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Towards Local Community Involvement in Students' Science Learning: Perspectives of Students and Teachers

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Résumé de l'article

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Abstract

The European Commission calls for schools to move towards becoming open to their communities, integrating external social, civil, and expert stakeholders into authentic learning experiences' development alongside teachers and students, particularly in terms of science education. However, little research or practical implementation has been reported on how community actors could participate in the development of such curricular learning activities. In this study, we present an implementation of the open science schooling (OSS) approach to science learning, where community involvement in the development of science missions takes a vital role. During the study, students developed science missions related to local societal issues that interested them in collaboration with their teachers and community experts, with frequent hands-on investigations outside their classrooms or laboratories, in five European countries and Israel. Questionnaires with quantitative and qualitative questions concerning students' and teachers' views and perspectives about implementing science education using OSS were administered after the participants finished their science missions. The results indicate the effectiveness of the OSS approach to science learning involving the community from both students' and teachers' perspectives. This study is a step towards supporting schools in becoming active agents of change through the implementation of contextualized learning experiences alongside external stakeholders.

Introduction

The current European agenda for science education for responsible citizenship encourages "open schooling," where schools, in cooperation with other stakeholders, such as enterprises and civil society, become agents of community well-being (European Commission, Directorate-General for Research and Innovation, 2015). Answering this call, we present the open science schooling (OSS) approach to science learning, bringing students closer to real-life science challenges to be tackled in close collaboration with societal actors. OSS engages schools and students in practical science learning in collaboration with resources in the community, including research, science, innovation, and social resources (e.g., experts in enterprise and industry as well as research centres and universities) (Suero Montero et al., 2019).

The idea is to motivate students to relate to science from a holistic perspective through practical group work and hands-on experience and immersion (Giamellaro, 2014) in finding solutions to cross-subject science issues. This offers students a variety of practice-oriented work forms that are very different from traditional theoretical and laboratory-based science teaching (Oh & Yager, 2004). This approach to science learning has its roots in constructivism and dialogic and interactive teaching and learning (García-Carrión & Díez-Palomar, 2015), where knowledge is generated through the interplay between ideas and experience (Wikibooks Contributors, 2017), with particular emphasis on the students' reflections and sharing of their learning process. As reported in the literature (e.g., Varelas et al., 2014), engaging students in hands-on, real-life explorations produces a deeper understanding of concepts and facilitates the process of meaning making while at the same time allowing students to make a personal connection with the topic under study.

Given the reported state of cognitive and affective disengagement of (science) learning in young people (Cowie et al., 2011; Murray et al., 2004), partly due to the disconnect between school science activities and young people's lived experiences, even as the demand for science-related professionals in Europe is increasing (European Centre for the Development of Vocational Training, 2016), it is essential to find innovative ways to bring back motivation for science learning as part of a life-long learning strategy to support responsible citizenship in our digital society. With this in mind, here we present the results of quantitative and qualitative data collected from 40 students (14–18-year-olds) and 17 teachers (4–32 years of teaching experience) across five European Union (EU) countries and Israel who participated in the practical implementation and development of science missions within the OSS methodological approach to science learning and who answered a questionnaire about their perspectives regarding the role of the local community as a facilitator of authentic and immersive science learning. The aim of the study was to explore the effectiveness of this kind of hands-on, real-world-contextualized approach to science learning with the community, in terms of science education engagement, participation, and educational added value, as experienced by teachers and students. This study contributes to the scarce empirical literature on exploring and understanding how community actors can participate in the development of engaging and motivating science learning activities that are also part of the school curriculum.

Literature Review

Research has identified several challenges with traditional K–12 science teaching and learning (i.e., lecture-based teaching delivered in a classroom or laboratory) that result in students' disengagement and disconnection of science from their real-world and everyday life (Moreno, 1999). For instance, science education traditionally encourages memorization of elements of scientific knowledge in a siloed fashion (Lee & Grapin, 2022) under the assumption that "teaching science is all about lecturing" (Sanger, 2008), gearing students towards only describing observations made of factual data instead of "making meaning of those observations in ways that are significant" (McNeill & Berland, 2017). These issues, among many others, have prompted educational reform efforts, e.g., in the USA (National Research Council, 2015), and policymaking recommendations, e.g., in Europe (European Commission, Directorate-General for Research and Innovation, 2015), towards revamping science education to provide rich and meaningful learning experiences through innovative pedagogical practices.

Modern pedagogical concepts have risen in the past decades to address the demand for connecting students' interests with science learning in a critical manner, such as culturally responsive science teaching (Ashbrook, 2021; Nasir et al., 2014) and justice-centered science pedagogy (Morales-Doyle, 2017). The Socially Empowered Learning Framework, which emphasizes group work and creative agency through tackling real-world issues and generating a positive social impact (Martin & Calvert, 2018), is a good example of pedagogical implementations towards boosting science learning interest, as is the general approach of inquiry-based learning (Towers & Panayotidis, 2012). One could say that such modern pedagogical concepts partly stem from Paulo Freire's (1972) critical *Pedagogy of the Oppressed*, which calls for teachers and students to think critically about what is being learned and how it supports students' empowerment to escape from cycles of oppression arising from poverty, unemployment, illiteracy, and other social issues that demand intervention.

Furthermore, many of these practices try to go beyond classroom walls and contextualize science learning in students' physical and contextual living environments. An example initiative is Lúcio's (2015) study based on the Educating Cities movement, according to which the city is "an educational environment (students learn in the city), an educational content (students learn the city) and an educational agent (students learn from the city)" (p. 170). Similar ideas have been implemented extensively in the published literature, guided by sociocultural theories of learning (Bandura, 1971; Vygotsky, 1991), social constructivist learning (Palincsar, 1998), learning communities, and dialogic participation (García-Carrión & Díez-Palomar, 2015). Such initiatives have highlighted that authentic, hands-on learning developed within peer groups fosters learning enjoyment as well as natural curiosity and long-term love of learning (Skinner & Pitzer, 2012). Cowie, Jones, and Otrel-Cass (2011) suggest reconceptualizing assessment, inclusion of student funds of knowledge (i.e., knowledge that students acquire from "their out-of-school experiences and their home environments"), and breaching the classroom walls as three strategies to increase the science engagement and participation of diverse groups of students (p. 348).

In our work, the involvement of the community is fundamental to the process of contextualizing meaningful, immersive, and real learning experiences (Giamellaro, 2014) in which the "territory is not only a context, but also an identitary construct" (Lúcio, 2015, p. 168) towards building active citizenship among the participants. Therefore, it is important to investigate and understand the perspectives of the students and teachers regarding the direct connection to and use of community resources—or "funds of knowledge" (Cowie et al., 2011)—in enhancing a science learning experience. Bouillion and Gomez (2001) have already provided evidence that real-world problems and school-community partnerships can be used as contextual scaffolds for bridging school- and community-based knowledge. In such mutually beneficial projects, in which both schools (teachers and students) and the community partners are served by project outcomes, it is important to understand the teachers' and students' perspectives. Bouillion and Gomez (2001) have shown that teachers are concerned about developing authentic, student-driven activities in which student protagonism is encouraged. Consequently, teachers are interested in identifying community partners that respect and support students' interests, agency, and decisions in ways that enhance students' learning experiences and achieve the goals of the curriculum. According to Lúcio and I'Anson (2015), "access to positive, healthy and safe participation experiences potentiates autonomy, the rise of a sense of identity and an overall perception of competence" (p. 133).

At the community level, such experiences scaffold better ways of social functioning, such as developing leadership skills, cooperating and helping others, valuing diversity, advocating participation and civic engagement, and other kinds of citizenship agency (Bruyere, 2010). At the same time, teachers are also concerned with bridging the students' interests with the local curriculum goals and active citizenship, especially regarding science learning. From the students' perspective, research has shown evidence of increased motivation of students in science and mathematics learning through student-centred, problem-based learning approaches (Chung & Chow, 2004; Hanewicz & Arendt, 2017). Moreover, students are not only more motivated to learn about science during school time, but they also talk about the science activities they have engaged in during such projects with their parents and friends outside school settings and report feeling that their voices are heard on societal issues, indicating empowerment through science learning (Bouillion & Gomez, 2001). Within this background, our study showcases the implementation of the OSS methodological approach to science education in which teamwork and community involvement take centre stage for tackling real-life contextual issues through science missions.

OSS Approach to Science Learning

In Europe, the European Commission has called for the development of new science learning didactics, framed within the concept of open schooling, in which science learning processes are strongly linked to students' participation in real-life science challenges in society and to their participation in real research and innovation circles (European Commission, Directorate-General for Research and Innovation, 2015). In this context, the OSS approach, as a student-centred, experiential learning methodology, falls within the educational constructivism philosophy in general (Bada & Olusegun, 2015; Matthews, 1998) and social constructivism in particular, where new knowledge is generated through peer interactions and first-hand experiences (Bada & Olusegun, 2015).

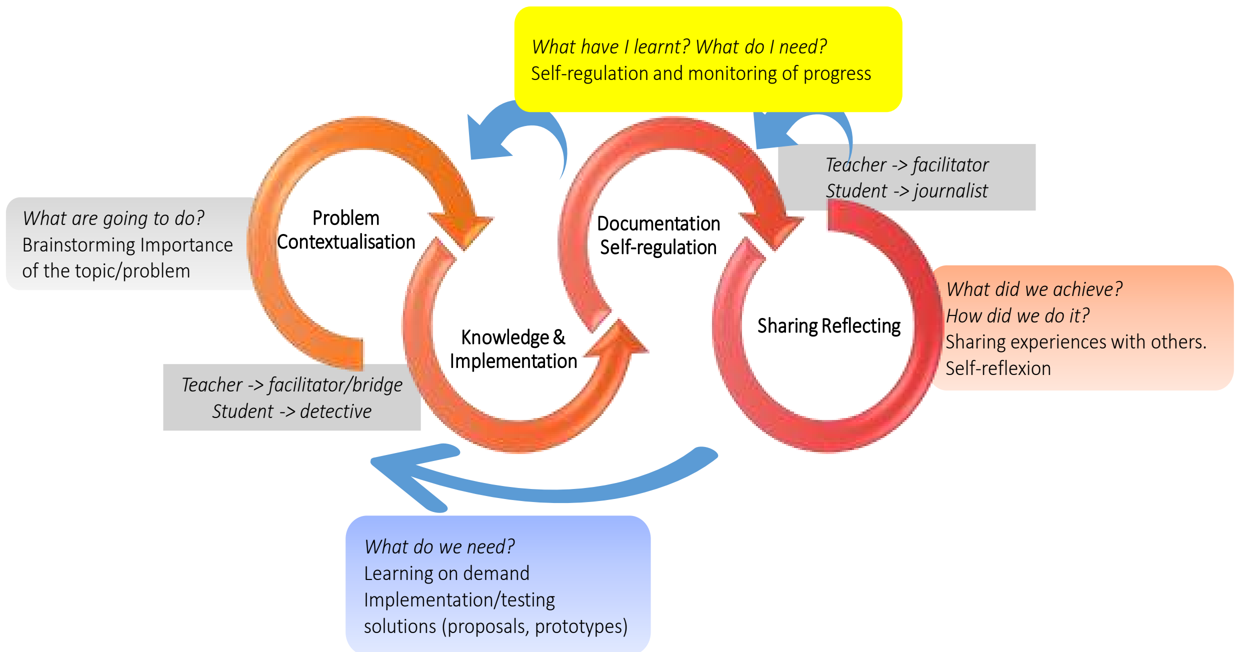


Figure 1: OSS iterative processes.

Within the OSS learning approach, four iterative processes are put forward (see Figure 1):

1. *Problem identification and contextualization*. During this process, which integrates similar phases of engagement and exploration from inquiry- and problem-based learning (Abdi, 2014), students brainstorm real problems that affect their local community and consider how science can offer support towards plausible solutions. As local community involvement is fundamental within OSS methodology, students are prompted to involve their local community as collaborators in their discussions and brainstorming. The teacher's role during this process is seen as that of a bridge, facilitating communication between students and community stakeholders to create opportunities to advance students' investigations through activities that involve, for instance, interviews and practical workshops with experts at research and innovation centres or local industries and non-governmental organizations (NGOs), as well as other social stakeholders. The students act as detectives, investigating and understanding the local problems and needs, while the teacher is a facilitator of the process as well as a bridge between the students and local community stakeholders.
2. *Knowledge and competencies acquisition*. During this process, students engage in training and obtaining information on demand, i.e., only when needed, to support their efforts towards implementing and testing their solutions to the problem or topic they are investigating. Here, students are detectives analyzing authentic and real-world situations, implementing plausible solutions to the mission under investigation, and getting new skills and knowledge needed to arrive at the sought-after solution. The role of the teacher here is that of an expert who supports the students' learning experiences through hands-on informative workshops, seminars, or lectures that could be orchestrated together with other stakeholders from the local community. Students are also prompted to acquire knowledge on their own whenever plausible. This experiential learning (Santhalia, Yuliati & Wisodo, 2020) invites the boosting of digital literacy skills and cross-subject-matter and cross-

disciplinary knowledge, as well as the development of self-regulation, collaboration and communication skills, cultural awareness, creativity, and problem-solving efficacy. This evokes a phenomenon-based learning approach to education that has been implemented in the most recent core curriculum for basic education in Finland (Symeonidis & Schwarz, 2016). Here, the students benefit from learning through a variety of practice-oriented work forms that support different learning styles. Furthermore, during this process, students may transfer knowledge that they already have to new contexts or learn new skills and concepts that assist them in their solution seeking and implementation processes.

3. *Documentation and self-regulation.* During this process, students are encouraged to keep a record of their progress and involvement in their missions. The record could be in the form of a mission diary with details on the activities that the students carry out. This serves the students as a tool for self-reflection on the work accomplished and provides them with a narrative of their experiences for self-awareness. Therefore, students' thoughts, feelings, and actions during their experiential learning become oriented to attain a defined goal anchored in real-world situations (Pintrich, 2004). This process also supports their organizational skills, as the students need to implement learning workflow strategies, monitor and reflect on what they have done to achieve their goals in their mission, and consider what else they need to do to achieve their intended solutions (Pintrich, 2004). Creativity is also supported by this process, since various methods of documentation are encouraged, such as drawings, pictures, doodles, and text. Students can be compared, therefore, to journalists recording and curating information related to their own learning experiences. Teachers are facilitators of the process.
4. *Sharing and reflecting.* During this process, students are encouraged to share their experiences with their peers throughout their mission completion journey and to share their proposed mission solutions with their schools and local community when the mission is completed. Through the process of sharing and reflecting on their learning experience while completing their science missions, we argue that students also develop their self-regulation skills, including strategies for recognition, monitoring and control of their behaviour, cognition, and emotional reactions in learning situations (Hirvonen, 2013, p. 569). This supports deeper learning and understanding, as students need to internalize concepts in order to share their findings, solutions, and experiences with others. The role of the student is that of a journalist presenting their findings and experiences to others. The teacher is a facilitator and coach, supporting the student in the process of sharing and reflection as well as providing suitable opportunities for this to happen. Sharing and reflecting could be achieved through a variety of activities and media, including workshops, websites and social media, scientific conferences, etc.

These OSS processes can come hand-in-hand with the development of a positive attitude towards science learning and a better connection to and understanding of everyday issues where science could play an important role (Suero Montero et al., 2019). It is important to highlight that these processes do not take place in a linear manner during the learning experience but instead overlap and reinforce each other. In this way, students could work on contextualizing a problem while documenting the process they are embarking on and sharing with their peers the knowledge they bring related to the topic or mission discussed, while at the same time acquiring new knowledge and skills.

It is noteworthy to state that within the OSS approach to science education, the community represents a vital partner in all stages of students' mission implementation. Community is thus seen in the broadest sense within OSS and could be categorized as follows (see Figure 2):

1. *Local physical community.* This refers to the neighbourhood where the students become aware of problems that become their science missions to resolve. This local community also includes sports clubs, after-school clubs, NGOs, local enterprises, municipalities, etc. The reach of this local community could be as far as the region where the science mission takes place and beyond.
2. *Virtual communities.* This refers to a group of people online discussing matters pertaining to the mission that the students are carrying out. These communities could be local or international, both accessible via social networks.
3. *Science communities.* This refers to a group of people who work on or follow in any way the issues that pertain to the science mission that the students choose. A science community could comprise peer teachers, university/polytechnic researchers, makerspace groups, etc. These communities could be physical or virtual.

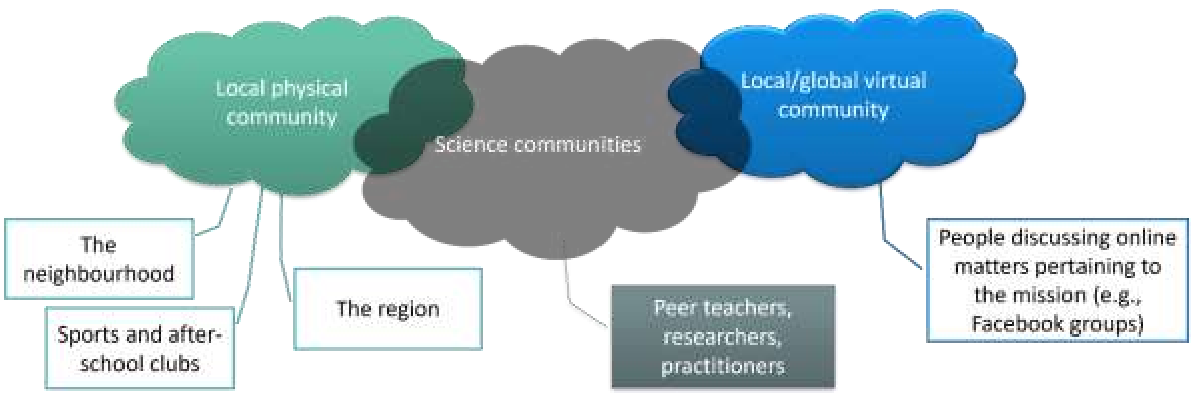


Figure 2: Defining "community" within OSS.

Contemporary globalized society and 21st century students do not separate these worlds in the way that the present educational systems do. They work with the physical and virtual communities as one world—and local science engagement might very well include considerable virtual social networking. For this reason, the OSS approach invited students, teachers, and parents to work with and in different forms of communities during the design, development, and implementation of science missions. Here, we report the outcomes of these implementations from the students' and teachers' perspectives.

Methodology

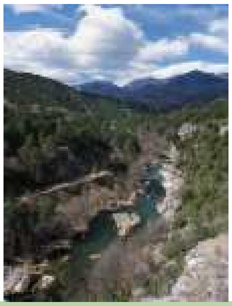
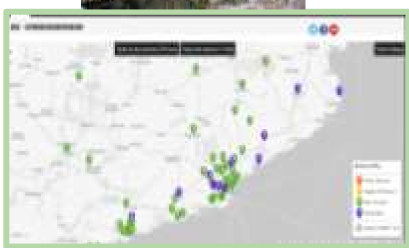
Research context and design

During our study, the students developed their science missions and investigations related to local societal issues of interest in collaboration with their teachers (cross-subject topics) and community experts (e.g., from local enterprises, universities, or research centres), with frequent hands-on investigations outside their classrooms or laboratories. The students' projects were varied and included interdisciplinary topics from biology, arts, business, physics, and environmental sciences (e.g., "Biodiversity in the Jata Reserve" was a topic chosen by students in Poland, whereas "Soil property and business prospects" was investigated in Lithuania). Table 1 shows the science mission contexts in more detail, describing the activities of each mission per country.

Table 1: Science missions' descriptions.

Country	Mission	Sample Activities	Description
Israel 	Introduction of science learning in the playground. (Cross-subjects: education, physics)	Students conducted field research listing and taking inventory of the various facilities and structures in the playground. They held meetings and consultations with engineers from a local firm.	Students placed informative signs in the playground with scientific content and added QR code videos for parents to show their children. They also prepared interactive lesson plans for middle-school students in the playground.
Greece 	Improvement of the school emergency lighting system. (Cross-subjects: STEM)	Students networked with engineers in local enterprises and other professionals in the field and gathered the information needed to develop a new emergency lighting system at their school.	The students' outcome was evaluated by an electrical engineer, who guided them with suggestions and open discussions.
Lithuania 	Local soil benefits. (Cross-subjects: science, English, geography, art, economics)	During the science and geography lessons, students identified the most suitable types of soil to start their own business without too many costly investments.	Students learned about different types of soil and their properties in the classroom. They considered the uses of soil in the everyday life of the local community and then explored which soil types are best for making certain items/products when starting their own businesses.

Country	Mission	Sample Activities	Description
Poland 	Investigation of moth diversity in the Jata Reserve. (Cross-subjects: biology, science)	Students learned about the scientific method and collected field data on moths using standard light traps in Jata Nature Reserve, Poland. After the field work, the student team identified the moth species and learned their Latin names. This information was then recorded in a special database. Field support from regional university biology experts.	This immersive mission was showcased as both a poster and an oral presentation during the national conference dedicated to students, Biopotencjał 2018, organized by Cardinal Stefan Wyszynski University in Warsaw.
Portugal 	Renewable energy solutions for a school in Madeira. (Cross-subjects: STEM)	Students had discussions and interviews with expert engineers in the community. They learned about the usage of renewable energy sources and their practical applications. They identified which renewable energy solutions are suitable for their school grounds.	Students learned about the different energy infrastructures of existing renewable energies and selected renewable energy solutions that could be employed on the island of Madeira and, in particular, installed in their school.

Country	Mission	Sample Activities	Description
Spain  	Comparison of environment and health in a small village (Gironella), a medium-sized city (Manresa), and a big city (Barcelona). (Cross-subjects: geography, English)	Students carried out fieldwork to analyze the water quality of Llobregat River and local springs in Gironella. They compared air quality over time using a local web application. Students acquired data on respiratory diseases related to air pollution from city records and made a comparative study of the impact of airborne allergens on health as well as the impact of landscape quality on health.	Students learned about the impact of pollutants on water, air quality, and health; the role of forests as reservoirs of medicinal and food resources that can contribute to improving health quality; and the need for forest conservation to avoid loss of medicinal and food resources.

To understand the perspectives of students and teachers regarding the benefits of involving local community resources in supporting and fostering authentic science learning experiences for students, we used a convergent parallel design with multiple-cases analysis (Creswell & Clark, 2017). The convergent parallel design poses the concurrent implementation of quantitative and qualitative data collection tools, the independent analysis of each data type, and the joint interpretation of the results (see for instance Demir & Pismek, 2018). In our study, qualitative and quantitative data were collected through questionnaires administered after the missions finished. The missions' implementation was carried out approximately within one school year in each participating country. Separate questionnaires were created for teachers and students. The questionnaires included multiple-choice questions with Likert scale items and open-ended questions. We find this mixed-methods approach to be a suitable choice for our multi-case study to gain more detailed views from the participants about the implementation of this type of teaching and learning approach. Through this mixed-methods approach, it was possible to collect sufficient data about the participants' experiences within the limited time resources of the teachers and students.

Research participants

Data were collected from 40 students (14–18-year-olds, M=15.31, SD=0.93, 23 female) and 17 teachers (4–32 years of teaching experience, M=20.41, SD=8.4, 10 female) across five EU countries and Israel who responded to their respective questionnaires about their perspectives on the role of the local community as a facilitator of authentic and immersive science learning. The students' profiles (grade, age, gender) varied according to the classes taught by the teachers who participated in the project consortium. The student groups thus were formed based on the students' voluntary decision to participate in the project. Ten students from Lithuania, eight from Greece, seven from Portugal, six each from Poland and Spain, and three from Israel participated in the data collection process (N=40), and students ranged from Grades 7 to 12 according to the K–12 system, as shown in Figure 3.

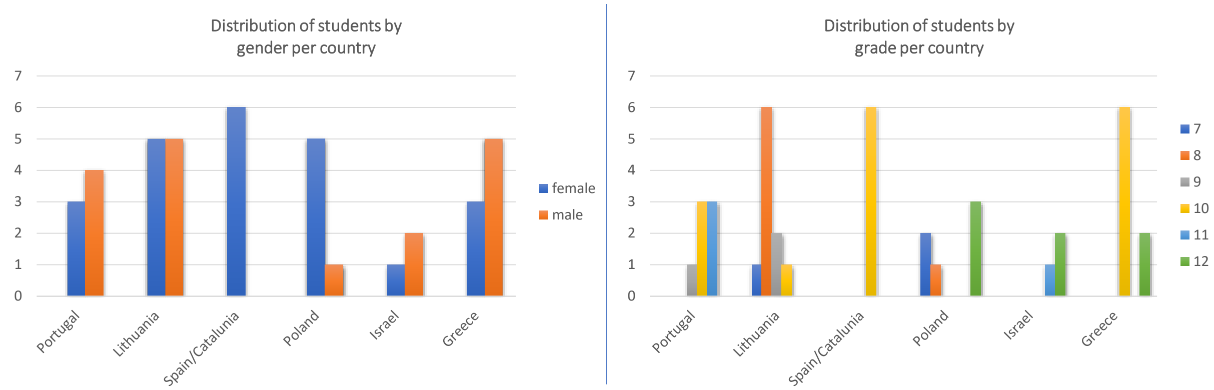


Figure 3: Distribution of students by gender and grade in each participating country.

The teachers also had different profiles in each country. Greece, Poland, and Lithuania had only female teachers; Israel had only male teachers; and Portugal and Spain/Catalonia represented both genders. The teachers also varied in teaching experience. The two largest groups by years of work experience were six teachers with 11 to 20 years of experience, followed by five teachers with 21 to 30 years of experience. The overall teacher profile is represented in Figure 4.

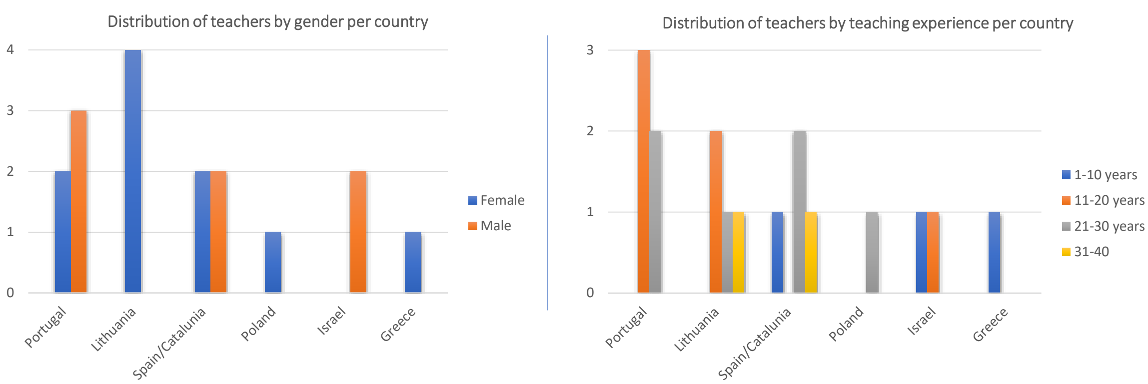


Figure 4: Distribution of teachers by gender and teacher experience in each participating country.

Research instruments

The data collection instruments were designed for the purpose of this study. The instruments were self-reported questionnaires, with different versions created for teachers and students. The questionnaires included multiple-choice questions with Likert scale items and open-ended questions. The questions were tailored towards acquiring relevant information about the local OSS implementation. The Likert scale questions were designed to gauge the level of agreement of the participant with a given statement (5: strongly agree to 1: strongly disagree) and, for teachers, included reflections about implementing OSS (e.g., "How do you rate the educational aspects of the activities?" from 5: very good to 1: very poor) and how well they thought their students learned compared with traditional science teaching methods (5: a great deal to 1: almost nothing). The open-ended questions, on the other hand, gave the participants the opportunity to express, in-depth, their experiences of and insights about their learning or teaching processes, focused on the methodological aspects of OSS. The instruments were empirically designed and constructed by the 1st author based on personal notes of observations of local implementations and discussions with the participating teachers. The instruments were further improved using expert judgement from another two external expert researchers (Olson, 2010). Furthermore, the students' instrument was further revised and improved in terms of relevance, wording, and appropriateness of questions by at least one teacher from each participating institution, who acted as experts to ensure that the students would understand the questions and that their perceptions could be successfully captured.

Students' questionnaire

The students' questionnaire (27 items, 5-point Likert scale from 5: strongly agree to 1: strongly disagree) was divided into four themes during analysis:

- Theme I: Impact of science learning through the OSS framework involving community stakeholders (10 items, e.g., "I learn better in authentic real-life science activities," Cronbach α: .88).
- Theme II: Students' interaction with teachers throughout the activities (six items, e.g., "I felt comfortable approaching my teacher with questions or comments," Cronbach α: .87).
- Theme III: Students' evaluation of their engagement and participation in immersive missions' activities (three items, e.g., "I was fully engaged in all activities," Cronbach α: .71).
- Theme IV: Students' views on their group work (eight items, e.g., "I felt encouraged to participate in activities and collaborate with peers," Cronbach α: .60).

Additionally, open-ended questions related to each one of these themes were also included in the questionnaire to better understand the learning experiences of the students during the project and their particular science missions. Examples of the questions are as follows:

- Theme I: "What would you like to change about your science learning based on OSS?"
- Theme II: "How could your teacher assist you in improving your learning through OSS?"
- Theme III: "What steps could you take to improve your own learning in this science course through OSS?"
- Theme IV: "What other ideas would you suggest to improve this science course (e.g., changes in course structure, assignments or exams)?"

Furthermore, we also posed two open-ended questions to students, "What aspect of this course (OSS implementation) did you like the most?" and "What aspect of this course did you find challenging?" to provide a space for them to express their views freely.

Teachers' questionnaire

The teachers' questionnaire was organized around questions about how they experienced teaching within the OSS didactical framework (11 items, 5-point Likert scale from 5: very good to 1: very poor; e.g., "How would you rate the educational aspect of the activities?" Cronbach α: .77). Additionally, one item inquired about how challenging it was to implement the OSS methodology compared to traditional science teaching approaches on a scale ranging from 7: very challenging to 1: not at all challenging. As with the students' instrument, two open-ended questions inquiring about 1) teachers' dispositions during the different phases (iterative processes) of the OSS experience and 2) additional reflections were included to gain deeper understanding of the teachers' views.

Data analysis

All the quantitative data analysis was done using the software IBM SPSS Statistics 23. Exploratory factor analysis (EFA) established the discriminant validity of the instruments' themes and dismissed possible common method bias concerns. In general, the instrument exhibited appropriate internal consistency, and Cronbach's alpha values for most of the dimensions were high (≥.70), with only theme IV of the student questionnaire presenting acceptable results below this criterion (Taber, 2017). After instrument validation, the items that compounded each theme in the questionnaires were merged into a mean variable to represent the general rate of each respective theme. In addition, descriptive statistics, correlations, and non-parametric analysis of variance were applied and reported in the results, including an analysis by gender and country across themes I–IV of the students' questionnaire.

The analysis of the qualitative text (data corpus) from the open-ended questions was made using content analysis (CA) as the analytical method (Neuendorf, 2017). The four themes of the students' questionnaire served as guiding categories for the content analysis of students' answers. For the teachers' instrument, on the other hand, the qualitative data from the open-ended questions was analyzed considering the teachers' reflections on the project.

Methodological limitations

When interpreting the results of the present study, some limitations should be considered. The study is based on a non-random and small sample, limiting the generalizability of the results. Further, we can assume a positive sample bias: it is likely that both teachers and students with more positive attitudes toward science and more competencies in the subject decided to participate in the study (i.e., voluntary participation). Additionally, it is important to consider that the findings of this study result from the overlapping of different factors across countries, grades, teaching styles, and school support provided for the implementation of the project, which demands further studies regarding the role of each of these aspects in supporting science learning and engagement. Nevertheless, this study presents a promising approach to the implementation of meaningful science learning missions with the support of community stakeholders.

Results

Students' perspectives

Theme I: Impact of science learning through OSS involving the community

Regarding students' general perspective on science learning with the community, students reported highly enjoying learning science within the OSS didactical framework involving their local community (item "I learn better outside classes in authentic real-life science activities (involving the community)"; 5: strongly agree to 1: strongly disagree; M=4.13, SD=0.80). Answering the open question "What aspect of this course did you enjoy the most?" students reported that the lessons were more creative and that the simple fact that they were not "sitting over books and memorizing long and boring texts" (Student ID27, Poland) and "got to learn science in a different way [than they] would normally do" (Student ID36, Greece) made the learning activities "more interesting" (Student ID4, Lithuania), "engaging" (Student ID12, Lithuania), and "fun" (Student ID30, Israel). This is also observed in the following answers: "[I enjoyed the most] finding out about science by visiting new places, because we could see how science changes our daily life" (Student ID26, Poland) and, explaining how their missions are connected to research activities about topics of their interest, "The most exceptional part of the programme was the ability to master problem-solving and critical thinking skills during the preparation of the research" (Student ID28, Poland). Beyond all the activities that the students developed during their missions, students from Lithuania are a good example of the general sentiment present in the students' answers to the open question "What activities would you have preferred to have more of?" when they reported wanting "more practical activities, more practical investigations, more laboratory works and workshops" (Student ID3, Lithuania). Students also reported wanting to develop "more video films to create, and then demonstrate to the community, more public activities in the libraries, workshops in museums and in the city, like wall painting" (Student ID9, Lithuania). This demonstrates the enthusiasm towards working with and in the community that the students were able to foster.

We also performed statistical analysis of the students' answers to the Likert scale questions across themes I–IV by gender and country. This analysis uncovered a statistically significant difference in theme I across the countries ($F(5)=4.36$, $p=.00$), specifically regarding the item "The OSS project helped me find solutions on my own." A post hoc Tukey test showed that Israel had lower results for this than the other countries. The Israeli students' answers to the open question "What aspects of this project did you find challenging?" revealed that they felt a need for more structured guidance in their project development. One student stated, "I believe it [OSS] has a lot of impact and it can be good, but I also … felt confused sometimes and like 'I'm not sure what I'm supposed to do' and stuff like that, and I think like … there is a better way to do it, but the original idea is like amazing" (Student ID40, Israel).

Theme II: Student–teacher interactions

Students rated their interactions with their teachers the highest among all four themes investigated in this study ($M=4.40$, $SD=0.67$). From the open question, "What aspects of this course [OSS implementation] did you like the most?" the following quoted response illustrates the importance of the teachers' role in guiding students' learning in exploring the community through science (Bouillion & Gomez, 2001) with the OSS approach: "They [teachers] show me the world from a different perspective and let me discover it in my own way" (Student ID27, Poland).

As a result of this new teacher–student relationship, the students reported that the teachers encouraged them to develop the activities themselves and that they experienced more autonomy in their learning process, as they had to find the solutions to their missions through their own efforts, albeit with their teachers' support. The following quotations further represent how teachers and students in the OSS approach have different roles in teaching and learning science when compared to more traditional science learning approaches: "[The teachers] encouraged us and helped us to interact more with colleagues and discover new things" (Student ID2, Portugal); "The teachers in the project were supportive and helpful" (Student ID9, Lithuania); and "There was some independence gaining from all the work developed" (Student ID1, Portugal).

Theme III: Students' engagement and participation

The students also reported high levels of engagement with their missions' activities (item "I was fully engaged in all activities"; 5: strongly agree to 1: strongly disagree; $M=4.08$, $SD=0.71$). In addition, the item "Now I can apply my learning to real-life situations" correlated with the students' improved interest in science learning (item "I think I am more interested in studying science more than before"; r=0.70, p=0.01) and with their excitement to involve community actors in their learning experience (item "I was excited about our school excursions (to the community partners)"; r=0.63, p=0.01). This result emphasizes the importance of contextualizing science learning through practical work in real-life situations involving the local community and its resources.

However, despite students' high levels of engagement and participation in the project, they also reported many struggles and difficulties along the new kinds of activities they had to undertake during their missions. Some students reported that a new way of learning, with so much new information and not enough time to adapt, was overwhelming, as the following quote illustrates: "The challenging part of undertaking different kinds of science lessons was memorizing all the newfound influx of information.… It was difficult to do this because a young mind requires rest between every instance that it learns something new" (StudentID12, Lithuania). Nevertheless, in spite of the reported challenges, students still continued their missions to completion, which reinforces their commitment to and engagement with the new modality of learning, as reflected in this quote in which a student reported the challenge of having to study a lot to be able to complete the mission: "Studying the different renewable energy and which one could be applied in our school, because we had to study a lot about this subject to see what was the best choice" (Student ID19, Portugal).

Theme IV: Students' views on their group work

Theme IV of the questionnaire—working in groups within the OSS framework (M=3.69, SD=0.91)—had the lowest rating among the students. Analysis of the students' answers on this theme by gender showed that girls tended to seek more guidance for their group work (item "I feel that I need more guidance for our group work"; 5: strongly agree to 1: strongly disagree; t(23)=2.13, p=.04), while boys tended to consider group work as functioning better when group members are assigned specific roles (item "I think that groups work better when each person has an assigned role in the group"; 5: strongly agree to 1: strongly disagree; t(38)=-2.93, p=.00). These views overlap and complement each other to some extent, and some students (both boys and girls) reported a clear need for more structured and guided group activities, with explicit task distribution and role assignment among the members. The following quotes from the open question "What aspects of this course did you find challenging?" illustrate this finding: "I found it challenging working in groups because some members of the group didn't do that much work" (Student ID15, Spain/Catalonia), and "It was difficult to me to talk with my group when we did group work because I'm afraid of saying some stupid things so I don't talk very much when I work in group" (Student ID22, Portugal).

On the other hand, while some groups participating in this study had problems developing collaborative and well-balanced group work, others reported benefiting, for example, from a sense of belonging to a team, from the exchange of ideas (which boosted learning), and from a sense of personal growth. These benefits are illustrated, respectively, by the following quotes from the open question "What aspects of this course did you like the most?": "I was a part of a big team, I like that" (Student ID8, Lithuania); "[I enjoyed] working with my group because it was good to listen to different ideas" (Student ID20, Portugal); "Ever since I began engaging in group activities, I have noticed a significant increase in my confidence around other people" (Student ID12, Lithuania).

Teachers' perspectives

Regarding the planning and implementing of OSS activities, the teachers rated how they felt about organizing activities outside the school highly positively (item "How did you feel about organizing activities outside the school under the OSS framework?"; 5: very good to 1: very bad; M=4.59, SD=0.62), followed by the quality of the students' learning experience during the activities developed (item "How do you rate the educational aspect of the activities?"; 5: very good to 1: very poor; M=4.41, SD=0.79). Comparatively, teachers indicated that it was more challenging to implement the OSS methodology compared to traditional science teaching (item "How challenging did you find teaching using OSS?"; 7: very challenging to 1: not at all challenging; M=5.82, SD=0.67).

Analysis of the teachers' answers by gender showed that female teachers rated the educational aspects of the activities higher than male teachers (t(15)=2.24, p=.04), which was also found in ratings of how they felt about the process of reaching out and networking with community partners (t(14)=2.50, p=.02). In addition, female teachers' answers to open questions showed a positive attitude towards trying innovative teaching methods and learning activities and towards investing a considerable amount of their time in planning the activities and coordinating and mediating the necessary community partners to help ensure a successful project for their students. The following teachers' answers to the open question "What were your dispositions during the different phases/processes of the OSS experience?" illustrate this: "I took part in all OSS activities, tried to produce ideas, tried different working methods, encouraged my students to be open to changes and to be active" (Teacher ID5, Lithuania) and "Initially it was a very exciting challenge that became a hard work and later we achieved interesting results" (Teacher ID8, Portugal). Female teachers' answers to the open question "What other reflections would you like to share?" indicate that they observed a more personal value in the learning experiences of their students: "My students are becoming more and more confident at expressing their need for changes in school, expressing themselves, meeting challenges and overcoming them" (Teacher ID4, Lithuania). On the other hand, male teachers' answers to open questions had a more insecure tone regarding the project planning, execution, and benefits, as illustrated by the following: "I do different tasks during the OSS experience, but our institutional organization does not allow us to have as many hours as I (we) really need" (Teacher ID10, Spain/Catalonia), "It's a different kind of teaching, so I felt some difficulties working this way. A little bit insecure about what I should do, and if it was the best way to do it" (Teacher ID13, Portugal), and this thoughtful consideration:

> This initiative is very challenging and demanding, but there's no "space" in school to apply such a sophisticated methodology. Of course, not every kind of it. The simpler projects based on OSS may of course be successful. Still, the education systems are not fit for the rapidly changing world and society and schools are still frozen in teaching in old-fashioned ways, concentrating on acquiring academic knowledge and passing the national tests. (Teacher ID15, Poland)

By country, there were statistically significant differences (F(5)=3.23, p=.05) regarding how well the teachers believed the OSS project met the students' needs, with Spain/Catalonia reporting the lowest scores in this item (item "How well has this course met students' needs?" from 5: very well to 1: not at all). This is exemplified by one of the Spanish teachers' answers related to their disposition during OSS implementation: "My main disposition regarding the OSS experience is scepticism. The OSS experience has been very difficult to apply in the 4rt ESO[1] subjects and, from my viewpoint, it has not specially improved the students' motivation towards science or environmental problems compared to traditional methods" (Teacher ID9, Spain/Catalonia). The same teacher suggested some critical areas for improvement, such as "better clarifying the learning objectives over the project years and making them coherent," as well as "reducing changes and improvisations over time, especially those related to project coordination."

By years of experience, the teachers were roughly divided across four major groups spanning from one to four decades of professional experience. In the post hoc Tukey test, teachers with more than 31 years of experience scored statistically significantly higher for how they rated the educational aspects of the activities, while teachers within their first decade of work scored this factor the lowest. Additionally, this result correlated with the value that the teachers attributed to the experiences that the students obtained from the implemented activities (item "How would you rate the students' experiences from those activities (implemented during OSS)?"; 5: very good to 1: very poor; $r=0.856$, $p=0.01$) and with the teachers' perspective of community involvement (item "How do you feel about the process of reaching out and networking/collaborating with community partners?"; 5: very good to 1: very bad; $r=0.657$, $p=0.01$). Furthermore, answering the open question "What other reflections would you like to share?" one teacher stated that "it was a gratifying experience since it allowed us to approach science in a real context. But the most important thing was to observe the involvement and growth of our students in the way they look at science" (Teacher ID2, Portugal).

Discussion

OSS educational added value from teachers' perspective

Regarding the teachers' perspective on the OSS implementation, it was interesting to find that the oldest teachers rated the educational aspects of the OSS project relatively higher than their younger peers and that female teachers demonstrated a more accepting attitude towards practically implementing the OSS methodology with their students. These results might have complex reasons. For example, young teachers might invest considerable energy in adapting to the new school environment; therefore, implementing innovative methodologies might be viewed as an extra workload in their school integration process (Beltman et al., 2011). On the other hand, older teachers might find that the OSS project brings opportunities for new science activities and teaching methodologies that they may have been lacking in their previous years of teaching (Kalantari & Kolahi, 2017).

Additionally, the low rating by the Spanish teachers regarding how well the OSS project met the students' needs highlights the necessity for more attention and support for teachers and students locally in terms of how these kinds of approaches could be successfully integrated with the curriculum. This stresses the need for further transnational initiatives and investigations, such as the one presented here, equipped with rich teachers' scaffolding and follow-up mechanisms that collect their feedback and practical experiences in their different countries and regions as to tailor the necessary support. Teachers might be undergoing completely different experiences due to a variety of reasons particular to their locations. Sharing with other international peers and receiving tips and support could generate for them new perspectives on how to tackle local issues. In

[1] ESO stands for Educación Secundaria Obligatoria (compulsory secondary school education, in English). 4rt ESO indicates the fourth year of compulsory secondary school education in Spain.

addition, beyond collecting feedback, it is crucial to develop efficient interventions and action plans to mitigate problems and challenges that may arise, as school principals' leadership has been reported to be one crucial factor that supports curriculum reform and implementation of innovative pedagogical approaches (Towers & Panayotidis, 2012).

Further considerations from students' perspectives

The impact of science learning through OSS in the community (theme I, students' questionnaire) as indicated by the students' answers is complemented by their perspectives reflected through their engagement and participation (theme III). The results emphasize the importance of contextualizing science learning through practical work in real-life situations involving the local community to foster students' engagement and participation in learning, even despite the challenges they might face during developing their science missions. The OSS approach's aims go beyond taking students away from the school building to carry out punctual activities (e.g., a siloed museum visit) and move towards bringing "the powerful elements of day-to-day life that exist beyond school into school in meaningful ways" (Boullion & Gomez, 2001, p. 879). The fulfilment of such aims can be identified in the students' perspectives when they openly and enthusiastically describe their science missions' activities and other activities they wish to carry out, reinforcing the value of hands-on learning within the community context (Boullion & Gomez, 2001; Lee et al., 2013). Additionally, by implementing a community-based, whole-school approach, the local OSS implementations supported the strengthening of social cohesion towards becoming sustainable over time, with students showing more interest and motivation in engaging with science learning, growing in active citizenship, and developing relationships beyond the school (García-Carrión & Díez-Palomar, 2015).

Students' answers from theme II (student-teacher interactions) highlighted the importance of the interactions between teachers and students as well as the teachers' role in providing feedback and scaffolding students' learning experience (Tobias & Duffy, 2009). In other words, within the OSS didactical framework, teachers were not knowledge gatekeepers who would transfer knowledge within the walls of a school classroom but rather mentors who scaffold (Bruner, 1985) students in taking ownership of their process of learning science connected to their real-life experiences in the community (Bouillion & Gomez, 2001; Hanewicz, Platt & Arendt 2017; Lee et al., 2013). Finally, the students' dissatisfaction with their teamwork (theme IV) demands attention. Such a complaint is well known in the literature on group work and student-centred learning environments, in which students are expected to be prepared for self-paced and self-directed study. Because students are mostly used to a teacher-centred style, they need to go through a change process guided by their teachers to learn how to identify their own interests, set goals for themselves, and take more decisions regarding what and how they want to learn (Hanewicz et al., 2017).

It is important to mention that during the implementation of the OSS didactical framework, general guidance on students' group work was provided, describing the main roles and responsibilities that students should take during their science mission. However, the specific dynamics of group work depend on many other circumstances beyond project guidance, such as teachers' resources and support for the students, students' engagement with the activities, and the types of interactions between the students (García-Carrión & Díez-Palomar, 2015). A common mistake made by teachers, widely known in schools and reported in the literature (Johnson & Johnson, 2009), was to assume that students would work cooperatively and collaboratively just because they were assigned a group task. However, if students have no previous experience of taking a role in a group with specific assignments to complete based on certain role responsibilities, it is very common for students to distribute tasks unevenly among themselves, with some doing the majority of the work while the rest remain sidelined; for relevant ideas and arguments to not be shared in ways that promote meaningful learning; or for the pace of content coverage according to curriculum demands to be slowed, for example (Baines et al., 2015). To overcome this issue, teachers need to dedicate sufficient time to developing teamwork and collaborative competences with students for group work to actually enable students to reap the benefits of sharing a common goal, exchanging ideas and resources, helping each other, and working together (García-Carrión & Díez-Palomar, 2015; Hanewicz et al., 2017).

Conclusions

This study presented the practical implementation of the OSS didactical approach to science learning involving community partners in several countries. The results of the implementations presented here indicate the effectiveness of the OSS approach to science learning involving the community from both the students' and teachers' perspectives. Students reported enjoying and effectively learning science within the OSS framework of activities, as well as appreciating the new way of interacting with the teachers and within their teams, while developing their missions in association with community partners. This finding confirms many other research studies investigating the positive impact of peer learning with meaningful dialogic interactions among students, such as a more positive attitude towards science and mathematics and an increase in self-efficacy in these subjects. This study presented a step forward in supporting schools in becoming active agents of change in their local communities through the implementation of contextualized learning experiences alongside external stakeholders, supporting in this way active and responsible citizenship in Europe.

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