciplinary perspectives simultaneously. This multidisciplinary design activity is in line with the STEM education model.

In the nineties, the National Science Foundation (NSF) developed the word STEM as a generic label for any event, policy, program, or practice that involves one or several of the STEM disciplines (Bybee, 2010). For educational policies, programs, and practices, the acronym should mean an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise (Tsupros, Kohler & Hallinen, 2009). In other words, STEM education removes any boundaries between the subjects and imagines them taught as one (Roberts, 2012). The teaching of the integrated subjects of STEM is gaining importance in some parts of the world, including the United States (Dugger, 2010), but it is still little known in Catalonia.

Furthermore, the contents of some EXPLORE courses connect the artistic or creative side to all the STEM components. This strategy to integrate the arts in the STEM education is called STEAM, by adding an “A” to the acronym STEM. A notable example of an EXPLORE course designed with STEAM education is EXPLORE natural pigments. The participants could examine natural pigments from the scientific perspective (physics and chemistry of colour, mineral deposits and resources, identification and characterization of pigments by Raman spectroscopy...) and arts (paintings and artistic techniques of Catalan Romanesque art).

2.2 Participants

The total number of enrolments in EXPLORE courses offered in 2012 was 219, and this amount was raised to 32% in 2013, with a mean number of participants of around 30 per course. With regard to geographical distribution, the participants of 2012 edition came from 76 municipalities in 27 regions (two of them out of Catalonia), while in 2013 edition participants came from 93 municipalities in 30 regions (three of them out of Catalonia). The regions primarily belong to the provinces of Barcelona and Girona, but also a large number of participants came from the provinces of Tarragona and Lleida.

2.3 Tools

All of the participants of the EXPLORE courses, which included mainly current secondary school teachers and university students, were invited to complete a questionnaire after attending the courses.

The initial version of the questionnaire used in the EXPLORE courses was designed to determine the participants' overall satisfaction level on the organization. Since 2013, a new version of the survey was developed for being used in the following courses. The purpose of the final variant of the questionnaire is to collect information not only about the level of satisfaction with the activities but also about the effect of the EXPLORE courses on participants in general and secondary school teachers in particular, who will transmit the knowledge learned to their students.

The final questionnaire is composed of three parts. The first part is designed to obtain information about the profile of participants. In the second part of the questionnaire, respondents are asked to provide their opinion about the organization of the EXPLORE courses. The information collected in this section is useful particularly for “EXPLORATORI: Natural Resources” organisation to measure participants' overall satisfaction level with the course and to reconsider and improve the negatively valued aspects for future editions. The last part of the questionnaire includes questions about the impact of the contents that the secondary school teachers have learned during the course on their teaching practices. In other words, the information requested in this section aims to identify and quantify the impact of the EXPLORE courses from the teachers' perspective. The purpose of the last questions of this part is to determine the specific type of educational resources and knowledge (theoretical, methodological or practical) that the participants have acquired during the EXPLORE course and they are expected to introduce the same resources in their day-to-day teaching work. The questionnaire items are presented in the Appendix B.

3 RESULTS

The numerical results that corroborate the observations are obtained from responses of the questionnaires completed and returned by participants at the end of each EXPLORE course. In this section, the most significant results of the questionnaires that were administered to the teachers after participating in a EXPLORE course in 2013 edition are discussed. It is important to note that the answers from the questionnaires have been taken into account only if the number of teachers enrolled in a EXPLORE course was over 15.

In most of the courses in the 2013 edition, more than half of the enrolled teachers were specialized in teaching one or more subjects at the secondary school level in the field of science and technology, such as physics, chemistry, biology, technology, natural sciences or Earth sciences (Figure 1). Even though the topics of the EXPLORE courses are related to natural resources from a scientific and technological perspective, in some of the courses, a high percentage of participants were teachers of non-scientific-technical fields. This fact particularly corresponds to the cases of EXPLORE the forest (61.5%) and EXPLORE food (71.4%).

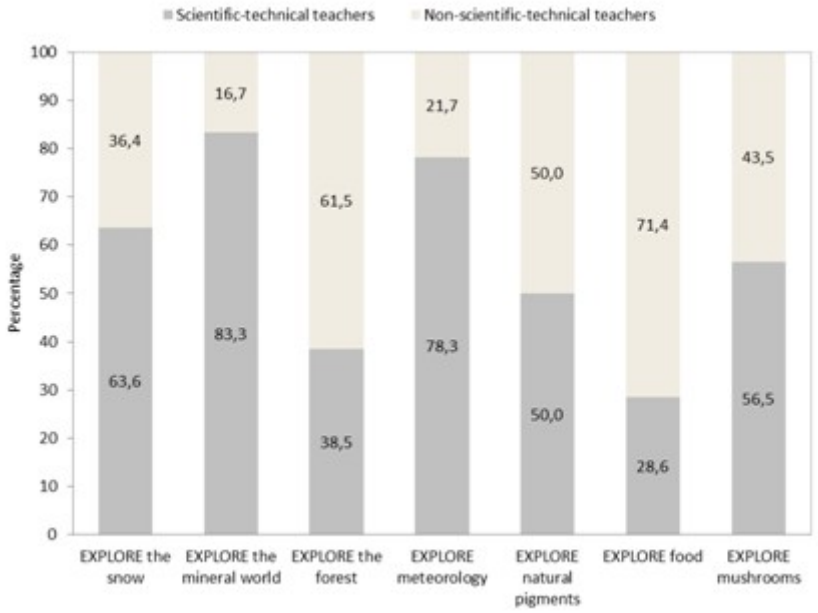

Figure 1. Percentage distribution of teacher participants in 2013 according to their specific field of expertise

Figure 2 shows the assessment of the teaching quality for all EXPLORE courses in the 2013 edition. As shown in the figure, a large majority of teacher participants reported a high level of satisfaction with the teaching quality in EXPLORE courses, with an average valuation of 8.2 points (SD = 1.1) on a scale from 0 to 10.

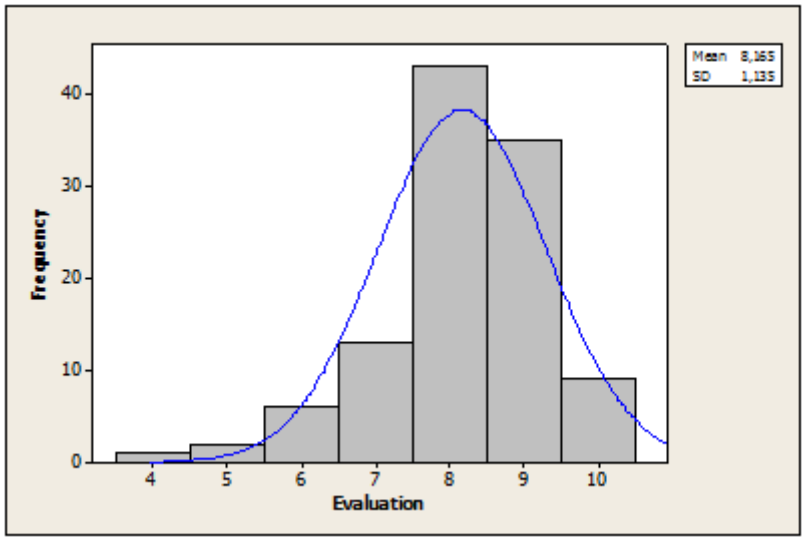

Figure 2. Assessment of the teaching quality in EXPLORE courses on a scale from 0 to 10, where 0 indicates "not at all satisfied" and 10 is "completely satisfied"

Figure 3 presents the impact of the EXPLORE courses contents on the teaching practices of teacher participants from their own perspective. The analysis in the figure reveals that the majority of teachers agreed that some EXPLORE courses contents will clearly have a positive impact on their teaching classes. In addition, the degree of impact of the course contents on their practice is relatively high from their own point of view, with an average score of 6.6 points (SD = 2) on a scale from 0 to 10.

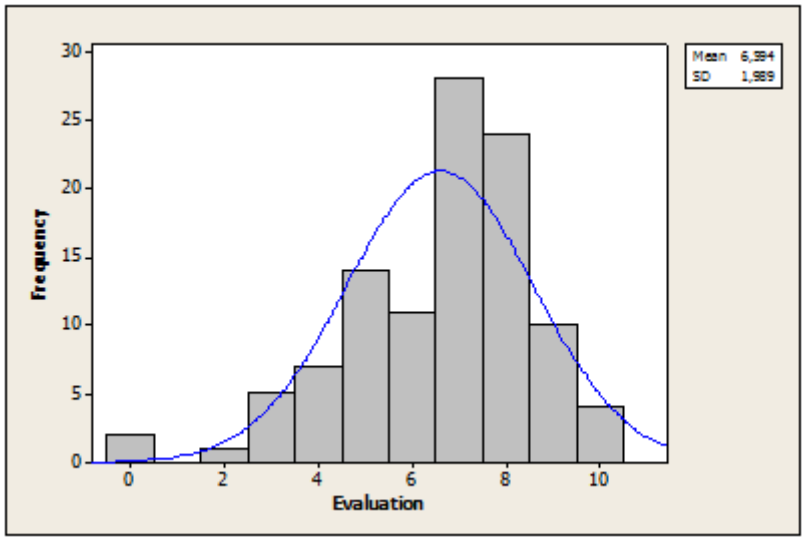

Figure 3. Assessment of the impact of the EXPLORE courses contents on the teaching practices of teacher participants on a scale from 0 to 10

Several significant findings were obtained from the responses to the question “Will you apply some of the EXPLORE course contents in your class?” As shown in Figure 4, the percentage of affirmative responses to this question is close to or higher than 90% for the most of the courses. These results indicate that many of the materials and tools provided in the EXPLORE courses are certainly applicable and useful for secondary school teachers.

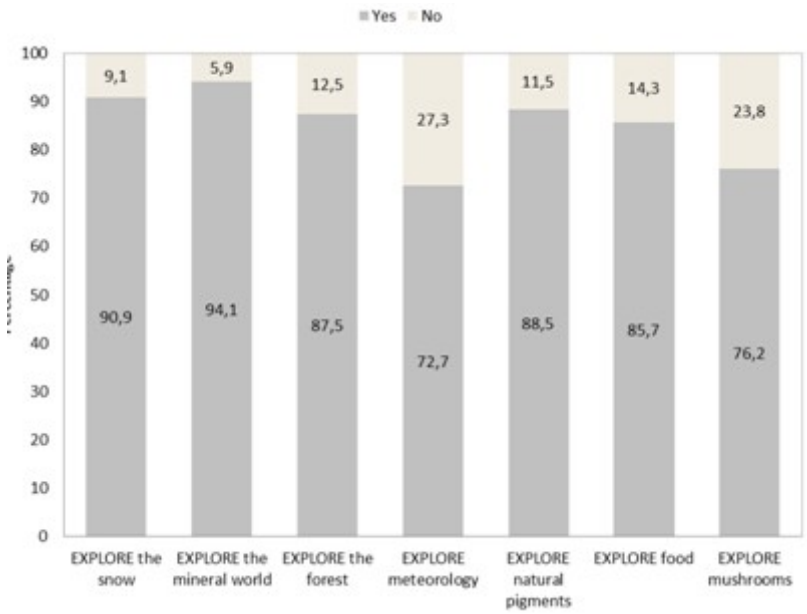

Figure 4. Percentage of responses to the question: "Will you apply some of the EXPLORE course contents to your class?"

The results of the question “Will you introduce some theoretical contents of the EXPLORE course in your day-to-day teaching work?” (Figure 5) show slightly different percentages of responses, depending on the EXPLORE course. However, it is important to note the participants’ responses to that issue for the EXPLORE the snow (100%). A possible reason for this is that EXPLORE the snow has particularly received much approval and positive comments from participants referred to the visits and workshops for its technical content.

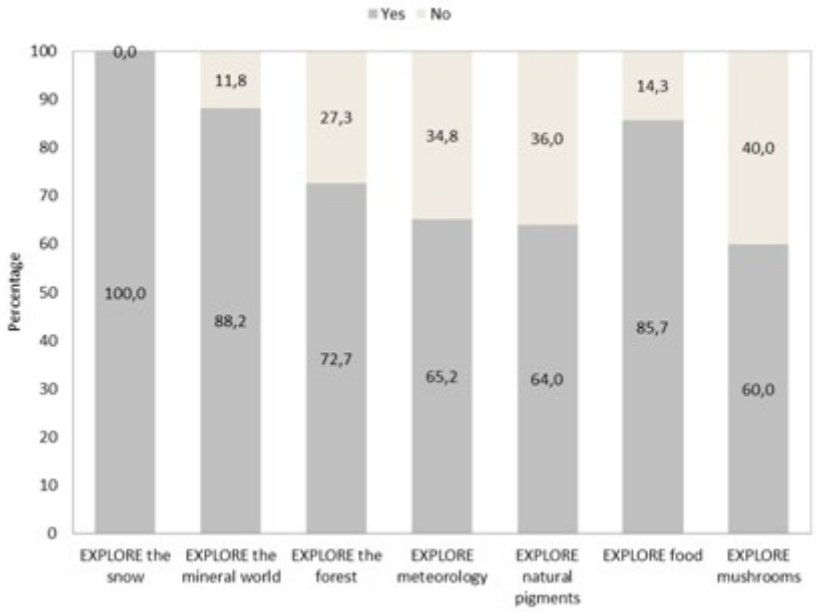

Figure 5. Percentage of responses to the question: "Will you introduce some theoretical contents of the EXPLORE course in your day-to-day teaching work?"

Based on the responses to the question “Will you introduce some practical contents of the EXPLORE course in your day-to-day teaching work?” (Figure 6), it is possible to observe that a higher percentage of participants gave an affirmative reply to that question in the cases of the EXPLORE the mineral world (82.4%) and EXPLORE natural pigments (83.3%) courses. The reason can be related to the practical lessons of these courses. A large number of workshops were organised in EXPLORE the mineral world and EXPLORE natural pigments, in comparison with other courses, which were surely useful for teachers in their practical day-to-day work.

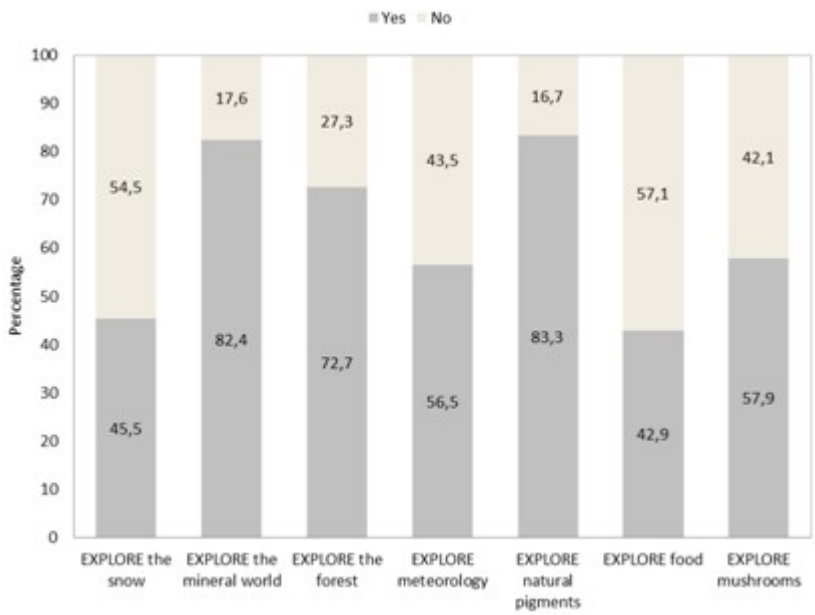

Figure 6. Percentage of responses to the question: "Will you introduce some practical contents of the EXPLORE course in your day-to-day teaching work?"

Finally, the responses to the question “Will you introduce some methodological contents of the EXPLORE course in your day-to-day teaching work?” (Figure 7) allow to evaluate the feasibility of application of the methodology of EXPLORE courses, based on the STEM method. These data reveal that a substantial number of teacher participants at the EXPLORE courses (between 39.1% and 85.7%) were encouraged to introduce this innovative methodology in their daily teaching work.

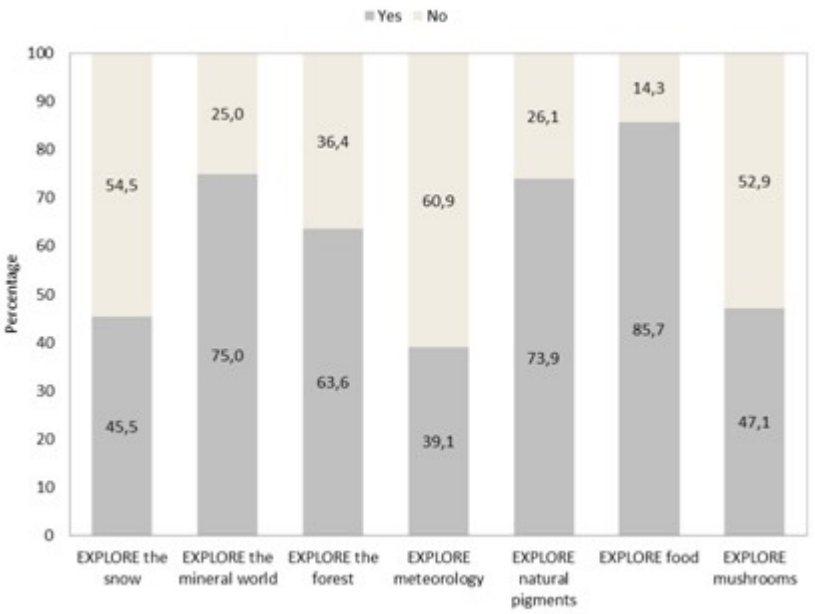

Figure 7. Percentage of responses to the question: "Will you introduce some methodological contents of the EXPLORE course in your day-to-day teaching work?"

Looking back at the Figure 4, a significant percentage of secondary school teachers (minimum of 73% for EXPLORE meteorology to maximum of 94% for EXPLORE the mineral world) believed that they will apply all three types of educational resources and knowledge. According to the last figures shown (Figure 5, 6 and 7), theoretical knowledge was the most chosen option (mean of all answers is 76%), followed by practical contents (63%) and then by methodological contents (61%).

It is interesting to mention that the participants in EXPLORE courses establish a special connection with science and technology professionals who deliver the sessions. This connection appears especially when participants and professionals move out of the classroom into countryside sites to visit places of interest and when they share their meals together. As a result, face-to-face sessions last about 10 hours each day. In all these situations, which may seem insignificant initially, interesting synergies arise between professionals and participants. Promoting the extra-academic relationship in this way allows to enrich science learning experiences, which have received a very positive feedback from participants.

Furthermore, analysis of the responses to the questionnaire reveals that between 30 and 45% of teacher participants at the courses had already attended a previous EXPLORE course. This confirms that the methodology was considered as appropriate by participants and they have a very positive opinion about the extra-academic relationship, as seen in the open-ended questions:

The issues that I have been satisfied with at the EXPLORE course are...

… the transversality of contents.

… the combination of activities, theoretical, practical and visits where one can see things in situ.

… the adaptability of practical lessons in the classroom at secondary school.

… the treatment of the organizers and professionals.

… the implementation of some theoretical content, such as the workshop of food databases and food research.

4 CONCLUSIONS

An initiative designed to bring science and technology closer to secondary school, the experience of the EXPLORE courses, is described and analysed in this paper. Data for this study were obtained from a written questionnaire completed by participants of the courses in 2013 edition.

Based on the responses to the questions of the questionnaire, it is concluded that teacher participants evaluated the teaching quality of the courses positively. The results also show that EXPLORE courses encourage secondary school teachers to introduce some educational resources and knowledge in the classroom related to natural resources. In other words, the contents of the EXPLORE courses can be useful for teachers in their day-to-day teaching and can contribute to the professional development of teachers.

In addition, the design of the EXPLORE courses is closely in line with the STEM method because each topic covers at least two or more different disciplines. Therefore, the experience described in this paper demonstrates the great potential for expanding STEM learning at the secondary level and may serve as a reference for those who implement STEM programs in the future in Catalonia, where they are not currently applied.

As a report by European Schoolnet (Kearney, 2010) shows, two actions are at the heart of the drive to make STEM studies and professions a more popular option for young learners: the development of effective and attractive STEM curricula and teaching methods, and improved teacher education and professional development. As a result, developing ways to implement STEM teaching and learning in schools is essential for increase students' interest and promote scientific and technological vocations. There are a number of ways that STEM can be taught in schools today. For example, in most United States schools today, each of the four STEM disciplines are taught with more emphasis going to one or two of the four (Dugger, 2010). However, the final decision on implementing STEM education and reforming the current education system has to be taken by the government.

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APPENDIX A. The topics of EXPLORE courses offered in 2012 and 2013 editions

2012 edition	*2013 edition*
EXPLORE the snow	*EXPLORE the snow*
EXPLORE Gaudí and "El Berguedà"	*EXPLORE the mineral world*
EXPLORE aromatic plants	*EXPLORE the forest*
EXPLORE the Sun	*EXPLORE meteorology*
EXPLORE the sky	*EXPLORE natural pigment*
EXPLORE natural resources	*EXPLORE food*
EXPLORE mushrooms	*EXPLORE Gaudí and "El Berguedà"*
	EXPLORE natural resources
	EXPLORE mushrooms
	EXPLORE geological hazards

APPENDIX B. Questionnaire items

Assessment area	*Item number*	*Question*	*Question type*
Profile of participants	*1*	*Administration type of the school where you teach*	*Closed-ended question: Public/Private school*
	2	*Subject/s you teach*	*Open-ended question*
	3	*Educational level*	*Open-ended question*
	4	*Years of teaching experience*	*Open-ended question*
	5	*Gender*	*Closed-ended question: Male/Female*
Participants' overall satisfaction level	*6*	*Was the area where the course has been conducted adequate?*	*Closed-ended question: Yes/No*
	7	*Was the topic of the course adequate?*	*Closed-ended question: Yes/No*
	8	*Was the course well organized?*	*Closed-ended question: Yes/No*
	9	*Has the course been adapted to your expectations?*	*Closed-ended question: Yes/No*
	10	*What would you delete from the course?*	*Open-ended question*
		What would you add to the course?	*Open-ended question*
	11	*My evaluation of the teaching quality of the EXPLORE course is:*	*Scale from 0 to 10*
	12	*My overall evaluation of the course is:*	*Closed-ended question: Excellent/Good/Fair/Poor*
Impact of the course contents	*13*	*Evaluate the impact of the content you have learned on your teaching:*	*Scale from 0 to 10*
	14	*Will you apply some of the EXPLORE course contents in your class?*	*Closed-ended question: Yes/No*
		Write the subjects in which you will apply some contents of the EXPLORE course:	*Open-ended question*
	15	*Will you introduce some theoretical contents of the EXPLORE course in your day-to-day teaching work?*	*Closed-ended question: Yes/No*
	16	*Will you introduce some practical contents of the EXPLORE course in your day-to-day teaching work?*	*Closed-ended question: Yes/No*
	17	*Will you introduce some methodological contents of the EXPLORE course in your day-to-day teaching work?*	*Closed-ended question: Yes/No*
	18	*Which specific activities of the course will have more impact on your teaching work?*	*Multiple choice, depending on the EXPLORE course*

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During her studies she obtained various grants from the UPC to collaborate on “technology transfer activities” and to aid the organization of the activities of the “EXPLORATORI of natural resources”. Currently, she is a Phd student in Natural Resources and Environment, with a FI-DGR 2013 grant from the “Agència de Gestió d'Ajuts Universitaris i de Recerca” (AGAUR) of the “Generalitat de Catalunya”.

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