SCIENCE4GIRLS
IO4 RESEARCH PAPER

FURTHER RESEARCH TO MAKE SCIENCE ATTRACTIVE TO FEMALE TEENAGE STUDENTS

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SCIENCE4GIRLS

Making Science Attractive to Female Students through Open Science Schooling Focused on Climate Change

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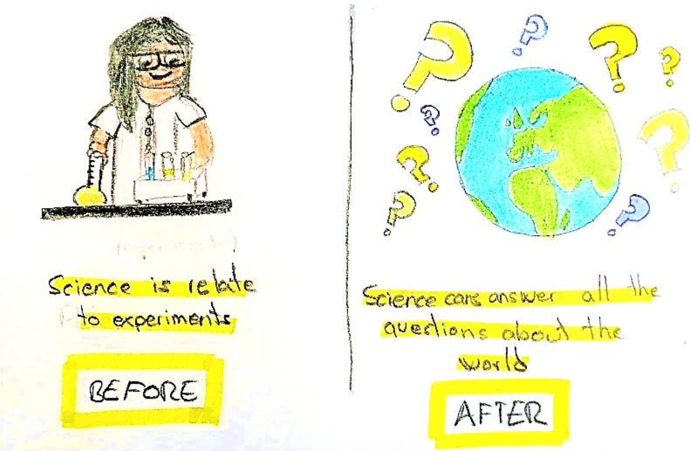
EXECUTIVE SUMMARY



Student's drawing about their view of science before and after participating in the Science4Girls project

This study presents the state of the art in relation to female students' (re-)engagement to science learning using open science schooling (OSS) pedagogical approach to develop community missions tackling issues related to climate change topics. The implementation of the project and this research falls under the Erasmus+ Science4Girls Project (2020-2022). To develop this research, we gather authentic and rich data throughout the project implementation, as well as monitor the research literature on aspects related to students' science engagement, female students' motivation in STEM education as well as gender stereotypes in society. The study follows a mixed research method design, where qualitative and quantitative data complement one another, supporting insights. The research exploration is also guided by the active participation of the involved students and teachers, combined with application of Open Schooling method of learning in developing community science missions to tackle local climate change issues.

Here we aim at summarising the experiences of schools, teachers and students from the 5 European countries that participated in the project, taking the standpoint of the following research questions:

RQ1. What are the characteristics of the Open Science Schooling that is focused on climate change?

To answer this question, we explore the methodology of the Open Science Schooling when the focus is climate change as well as how the OSS methodology employed to develop learning experiences regarding climate change can be of advantage towards students' re-engagement.

RQ2. How the Open Science Schooling linked to climate change facilitates female students' re-engagement and interest in science?

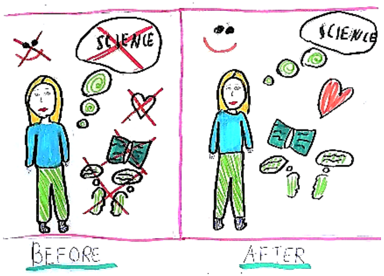
Through this question, we explore how girls engaged in learning science during climate change missions. We also ponder in what ways this methodology makes learning science more attractive to girl students.

RQ3. How the OSS linked to climate change transforms female students' image/idea of science and their academic identity?

In this question we address the female students' individual perceptions of science and how it changes as a result of project implementation. We also explore the students' development of academic identity as influences by the project participation.

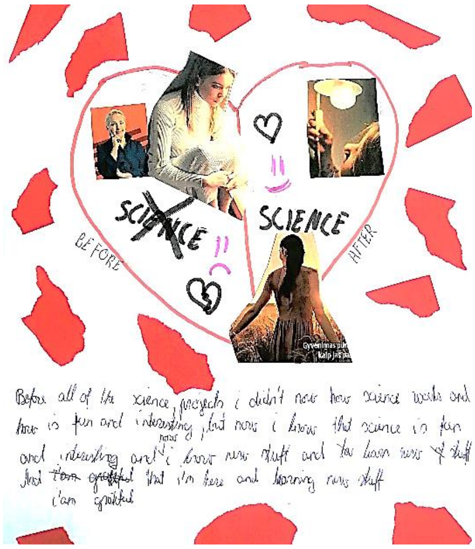
KEY FINDINGS

KEY FINDING 1 – INNOVATIVE PEDAGOGY CHARACTERISTICS



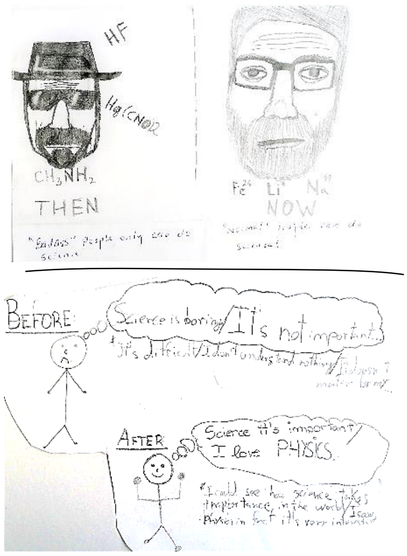
A science-inquiry, hands-on methodology applied to develop hands-on community missions brings forward 4 distinctive factors that support students' (re-)engagement in science learning*: importance of the topic locally and globally*, *student-centred learning*, *role of community collaboration and immersiveness of the learning experience.* These factors combine support the implementation of engaging learning experiences that boost students' motivation. This requires a redefinition of teachers' comfort zone in terms of their role.

KEY FINDING 2 – SCIENCE MADE ATTRACTIVE



The data shows that students are motivated to study a topic that is personally important, significant to them particularly when they can identify in it their own personal values such as caring, empathy and altruism. Furthermore, learning on demand through the student-centred strategies offered by OSS facilitate students' agency development and empowerment.

KEY FINDING 3 – SCIENCE IMAGE EVOLUTION



The combination of a locally meaningful, globally important topic such as climate change with a science-inquiry hands-on methodology such as open science schooling proves to bring forth the necessary factors to support the creation of a positive image of science in the participating students over the implementation of 2 immersive rounds of community missions.

INTRODUCTION

UNDERREPRESENTATION OF FEMALE STUDENTS AND PROFESSIONALS IN SCIENCE

Much science re-engagement for female students' research has over the past decades been forced to conclude that the innovative strategies applied until now have resulted in very little change. The innovative strategies did not manage to create fundamentally new images of science among teenage girls. Even though they are doing quite well in classroom science and even enjoy some of the topics, they still find it very hard to identity with a "life in science". This is echoed, for instance, in The WISE Campaign[1] Report of 2014 (Macdonald, 2014) which candidly states that over 30 years of focus on 'enthusing, fascinating or encouraging' girls into science, technology, engineering, and mathematics (STEM), have achieved very little change in the proportion of girls and women choosing science careers in EU.

The introduction of arts and design (STEAM) has attempted to generate a more positive response towards science by articulating multidisciplinary project-based learning experiences at K-12 level (Ng & Fergusson, 2020), however the problem persists. One-off interventions do not seem to work as initiatives that seek to encourage girls into STEAM by implying girls must change to fit into the science world are misplaced. Using competitions as a motivating strategy is also a risk. Girls might not need competition to motivate them as they are often more inspired by cooperation. (MacDonald, 2014). And simply being a woman who works in STEAM does not make someone an effective role model to inspire others to follow a similar career path (Bamberger, 2014). Therefore, such strategies when implemented have often resulted in mixed success (Bello, Blowers, Schneegans & Straza, 2021).

Recent ongoing initiatives have also been established, for instance UNESCO Women in Science, looking at developing indicators to understand how women take the decision to embark on a STEM career[2]. Nevertheless, independent studies point out persistent underrepresentation of women and girls in STEM studies and careers (UNESCO, 2018; OECD, 2012; OECD 2017). Related to it is the gender segregation in STEM education and vocational participation observed by researchers – STEM studies and careers are predominantly chosen by men, while women tend to turn to non-STEM disciplines as education or healthcare (Makarova, Aeschlimann & Herzog, 2019).

The factors behind girls' and women's lower interest in STEM field may be of cultural nature as girls and boys display same level of cognitive abilities to succeed in STEM (Makarova et al., 2019). Among the cultural determinants of the girls' and women's underrepresentation in the field, research identified the following:

- Perception of STEM as science(s) as the male domain (Cvencek, Meltzoff & Greenwald, 2011; Miller, Nolla, KEagly & Uttal, 2018)
- Perception of career in STEM as men's career and as 'wrong sex career' for women (Makarova et al., 2019; Gottfredson, 2002)
- STEM 'favouring' boys' and men's styles and habits of work (Hand, Rice & Greenlee, 2017; Balart & Oosterveen, 2019) and impeding 'female values' (Diekman, Clark, Johnston, Brown & Steinberg, 2011; Tellhed, Bäcktröm & Björklund, 2018)
- Stereotypes[3] that disfavour girls and women in STEM that are embedded in the school educational materials and reflected in behaviour and attitudes of teachers, students and their parents (Lavy & Sand, 2015; Bunikowska & Suero Montero, 2021)

To sum up, female underrepresentation in STEM field stems from how the image of STEM as science and career along gender lines on the one hand and with the way girls' identity in the context of STEM, on the other.

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[1] The Women Into Science and Engineering (WISE) Campaign started in 1984 as an initiative in the UK targeting at increasing female participation in science and engineering fields.

[2] Women in Science | UNESCO UIS

[3] Math textbooks – a study from Lithuania, 2019: https://www.lygybe.lt/en/news/school-textbooks-are-stuffed-with-gender-stereotypes-new-study-says/1146, (accessed 28.11.2022)

The girls' identity from a STEM education/career perspective is composed of the *academic identity* that is anchored in self-evaluation of one's capacities in the field (self-efficacy) and *examination of possibility to fulfil one's goals* through engagement in the field. The biased images of STEM as male science and career and perceptions of girls belonging to non-STEM identities are maintained and constantly reproduced by gender biases and stereotypes regarding women and science.

The research objective is the explore how the OSS pedagogical methodology applied to tackle issues related to climate change could influence girls' (re-) engagement in STEM science. Specifically, we want to probe into the OSS' effects on redefinition of the image of science and science career as well as its impact on re-shaping the girls' self-images in the context of STEM. To appeal to female values in science learning, the project adopts a pronounced focus on climate change as challenge that can be addressed by science.

THE OPEN SCIENCE SCHOOLING METHODOLOGY

Since 2020, a consortium of educators, researchers, and students, as part of the Science4Girls European endeavour, have deployed science learning activities using multidisciplinary climate change topics under the umbrella of Open Science Schooling (OSS) methodology in Lithuania, Romania, Slovenia, Spain and Sweden. During the project, students are active agents at the heart of inquiry-oriented science learning implementing science missions concerning climate change in their local communities. Working under the OSS methodology, students identify and frame problems that they are intrigued and interested in tackling, and they lead the discovery of solutions and innovations, helping them to situate science in their every-day lives. We believe that such a framework of science education for responsible citizenship, which contributes to solving social problems in the learners' own context, can work as an educational setting that re-engages students with science by incorporating scientific practices and ways of thinking, i.e., by developing a science identity (Vincent-Ruz & Schunn, 2018).

During Science4Girls, secondary school students worked in teams to engage or re-engage in science learning. The OSS science engagement methodology included originally four progression elements. This methodology and its progression ensured that the project built its results on solid and authentic student team practice from the science engagement missions:

PROBLEM CONTEXTUALIZATION. Students are engaged in understanding what are the real problems that affect their local community and how science can offer support to understand and meliorate the situation. In order to understand the problems students are prompted to involve the local community as collaborators in their investigations, including research and innovation centres, industries, NGOs, and other social stakeholders. The result of this phase is a selected problem that students 'teams will work on.

KNOWLEDGE AND IMPLEMENTATION. Once a problem has been selected to be tackled, students receive training and information on demand from schoolteachers and other stakeholders from the local community as well as from their own investigations. This invites the acquisition of digital literacy skills, 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. Here the students benefit from learning through a variety of practice-oriented work forms that support different learning style and practically test and implement their solutions.

DOCUMENTATION AND SELF-REGULATION. The students are encouraged to keep a record of their process and involvement on their projects. This serves the students as a tool for self-reflection on the work accomplished and provides them with a narrative of their experiences and gives them the opportunity to understand how their learning experience is progressing, what they have so far achieved and what else they need to do/learn to complete their work.

SHARING AND REFLECTING. The students are also encouraged to share their experiences and solutions with peers in their schools and also with their local community. The sharing can take place online, e.g., through websites and social media, at scientific conferences, through eBooks, etc. The sharing and reflecting process is fundamental and can occur at any time during the learning experience –through this process the students internalise the knowledge and skills acquire and are ready to let others know what they know.

SCIENCE4GIRLS CLIMATE CHANGE MISSIONS

LITHUANIA. School in Lithuania concentrated on pollinators, specifically butterflies in their Mission I, as the students noticed the community concerns about less and less honey produced by the local beekeepers. Throughout the mission the students and teachers collaborated with various community stakeholders including private companies and local farmers. They engaged local citizens too, by providing them with bee friendly flower seeds. The Mission's biggest achievement, however, was that the local farmers volunteered to spare strips of their fields from cultivation and leave it to the pollination. After completing the Butterfly Mission, the Lithuanian team moved on the second mission that was focused recycling and upcycling old clothes and used items.

ROMANIA. The Romanian team focused in their climate change mission on the issues related to drought and volatile water situation in their region called Romanian desert. The Mission implied collaboration with the regional institution responsible for water management on the one hand, while on the other collection of water samples and analysing them in the school laboratory. The second mission was a continuation of the first but its main focus was finding solutions to offset the global warming effects in the region – planting drought resistance plants. A regional research centre experts and local organizations helped the girls better understand and explore the possibilities of drought resistant plants.

SLOVENIA. The team from Slovenia decided to focus on e-waste in both of their missions. Being a school for electronics and electronic engineering, the school uses a lot of computer software that is frequently replaced by newer version; this produces a lot of electric waste, students concluded. The students were initiated collaboration with local companies that provided them with know-how on garbage collection and recycling and reuse as well as on environmental problems related to electric waste. Students' parents and families were reached too with presentations on the topic. The school's main community partner – recycling company gave a workshop to the whole school students and offered containers for e-waste.

SPAIN. Spanish students focused in their missions on the negative effects of climate change on their immediate environment. They explored issues of air pollution, global warming effects on plants and animals as well as natural disasters. These various explorations made students turn their focus on their local river, which bank soon became the research site. Students wanted to better understand the negative effect of invasive species that threatened the river ecosystem. As part of their missions, they collected various samples that were later on examined in the laboratory. To supplement their own discoveries, the students contacted the specialist from the meteorological institute for interviews and discussions.

SWEDEN. The Swedish team of the Science4Girls project begun their first mission exploring climate change issues related to food- and textile industries. The students watched documentaries touching on the issues, researched the relevant problems and interviewed local companies from the relevant fields. This research and inquiry activities brought the students to identification of the problem to address in the second Mission – food wastage at their school cafeteria. The Mission II of the Swedish team was about measuring (weighing up) the school cafeteria food waste and piloting a solution implementation to the problem, which was introduction of the meal choice. The students learned (and evidenced it) that introduction of the meal choice option resulted in less food being thrown to the trash. They followed up their idea by learning how to design an easy phone application for the purpose of food waste reduction.

THEORETICAL FRAMEWORK

EXPECTANCY-VALUE THEORY OF MOTIVATION

Expectancy-Value Theory of motivation (Eccles, 2005, Wigfield & Eccles, 2000), is seen as a process in which several elements interact with each other to influence student's motivation to engage in task, activity and in a particular field of studies in general. Its key concepts are:

- Success- and failure expectations
- intrinsic utility
- attainment value
- self-concept of abilities

According to this theory, people make choices that reflect what is important to them and thus engage in activities that they value and in which they expect they would succeed. In the context of education, students choose courses, subjects, disciplines they personally value as interesting, important and useful and in which they expect to have good outcomes. As Eccles (2005) explains, expectancies consist of two dimensions:

- the ability self-concept that is a self-perception of one's own abilities and competencies in given domain(s) – *How good I am at that?*
- success or failure expectations regarding specific tasks – *Am I likely to success in it or fail?*

Values can be divided into three categories: intrinsic, utility and attainment values.

- Intrinsic values reflect one's genuine and personal interest in activity, domain – *How much do I like it?*
- Utility values refer to perception of usefulness of an activity/domain – *Is it useful for me? Do I need it?*
- Attainment values denote importance of succeeding in a task/ field – *How important is it to me that I succeed in it?*

Both expectancies and values are subjective, which means that they come from individuals rather than being imposed on them. They are also domain- and task specific, for example, one thinks he is good in maths but not that good in history or vice versa.

As noted by Eccles and Wigfield (2000), students approach tasks and activities also from the perspective of costs – *emotional, effort and opportunity costs. Emotional cost* refers to possible negative emotions that may be elicited in engagement in the task, activity – *Will it upset me, will it make me feel miserable? Effort cost* reflects how much work and effort is expected to invest in a task, activity. *Opportunity* cost means that students judge whether engaging in an activity prevents them in taking part in other activity that is of their special interest and liking.

As Eccles and Wigfield (Ibid) conclude, students make choices about engagement in the activities that reflect a balance between the values they identify in the tasks and the costs of the task they need to bear. Additionally, in the context of the Value- expectancy theory of motivation the self-efficacy concept of Bandura (1988) is very relevant, as it refers to a belief in one's ability to perform specific tasks.

From the perspective of the **Science4Girls** project it is important to highlight the 'cultural milieu' that encompasses gender role stereotypes on one hand and cultural stereotypes of subject matter and occupational characteristics (i.e., characteristics of scientist).

SELF-DETERMINATION THEORY

The self-determination theory, SDT, (Deci & Ryan, 2013) proposes that people's natural tendencies to grow, tap their talents, master competencies, face challenged and retain a coherent sense of self are either supported or suppressed by their social context.

According to Deci and Ryan, the proponents of the theory, self-determination is "freedom from control … (for) initiating one's behaviour" (Deci & Ryan, 2013). Self-determination theory poses that with the freedom to exert control over initiating one's behaviour, intrinsic motivation is enhanced. Furthermore, the feeling of competency is only maintained when the individual continuously stretches their capacity to further enhance their competences, thus avoiding stagnant boredom. Deci and Ryan, developing the SDT, highlight three innate psychological needs that motivate the individual to initiate behaviour: competence, autonomy, and relatedness. Competence refers to the perception of (self) efficacy to engage in a behaviour that the individual poses; autonomy refers to the perception of self-determined behaviour, choice and the opportunity for self-direction that the individual has; and relatedness refers to the sense of safety that the individual has within a social context, where a secure proximal relational support can be found (e.g., from family and friends). (See: Ryan & Deci, 2000). These needs or factors are the basis for the cognitive evaluation theory (CET), within SDT, to explain the variability in intrinsic motivation in the individual. CET then highlights that the social environment can hinder or facilitate intrinsic motivation by "supporting or thwarting people innates psychological needs", however "people will be intrinsically motivated only for activities that hold intrinsic interest for them, activities that have the appeal of novelty, challenge, or aesthetic value." (Ibid, p71).

To understand human motivation towards activities that are not 'intrinsically appealing', Deci and Ryan propose the construct of extrinsic motivation, related to initiating a behaviour to gain a separated outcome, not only to gain the inherent satisfaction of carrying out a behaviour (or activity) in itself. To develop the construct of extrinsic motivation alongside its different forms, Ryan and Deci proposed the organismic integration theory (OIT) within SDT. OIT highlights the process of internalisation, "through which an individual acquires an attitude, belief, or behavioural regulation and progressively transforms it into a personal value, goal, or organization." Internalisation comes alongside integration, which covers the psychological process of bringing inside the person the regulation of externally motivated behaviour, due to their value towards the person's own social-environmental adaptation, so that the external motives and regulation are eventually experienced as self-determined (Ryan & Deci, 2000 a; Ryan & Deci, 2000 b). OIT deals with the different forms of extrinsic motivation and the socio-environmental factors that foster or hinder internalisation and integration processes of human behaviour.

SDT proposes a taxonomy of human motivation that ranges from *amotivation* (lack of volition to act) to *extrinsic motivation* (acting to achieve an external reward) to *intrinsic motivation* (acting for the pleasure of performing the activity). In turn, extrinsic motivation is subcategorised into external regulation (least autonomous form of motivation), introjected regulation (motivation by contingent self-esteem), identification (partly self-determined due to the importance of the activity) and integrated regulation (self-determined regulations assimilated into the self) (Ryan & Deci, 2000 a).

According to this theory, the student's motivation to engage in activities, subjects and subject domains depends on their perception of freedom to make own choices (need for autonomy), show competence (need for competence) and be/ feel related to others and have a sense of belonging and connectedness with others (need for relatedness). These tenets will support the discussion of the data for the **Science4Girls** project.

METHODOLOGY

The background to the Science4Girls project is that climate change, despite its horrible consequences for life on earth offers a historic opportunity to re-engage girls in science. However, science engagement through climate change is a brand-new and hardly yet explored research field. Therefore, this research study focuses on investigating how this kind of innovative pedagogies support the re-engagement of teenage girls into science learning. For this, the following research questions are investigated (Figure 1):

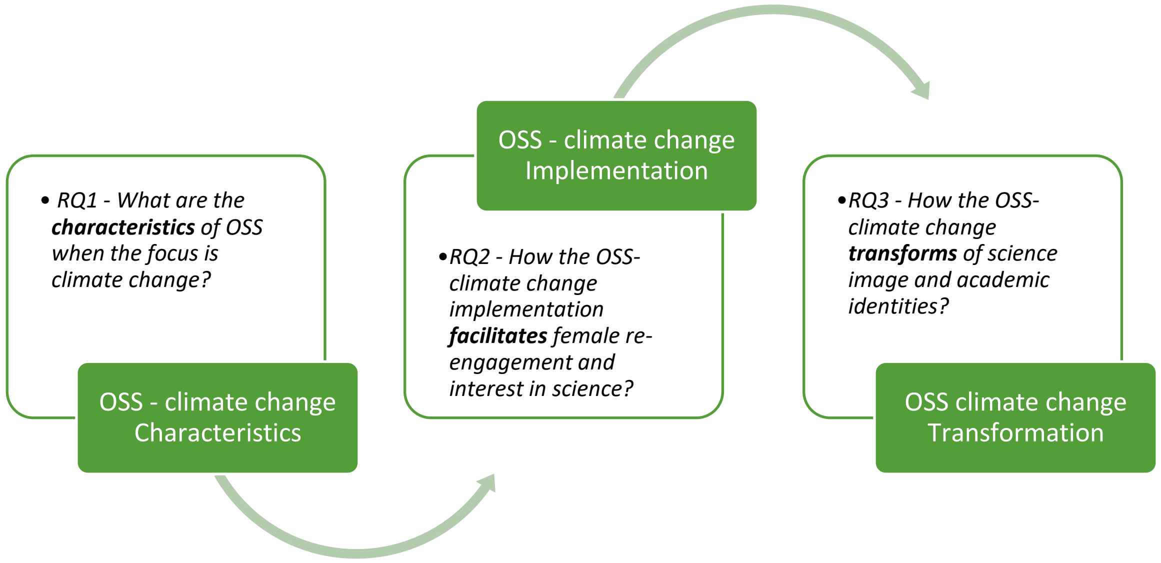

Figure 1. The research' progressive approach following the research questions

Each research question (RQ) was further analysed through specific sub-questions as indicated here:

RQ1. What are the characteristics of the Open Science Schooling that is focused on climate change?

- How does the OSS focused on climate change **tap to the advantages of the OSS** innovative method? Specifically, in what ways linking the OSS to climate change develops and enhances the OSS as a learning method?
- What are the main **challenges** related to focusing on climate change in the OSS learning strategy?

RQ2. How the Open Science Schooling linked to climate change facilitates female students' re-engagement and interest in science?

- How do girls engage in learning science during climate change missions?
- How the Open Science Schooling focused on climate change is different and/or similar as compared to other innovative learning strategies?

RQ3. How the OSS linked to climate change transforms female students' image/idea of science and their academic identity?

- How the perception of science (image of science) and the interest in science change along the project implementation? What are the new images of science the girls created along the project?
- How the female students' academic identity changes when they encounter science through OSS focused on climate change? What factors mediate this change? what factors inhibit, limit the change?

- What should be the characteristics of innovative science education strategies that will be considered attractive by girls? What factors play role in seeing science as an attractive career path for female teenage students?

To investigate and answer these research questions, **the methodology of this study primarily follows a mixed research design**, as the direct participation of students and teachers in the project made it possible to collect rich data. In addition, the data includes both qualitative and quantitative inputs, which have been analysed accordingly. The quantitative data has been presented in graphs and as descriptive statistics and refers to the project's information as well as to the results of the surveys (students' surveys (pre- and post), teachers' surveys and parents' survey). The qualitative data analysis was carried out through a qualitative lens, broadly inductivist, constructionist and interpretivist (Bryman, 2012) emphasising words and expressions from the participants. The collected data is rich, gathered from various sources as indicated in Table 1.

Table 1. Data sources

PROJECT DOCUMENTATION Mission stories, video clips, pictures		
DATA GATHERED DURING PROJECT EVENTS' ACTIVITIES		
Empowerment Mobility I - Online, 22-23 March 2021		Participants
Science4Girls_MOB1 - Students	Jamboard exercise: Expectations from boys and girls: A boy/girl should … Restrictions for boys and girls: A boy/ girl shouldn't … What does it mean to do something like a girl? What does it mean to engage in science/ do science like a girl?	School Team Lithuania School Team Romania School Team Spain School Team Sweden
Science4Girls_MOB1 - Teachers	Miro board exercise: Why is it important to include more girls in science? - Benefits for boys and girls - Benefits for science - Benefits for society	
5-day Empowerment Mobility - Lisbon, May 2022		Participants
Teachers and Students Gallery walk regarding the topic: Effective teaching on climate change and gender equality	Students and Teachers were invited to get familiar with key research derived information on effective ways of teaching about climate change and in a gender equitable way (posters on the wall). They were probed by questions to reflect and provide their perspectives on gender bias-free teaching and about climate change.	School Team Lithuania School Team Romania School Team Slovenia School Team Spain School Team Sweden
Draw-A-Scientist-Test exercise	Students draw pictures of 'scientist' – the exercise was inspired by Draw-A- Scientist Test (DAST), an open-ended projective test designed to investigate children's perceptions of the scientist.	

Transnational Partners Meeting Maribor, October 2022		Participants
How did girls' science image and their academic identities change?	The students were asked to describe in drawings how, if at all participation in the project changed their perception of science and their identity as scientists.	School Team Lithuania School Team Slovenia School Team Spain School Team Sweden
SURVEYS		
Students' surveys		Number of respondents
Is it a boy of girl thing? survey	Implemented during Empowerment Mobility I (online) 22-23 March 2021, Webropol based	n=36
Science4Girls - Perception of Science and Scientist Identity: Pre-Survey	Pre survey was administered using the Webropol tool in the beginning of the project. The survey was composed of 26 questions that addressed issues related to: perception of 'scientist' and 'science'; evaluation of academic identity of the respondents, gender and science teaching and learning and careers; respondents' goals and values.	n=77 *(Note: only 24 answers participants' responses were analysed as these participants were the ones who responded the post survey. 7 of the respondents were boys. No student from Romania answered both pre- and post-surveys).*
Science4Girls - Perception of Science and Scientist Identity: Post-Survey	Post survey was administered using the Webropol tool in the final stages of the project. The questions were exactly the same as those asked in the Pre Survey (see above)	n=28 *(Note: only 24 answers participants' responses were analysed as these participants were the ones who responded the corresponding pre-survey. 7 of the respondents were boys.)*
Parents' survey		Number of respondents
Science4Girls_Pre-survey Parents Guardians	The survey was administered using the Webropol tool in the beginning of the project alongside with the students' Pre-survey. The surveys' questions probed into the topics: perception of science, evaluation of respondent's child academic identity, views regarding gender in the context of science and career.	n=35 *(Note: The pre survey input was not representative (lack of Slovenian students' parents' responses) of the students' parents across partner countries thus we decided against administration of the Post version of the survey).*
Teachers' survey		Number of respondents
Science4Girls_Teachers_ Gender bias in education	The survey was administered to the teachers present at the project Kick off meeting, Online 15-16 December 2020. The survey – Webropol tool- was composed of 16 open-ended questions that probed into: gender biased and stereotypes in education, specifically noticing and addressing gender	n=16

	stereotypical and discriminatory students' and teachers' behaviour and attitudes; noticing gender stereotypes and women's underrepresentation in textbooks and other educational materials.	
Science4Girls Teachers' Survey	The survey was administered using the Webropol tool in the final stages of the project. The survey objective was to collect data on the teachers' perceived ability to notice and address gender biases in the context of teaching and learning as well as their perception of the OSS method utility in addressing gender biases in science learning. It was composed a mix of open-ended and single-choice (5-point Likert scale answer option), in total 22 questions.	n=13 *(Note: The survey was addressed both to the project teachers and to the partner school's teachers not participating in the project – to verify the OSS possible application and impact in addressing gender biases in science teaching and learning).*
SEMI-STRUCTURED INTERVIEWS		
Students' interviews		Number of participants
Science4Girls Students' Interview	The interviews were conducted online via Teams application. The students' interviewees were the Team Captains – two students (in case of one Team only one student was able to participate due to COVID/ flu high infection period). The interview questions were organized around 8 key topics: project missions; climate and science in the missions; mission teams; students' engagement in the missions; learning science; learning science through OSS method; 'Me scientist?'; girls, boys, and their interest in science. The interview guide was distributed to the students beforehand.	Lithuania n=1 Romania n=2 Slovenia n=2 Spain n=2 Sweden n=2
Teachers' interviews		Number of participants
Science4Girls Teachers' Interview	The interviews were conducted online via Teams application. Each school Team was represented by two teachers. The interview questions were organized around nine key themes: missions in the project; science and climate in the missions; mission teams; students' engagement in the missions; OSS methodology; teacher's role in the OSS methodology; girls, boys and science; OSS and climate change as means to make science attractive to girls; making science attractive to girls; extra: making science attractive to girls and boys. The interview guide was distributed beforehand.	Lithuania n=2 Romania n=2 Slovenia n=2 Spain n=2 Sweden n=2

ANALYSIS AND FINDINGS

Here we present the analysis of the collected data towards answering each one of the posed research questions (RQs).

RQ1 – WHAT ARE THE CHARACTERISTICS OF OPEN SCIENCE SCHOOLING THAT IS FOCUSED ON CLIMATE CHANGE?

IN terms of the advantages of developing innovative learning experiences related to climate change through OSS, we identified the following 4 main characteristics of the combined approach*: importance of the topic locally and globally*, *student-centred learning*, *role of community collaboration and immersiveness of the learning experience*.

1. The data shows that **focus on climate change means learning about important, pertinent locally- and globally relevant issues.**

   The real-life and real-time focus of the OSS in the context of climate change translates into addressing issues that are locally, regionally important and pertinent to the communities of the students and their schools. Several quotes supporting this finding:

   > *Our missions were about various things, but mainly they were focused on various global issues that are currently important. (Lithuanian Student, Interview)*

   > *Our missions were about drought, in general, which is the main problem in our region. (...) In both missions, we were introduced to how we can save the planet with the help of soil. (Romanian Student, Interview)*

   > *It was the continuation of the first mission because we started to feel concerned about the climate change then putting up questions: "What can we do to stop climate change? Maybe not to stop, but at least to reduce climate change consequences, at least in the place where we live. (Lithuanian Teacher A, Interview)*

   > *It was based on the major concerns of the climate changes, the global warming, the lack of water and the drought, especially the drought that affected our lives today and our Altania region. (Romanian Teacher B, Interview*)

   > *Because we changed computers and tablets and everything quite often and it's a big problem with e-waste. This is kind of scientific view, what to do with it, how it influences the natural environment and so on. So we went that way. (Slovenian Teacher A, Interview)*

   > *They are about why invasive species affect our river and how they affect our environment. (Spanish Teacher A, Interview)*

Furthermore, deploying climate change missions using OSS methodology made it possible for the students to implement their solutions and to witness its real climate change impact. We notice this particularly in the case of the Lithuanian Team, that managed to engage community members in planting bee-friendly seeds. Their biggest achievement, however, was the fact that the local farmers became more aware of the pollinators' situation and out of their concern they decided to leave pieces of their field uncultivated for the bees and butterflies to thrive there:

So, the biggest achievement of our first mission was that some of the farmers, very big farmers of our district agreed to leave very big pieces of land untouched by chemicals or pesticides or insecticides, and that saved a lot of natural habitats for butterflies and bees. (Lithuanian Teacher A, Interview)

There are no words to explain how much was done in every class in every step in every activity. Students and parents, they started to pay attention to the things. Many people, we were indifferent before the mission started. Now, even though the mission is not so active anymore, we belong to the groups we visit, the workshops. But maybe, for example the seed planting, we don't distribute the seeds anymore, but I know for sure that many people still continue to attract butterflies by planting their butterfly and bee friendly plants, because through us, through our missions, they learned that it is very important. And farmers will continue to leave the edges of the fields untouched to attract the communities of pollinators. And also, at home we still do our best to save water. At home we still do our best to explain the smaller kids or our siblings what is good and what is wrong with dropping the litter with water waste in the wild? (Lithuanian Teacher 1, Interview)

2. The data suggest that **the OSS combined with climate change supports student-centredness where students' and teachers' roles are often reversed.**

This is apparent in the following quotes from the teachers' interviews:

the girls identified the problem in our area due to the lack of water. (Romanian Teacher A, Interview)

… And the girl just came to school and said "teacher, maybe we should take into this topic deeper" [not enough honey, something happening to the bees], and we found this topic very interesting and that's why we started the topic——the butterfly. (Lithuanian Teacher A, Interview)

They decided that they would focus on the food wastage and how that impacts climate change and so that is what they've been doing now in the second part of the mission. (Swedish teacher A, Interview)

they wanted to see if we had an app to choose their school lunch, and if they had an option of choice, whether that would reduce the waste. That was their idea. (Swedish Teacher B, Interview)

But in the normal lessons, it's the teachers that decide on this day you will do a test, this day you will answer these questions and so on. But now we are the teachers. We get to decide when we're going to finish our goals and so on. (Swedish Student A, Interview)

Furthermore, we find evidence that the **OSS student-centredness promotes development of the students' agency in learning** because it encourages their proactive attitudes and behaviours in the context of learning:

We feel less interesting to be in normal lessons and we felt more and engaging, and we felt more motivating, and more demanding because we can plan how we wanted. But in the normal lessons, it's the teachers that decide on this day you will do a test, *this day you will answer these questions and so on. But now we are the teachers. We get to decide when we're going to finish our goals and so on. (Swedish Student A, Interview)*

Consequently, the students become more responsible for the learning – thus, we conclude they claim **ownership of their learning process**. Additionally, we find that this promotes unity and solidarity among the students too:

Since there is quite a lot of responsibility to put on the students. They need to come up with ideas and take a big part of their learning. (Swedish Teacher A, Interview)

I think they have become more responsible. I think students have become more united. (Lithuanian Teacher A, Interview)

With this paradigm shift the teacher role is redefined as indicated by teachers in the following quotes:

So, we [teachers]*, our roles are about being organizers and the supervisors, motivators, tutors, guardians, and it was a challenge for us as teachers, as mentors, as a project partners. It was different from just go to the class and open the book (Slovenian Teacher A, Interview)*

In every mission, me as a teacher, I'm an advisor, sometimes supervisor, but not the initiative taker. (Lithuanian Teacher 1, Interview)

As a teacher, we orientate the students, to distribute them in groups, to help them when they don't know anything, to give instruments because they are not used to work in projects. (Spanish Teacher A, Interview)

On this project, it is the role of guiding, organizing, coordinating the whole the group and activities joined by the two teams in the project. (...) (Romanian Teacher A, Interview)

3. Pronounced **role of the community collaboration** in the OSS focused on climate change missions.

Collaborating with local community members and creating ecosystems of OSS by schools is a generic trait of the Open Science Schooling method. We found that the **community collaboration is particularly important when the mission focus is climate change**.

- Going outside of school's OSS feature deeper dimension when the focus is climate change. A feature of community collaboration is the fact that students leave the school's premises to learn and explore the topic they work on. Due to their 'open air' nature, climate change related issues cannot be studied and understood from the perspective of schoolbooks and position of school benches. Climate change issues are the phenomena which studying requires going out,

As I said, we went to public house and institutions like hospitals, museums and so on. (...) Because I find working in the field of work like outside with butterflies and in the forms and in the museums, I like that and I find it interesting. (Lithuanian Student, Interview)

- Learning-oriented community collaboration. The OSS community collaboration means involving various members of the local community. In the case of climate change focus, we find that collaboration with experts has been particularly significant. Climate change related topics are still relatively new, they did not find their way into the school curricula. As one student point out, their curriculum is outdated in this regard (Lithuanian Student), other student points out the climate change is addressed in the curriculum but not in the science subjects (Swedish Student A). For these reasons the best way of learning about and understanding climate chance is to turn to the experts in the field:

  > *we established a written partnership and signed partnership with the Regional Water Institute (Romanian Teacher A, Interview)*

  > *We were interviewing different companies and the things they were working on, like food and clothes, and getting facts about them and how they work. (Swedish Student A, Interview)*

  > *It was one local community company at the beginning. They prepared for us a lecture about environmental problems, about the garbage collecting, and maybe recycling, but only collecting and recycles, so that's what our first mission was. (Slovenian Teacher A, Interview)*

  > *And then we made different interviews with different meteorologists about how change climate affects it. (Spanish Teacher A, Interview)*

  > *And we've been in contact with IT company called Amentum, which created the school platform that we used here at our school, been in contact with them too, because they've themselves have created an app. So, we wanted to get interview. We got in contact with the owner of that company and the girls asked questions about where do you start with? When you wanna do an app, where do you begin? Like, how do you do it? (Swedish Teacher A, Interview)*

  > *He [ICT company CEO] talked about how there were missing girls working in the computer science areas and as program developers and staff, and they(students) asked him about how to start making a computer program or an app at this school platform. (...) And he told them about how you could actually work with just pencil and paper, sketching out the different parts and the next step that will happens when you get to this part. (Swedish Teacher B, Interview)*

- Reaching out to the experts in various fields in which climate change issues manifest is important for one more reason. Due to relative novelty of the climate change topics and a challenge of attributing them to the school's subject, the teachers often do not have the knowledge to explain the intricacies of the climate change mechanisms and processes. Of course, the OSS community collaboration feature has been designed having in mind that teachers cannot know it all. But in case of the climate change topic – new, complex, intertwining and overlapping nature it is especially important that the teachers can draw from the community experts' knowledge and know-how:

  > *We involve the Community partners from which we also learned. And sometimes the teacher in class cannot explain everything in the same very up-to-date and maybe a very easy way as the professionals understand this and do because for the professionals, it's very easy. For example, for the farmers they would answer our*

question why the pollinators disappear, and farmers also are to blame for that, and they understand it. (Lithuanian Teacher A, Interview)

I think this will be our Mission 3 because for the beginning we found we were collaborating with the second local partner. It is a company, and they are strictly working on recycle more on repair and reuse. Because the students found out that all the parts can be reused, or the appliances can be repaired. And this is a company which has a workshop with the big van, they came to our school, they prepared workshops for students. They only involved the students from this project, but also other students, so this was extracurricular. (Slovenian Teacher A, Interview)

4. Immersion in the studied topic through **inquiry and research – data collection – experiments – solution identification.**

The inquiry-based characteristic of Open Science Schooling gave students the opportunity to fully immerse intellectually in the process of exploring the climate change issue at hand. All of the project teams reported being actively involved in conducting extensive research on the topic of their mission:

Are vaccines effective? How effective are they? Should vaccine passports be implemented? Should little children be vaccinated, all those stuff and other things and we tried to research as much as we could Our research focused mainly on biology. But also included behavioural science and psychology because a lot of people were kind of new to the idea of vaccination. (Lithuanian Student, Interview)

The research part was followed up by excursions and on-site visits to collect evidence and material for further analyses:

We did it mostly at school but, we went to an excursion, we searched online, and we did some practices, experiments and more. (Spanish Student, Interview)

We weighed food at our school, at the 9th graders food. (Swedish Student A, Interview)

We took samples of soil, which we then studied in the lab. (Romanian Student, Interview)

Collected data was then analysed in by the students their school laboratories:

The girls, together with the science teachers, put it into practice in our laboratory. So, they tested the quality of water in the biology class, the pH and how water reacts two different factors impacts. (Romanian Teacher A, Interview)

And then we made different activities in our laboratory like how affected the CO2 in the water, of the rivers, riverside and river plants. And then we made an aquarium, and we investigate different features. We increased the temperature, we made tables and graphs about how this affected the features. And then we made the practice of crystals about the source of the river. (Spanish Teacher A, Interview)

The whole above-described process was bound by lot of organization (Lithuanian Student, Interview) and met the requirement of, resembled the true scientific inquiry process (Swedish Teacher A, interview). However, the last element of this comprehensive and fully-fledged scientific inquiry was identification of solution to the researched problem – not that obvious outcome of a typical scientific inquiry. Depending on the climate change issue, the teams were able to point out the possible solution to address is. Here are some examples:

> *We found out another interesting thing that the Research Center was also trying to grow certain species of plants and small trees just to make the soil stay together because of the lack of water. (Romanian Teacher A, Interview)*

> *Because the students found out that all the parts can be reused, or the appliances can be repaired (...) we are starting to have e-waste containers in school. (Slovenian Teacher A, Interview)*

> *And also students wanted to make XXX (the game name) do an investigation here at school to investigate if the students got to choose their food, would they throw less food? So that's what we've been doing lately. (Swedish Teacher A, Interview)*

IN terms of the limitations or challenges of implementing climate change through OSS to promote students' reengagement with science, the teachers report that giving more freedom and autonomy for the students poses challenge and initial uneasiness, as some of them admit.

Redefined teacher's comfort zone.

> *We have to admit that they (the teachers) were not just as comfortable because we had to overstep the comfort zone, go out from the classic way of teaching. (Romanian Teacher A, Interview)*

> *Perhaps it is more difficult for the teacher because we have to create more autonomy to the students, we have to guide the students. (Spanish Teacher A, Interview)*

As we see in/ through the accounts of the project teachers, many teachers who find their new role difficult and display self-doubt they also see the positive effects it produces:

> *Well, at the beginning, the teacher was very worried when I proposed her to start teaching this way. It was like, wow, are you sure I can do it? Yes you can. Because the teachers are afraid that they don't have something, like a guide for them to start teaching this way. But well, she's very happy now. (…)*

> *So yes, because if I see the students are implicated and they are willing to participate, this is very comfortable for the teachers, but sometimes difficult. (Spanish Teacher A, Interview)*

A way to bridge the gap between challenges and benefits is, as some educators observe is to find the right balance between stepping back and intervening then needed:

> *But then it was also a challenge to keep them on the right track without telling them what to do or saying, no, you're thinking wrong here. I find that sometimes they wanted that from me, but other times I had to take a step back and hope they would get on to the right path. I'm guessing the challenge there is to know how big of a role*

do you play in this and how much freedom do you give them? (Swedish Teacher A, Interview)

School realities versus resource requirements of the OSS.

For many Science4Girls teachers, the methodology of Open Science Schooling was challenging to implement due to additional resources the method requires. The type of resource that was mentioned most frequently was time. The OSS was found time-consuming to implement, especially in the context of the fulfilment of the curriculum requirements.

> *it involves a lot of material resources and of course a more time is needed here. (…) and it works with a small number of students compared to teaching in the class with the whole 30 students (…) I love open science schooling. (Romanian Teacher B, Interview)*

> *It's a very positive experience because this is the type of methodology that you want to use, but it's quite time consuming. If you want to cover a lot in the curriculum, it's hard to do this. (Swedish Teacher A, Interview)*

Also, in the context of resources, one teacher pointed out that while the method works very well in the smaller groups (project), back in the school's reality, the teachers have 30-student group to work with. These work conditions – group sizes constitute another resource-type limitation to the OSS implementation.

Furthermore, being **constrained by the national curriculum requirements** was mentioned as another challenge for the OSS implementation. Some teachers found the OSS and their national curriculum particularly incompatible with each other, and they did not mean the extra time that would be needed to deliver the curriculum through the OSS tools. The problem they pointed out was the strict curricular obligation to follow the textbooks and its content which does not allow neither student-centred not project based learning:

> *But we cannot implement this way into our curriculum. That's the problem. We would like to, as much as we tried to even before. But it's very difficult because of the curriculum. We are aware of this student-centred teaching/learning, even a project-based learning, but it never came out any good results. It cannot be done because we are obliged to do that and that, and a lot of things, a lot of contents. We cannot combine them because you have a book, and you have to stick to the book if we decided that way. (Slovenian Teacher A, Interview)*

♦ The findings presented here suggest that climate change, as an interdisciplinary issue, provides further advantage to the deployment of the OSS methodology for implementation at school. Climate change related topics support the implementation of learning activities that are suitable to be developed through hands-on, practical missions in the community.

♦ The findings point towards the need for teachers' revised attitude and perception of their role in the classroom as a facilitator and orchestrator of the learning experience when implementing this kind of innovative pedagogies.

♦ The findings also highlight issues related to the need to rethink the curriculum currently in place in order to facilitate 21st century education.

RQ2. HOW THE OPEN SCIENCE SCHOOLING LINKED TO CLIMATE CHANGE FACILITATES FEMALE STUDENTS' RE-ENGAGEMENT AND INTEREST IN SCIENCE?

IN terms of how girls engage in learning science during climate change missions, here we explore how the 4 characteristics of the Open Science Schooling combined with the climate chance described earlier mediate the female students' interest, engagement, and motivation in learning science.

1. *Focus on climate change means learning about important, pertinent locally- and globally relevant issues.* The key feature of the OSS method is the focus on real-life and real time issues in learning and teaching in the case of the Science4Girls project, these issues were predetermined, pre-identified as pertaining to climate change. **Concentration of climate change issues in learning proved to significantly influence the students' engagement in learning science for reasons related to perceived significance of the climate change issues as well as teaching on demand** - that is naturally induced by the focus on real-world issues.

Climate change's 'realness' and significance a key motivating factor.

Learning and studying issues that are 'real' – pertain to the students' everyday reality and thus have special significance for their lives and their communities' wellbeing has been identified as a key factor driving students' motivation in learning as indicated in the following quotes:

> *Focusing on real life problem, I think it is really positive, which makes them more interested and more motivated and more engaged because of the reason that they actually get to take part in choosing and they got to choose in a topic that they feel more interested in. (Swedish Teacher A, Interview)*

This is compounded by the agency that is given to the students regarding the choice of what they are learning – something the traditional pedagogy does not allow. Additionally, focusing on climate change entailed looking for solution to the problem, this further enhanced the students' motivation and engagement in the topic.

Students identify values and purpose in their learning.

The data shows that students are motivated to study a topic that is personally important, significant to them particularly when they can identify in it their own values like caring and empathy as well as altruism. Based on our evidence we may say that what drawn students to study climate change was the fact that doing so they were convinced they are doing something towards a great cause like helping community, changing climate or saving millions of lives as indicated in the following quotes:

> *I would really like to put my knowledge to the task and save millions of lives along the way. (Lithuanian student, Interview)*

> *We are setting a goal and we are more motivated because we want to change the climate, we are girls, girl power. (Swedish Student A, Interview)*

> *I would like see myself as a scientist because I am a fighter and I like to help the community. (Romanian Student, Interview)*

Climate change focus does not only help students see real purpose of their learning but also strengthens their perception of the effectiveness of their actions and endeavours as they begin to see themselves in position and power to important things (agency and self-efficacy development).

Climate chance is engaging because it entails learning on demand.

Focus on climate change in learning science – a complex, interdisciplinary issue that is often not included in the schoolbooks ("outdated curriculum", according to one of the Lithuanian students) naturally requires the teachers to adopt a different teaching strategy. If the climate change issues are to be identified by the students', their interests and concerns it means that the learning and teaching becomes 'on demand'. Students raising, bringing, introducing topics of their interest are more motivated to engage in studying it:

> *As to working through mission and learning on demand, this was also quite important because e-waste was definitely what they were interested in, even among the community partner, the local partners etc. They showed interest especially with this advanced presenting, circular economy, e-waste. (Slovenian Teacher A, Interview)*
>
> *I also teach English and a challenge there is to get especially boys to read books, read texts and they often say that if I find something that is interesting, I'm more likely to read it. And I think that's the same in everything. If you work with something that you are interested in, you are far more motivated to go deeper into that area and learn better. So, it's a great way to learn.*
>
> *(...) obviously it's your job as a teacher to make it interesting and fun and make those real-life connections. And it's a challenge itself. (Swedish Teacher A, Interview)*

2. *Student-centredness where teachers' and students' roles are often reversed.* The OSS puts the students in the centre of the learning process, both its design and implementation. But student-centeredness hinges on teachers relinquishing their traditional authoritative position and redefinition of their roles first. Here, we describe our findings regarding the motivating effects on students' learning of the teachers' taking a step back as well as challenges implied in the teachers' role transformation. As we found, the way to become a student-centred teacher is to find a balance between intervention and stepping back. Being able to achieve it, creates space and conditions for the student's agency to be nurtured and developed.

More effective learning – doing less while achieving more.

As we find, teachers' reduced role does not mean losing control over the learning process, on the contrary, by doing less teacher do (achieve) more. The achievement entails more effective learning outcomes and more rewarding teaching experiences which, as we conclude mediate satisfaction and motivation of the teachers and students alike.

> *But I think they learn a lot with this form of working and I think they will remember much more what you are doing now in class in this Erasmus project than in the normal class. (Spanish Teacher A, Interview)*

But I think they learn a lot with this form of working and I think they will remember much more what you are doing now in class in this Erasmus project than in the normal class. (Spanish Teacher A, Interview)

Students' agency development.

The space and freedom for initiative created by the teachers' stepping back serves as a platform for students' **proactivity** and enables them to claim ownership of the learning process, as we observed in the previous chapter. We find that the students' taking initiative and being accountable for their learning activities contributes to development of their agency in learning. We identified three dimensions in which the agency emergence manifests: courage, confidence and critical thinking.

I can see that I can give more freedom to my students to do the mission in the way they see it. "They see it" will be more effective. (...) So I like that project-based learning gives me the possibility to become a student-centred teacher. Because first I asked for the students' opinion, for the students' points of view, for the students' methods, how they would like it to be. And then, I try to accept, try to act in the way they would like me to be with them, for example, if they don't want me to interfere, I would just be an observer. They would take all the initiatives. (Lithuanian Teacher A, Interview)

Furthermore, **courage and confidence** that can be derived from the OSS process are important empowering factors particularly for the female students that often lack it. The empowerment that comes from being more confident leads to personal transformation, as one of the teachers described:

... because when children get this opportunity to study using open science schooling, they are becoming more open minded. They are not reserved. They're not like, for example, very vivid example. I have a girl who used to be very silent and shy during the lessons. But I started asking her to do a lot of things, to speak up during our presentations during our meetings. And one day, we also travelled to Greece, and they were to do the presentation in front of the public and so on. And the girl, just last week, she said to me, "Oh, teacher, now, I am a different person. I am not so shy anymore. And I'm not afraid to speak and to explain my ideas to the others and even to the foreign fellows and friends in the same project". (Lithuanian Teacher A, Interview)

The teachers report the impact on students' 21st century skills, particularly critical thinking as they develop their own agency through self-regulation of their learning experience. Students do not only become open-minded but driven by concern and curiosity evoked in the process start to critically question the reality around:

They also have become the critical thinkers. Because, if they put up a question to themselves, what can we do? They will definitely find the answer because when they see how situation is and they start to feel concerned about it. They will want to find the way out of this, they will want to improve the situation. (Lithuanian Teacher A, Interview)

Additionally, girl students reported in the interviews to feel more comfortable and thus more engaged in learning setting without boys (as was the case in the project missions). We observed the same sentiment of more work **comfort** and stronger motivation in boys- free teams across all the interviewed girls' national teams (except for Lithuania from where the interviewed student was male):

> *It was more comfortable for me. I felt like I wanted to do more for the project. I felt more comfortable. I felt more confident. I felt more ability to focus on different issues and topics in the girls only team. I have a better collaboration and teamwork (Slovenian Student B, Interview)*

> *We would have more confidence with only girls. (...) I think more collaboration with only girls team. (Spanish student, Interview)*

In the light of these student statements, we can invoke the teacher's observation that boys take a lot of space in the classroom, disproportionally as compared to girls who tend to be quiet and shy (*Swedish Teacher A, Interview).* We can conclude that the boys' domination is overwhelming for the girls and negatively impacts their courage to participate and engage.

The students were aware of the limitations related to working without boys, such as narrowed perspectives and limited discussions due to too the homogeneity of the girls' opinions. We can assume that they understood that separating girls and boys would be a good alternative. Yet, their accounts were eye-opening for us as researchers. Regarding our exploration on how to facilitate the girls' engagement in science, we take this finding as a valuable insight requiring further research. As it is unconceivable to begin implementing sex-segregated science education for the girls to be more motivated; it is important to create and nurture the class atmosphere in which girls feel comfortable because it drives their motivation and engagement in science. More research is needed regarding how teachers can navigate classroom dynamics and shape interactions to provide girls the space and comfort they need to engage and participate.

3. *Pronounced role of the community collaboration as learning motivating and career in science inspiring.* Community collaboration gives the students opportunity to leave the classroom setting and meet the world outside, learn from and work with experts. Our research finds this as a very strong motivating factor for the students that mediated their interest and curiosity in learning. We also were able to find evidence that meeting with experts and professional can influence students' decisions about their future career.

Community collaboration is "just so good" for students' motivation and engagement.

Going outside, visiting places, meeting community actors and learning from experts is in itself a strong motivator for the students, something that draws them to the process of learning. According to one teacher's account it is very well appreciated and rewarding for the students:

> *Then if I heard already the opinions, for example children say to me teacher, it is so good when we have these practical activities, when we go to the partners, to community partners, to their factories, to the museum or to the library to do research together with some, for example, like librarian or specialists or children. It's so good when we have lectures of this professionals, for example, we had a lecture of a professional photographer, wildlife photographer. (Lithuanian Teacher A, Interview)*

Learning from experts, as we find based on the experiences of the Sweden's Team, enables students to see science in a different way – applied in practice in a simple way. Maybe communicating that idea of science could not be possible or convincing if it was done by a teacher in a classroom. But, as we suggest the change of setting and communicator may change the way students, especially girls perceive science:

It gets them to realize that even if it's science, it could be as easy as sketching up your ideas and thinking things through, or you don't have to start with the programming or different languages. (Swedish Teacher B, Interview)

Furthermore, **meeting experts at work in their professional environment** may inspire young people to a career in the field. This career inspiring effect of encountering science experts was reflected in one of the students' accounts:

Of course, because when I got to see professionals at work and that is what inspired me more than the things I learned in class... And the fact that I got to implement that knowledge and got to experience what professionals work made me even more motivated to pursue a career in science. (Lithuanian student, Interview)

4. *Immersion in the studied topic through inquiry and research.* Being fully engaged in the research process in the OSS climate chance missions proved to increase students' interest in science, their motivation to pursue it and even made them simply enjoy it. The inquiry and research part brought them joy of 'finding out' information they were genuinely interested in finding:

You need to know why it's happening if you want to try it out, you can't do the fun part without information on why you're doing it. Where does it go? what's happening and so on. So I think that's what's really good. (Swedish Student A, Interview) And we think that it made us more interested in science. (Swedish Student B, Interview)

Practical knowledge acquisition and application.

Being able to put the acquired information into use – something that is lacking in the traditional pedagogy combined with conducting experiment further amplified their interest in learning science:

Obviously, it was different because in class you only learn raw data you don't really to put it to use. Whereas in the case of the missions, you already have the data, you have an organized and you have to work with what you have. (...) And go out there and experiment. Find out what works, what doesn't. And just do the good old try and error. And I think that in comparison to usual classes, it was more interesting both for me and my colleagues. (Lithuanian student, Interview)

Particularly the opportunity to work in a laboratory, contributed to one of the student's 'change of heart' regarding science:

Because I did three laboratory practices and my opinion of science change because now I like science. (Spanish Student, Interview)

Students also admitted that the practice emphasis of the OSS learning mediated their interest and motivation to learn science because it made science easier to understand:

I certainly prefer the proactive way of learning science because we can more easily understand what is being explained to us. (...)

I like to learn science through practical missions because it is much easier and more interesting. It is even more motivating because you are in a constant contest. (Romanian Student, Interview)

Another important motivator to pursue science was the opportunity to see the transformational (positive) effects of one's work:

Yes, I did want to put more effort into science because I saw the impact that it could make at the end of my efforts, so that is also a point of inspiration. (Lithuanian student, Interview)

That was more motivating to study science since you are more stuck about it and what the impact it has and made us want to put more effort into science and working with it. (Swedish Student B, Interview)

From the teachers' perspective, being able to engage with science practically breaks away with the traditional classroom routine that students are bored with and tired off. Doing inquiry and conducting hands on activities like experiments in which students have autonomy is key to their engagement in science:

They are tired of being in class with a teacher, telling them what to do. When you give them the responsibility to think, what would you like to do, we could do this, we could do that, that would be an experiment in the lab if they engage. And they like to research the information. Sometimes on the Internet there are a lot of information and sometimes they have problems to select the information and graphs because there are a lot on the Internet. (Spanish Teacher A, Interview)

IN terms of how the Open Science Schooling focused on climate change is different and/or similar as compared to other innovative learning strategies, teachers in Science4Girls project found the OSS methodology both effective and challenging. As it was mentioned earlier, the teachers observed that the OSS increased the students' engagement and motivation in learning that further enhanced the effectiveness of their studying. Some of the teachers drew parallels between the OSS and some other pedagogical approaches familiar to them to make the implementation of the OSS easier. They view the Open Science Schooling as similar to inquiry-based learning, entrepreneurial education, and the learning approach applied in handicrafts (see Figure 2).

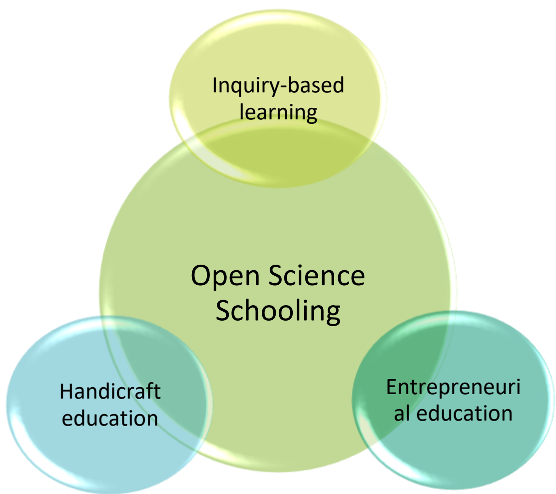

Figure 2. Teachers' views of Open Science Schooling and other similar teaching approaches.

OSS and inquiry-based learning.

Some of the teachers found elements of the inquiry-based learning approach in the OSS, specifically interdisciplinarity and a holistic perspective of the topics:

> *OSS is like inquiry-based learning, which I think is the best way to learn because you get a bigger picture of all the topics, and you get to be part of many parts of your learning. So, it's fun to do this because you don't get to do it very often. (...) Once I made a connection to inquiry-based learning was that I used to teach in Australia and it was quite common to use inquiry-based learning there and so once I read it, it's like what we used to do in Australia. Then there was more exciting. (Swedish Teacher A, Interview)*

OSS like entrepreneurial education.

For some, the OSS seemed like entrepreneurial education they had been introduced in the past. What linked the OSS and the entrepreneurial approach the teacher mentioned was the fact that students were the leaders in learning process, while the learning took a form of a mission during which they collected information.

> *But I would say about 10 years ago we had a methodology that was similar to the OSS methodology, and we call it entrepreneurial studies or learning like this. It was also part of, like the students leading their way and going into different missions and trying to find facts and shaping and learning on a mission base. (Swedish Teacher B, Interview)*

OSS like filling the frame in handicrafts.

Another interesting parallel connected the OSS with the way handicraft subject is taught. As the teacher (who made that analogy) explains, the OSS method like handicraft instruction provided the students with frame (structure) to work and a technique of working but it is up to the students to decide how they are going to use the technique to fill in the frame. The OSS, like handicraft encourage students' creativity, while teacher guides them through the process:

> *I teach handicraft and as a handicraft teacher, I encouraged students, I gave them like a frame. You're going to work with this technique, but you going to come up with your own idea. And I work this way, guiding them through their project because it's their creation, it's their project. But I'm helping them along finding the right and quickest, easiest ways. (Swedish Teacher B, Interview)*

Furthermore, teachers' views also indicate the effectiveness of OSS in addressing gender stereotypes in the classroom as well as managing differences between boys' and girls' participation in science (Figure 3).

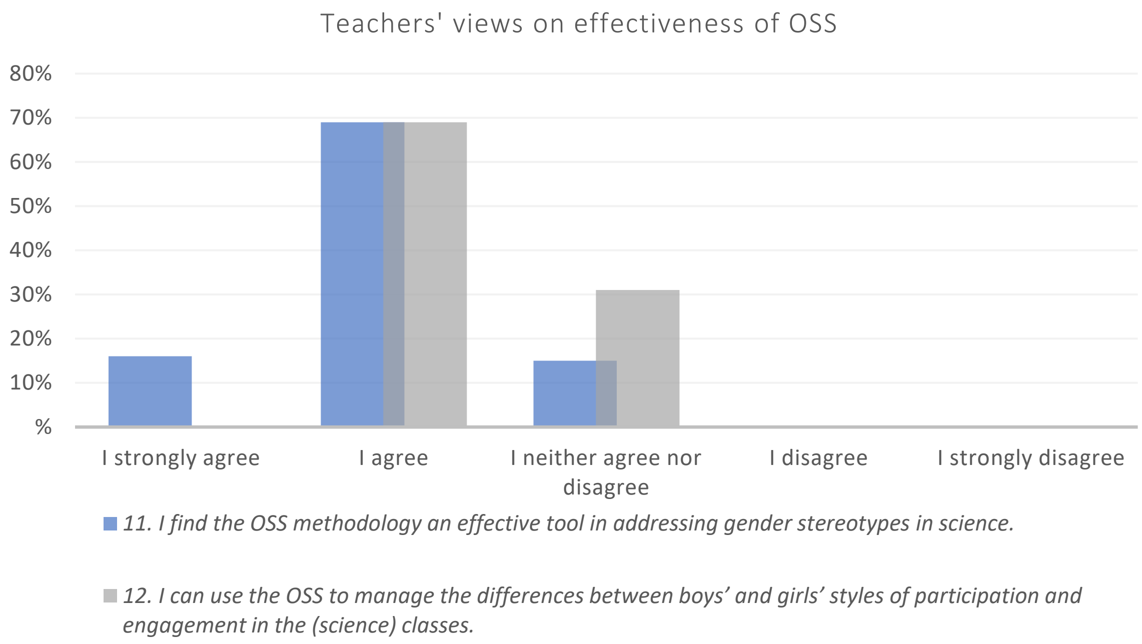

Figure 3. Teachers' views on the effectiveness of OSS in dealing with gender bias (source: Teachers' survey)

♦ Based on the findings presented here, we suggest that the effect of the OSS' student-centred approach on students' engagement in learning is amplified by the focus on climate change.

♦ We argue that the proactive behaviours and accountability for one's learning are enhanced when the topic at hand is of particular importance and significance for the students, as climate change is. The engagement derived from autonomy in leaning translates into development of the student's agency in science learning – which is particularly crucial for the girl students. Therefore, we may conclude that student-focus of the OSS that is concerned with climate change promotes female students' agency in science learning.

♦ From this research we are unable to establish if the immersive research inquiry feature of OSS has special effect on girls' engagement in science. All the evidence we collected links features of research, experimentation and solution identification to the self-reported increase in motivation towards learning science both in case of male and female students. We are unable to determine, however, if this was stronger or weaker depending on the students' gender.

♦ Nonetheless, based on our findings we can claim that practice-orientation of the OSS focused on climate change may be regarded as a factor modulating female students' motivation and interest in learning science.

RQ3. HOW THE OSS LINKED TO CLIMATE CHANGE TRANSFORMS FEMALE STUDENTS' IMAGE/IDEA OF SCIENCE AND THEIR ACADEMIC IDENTITY?

To answer this research question, we dive into exploring *how the perception of science (image of science) and the interest in science change along the project implementation for the participating students*, *how the female students' academic identity changes when they encounter science through OSS focused on climate change*, and *what factors mediate this change.*

In terms of how the image of science and interest in science changed along the project we started by investigating what were the students' ideas about science at two points during the project development (at the end of the 1st round of missions and at the end of the second round of missions towards the end of the project). In the administered survey we asked ***what is science, in your opinion?*** Here we visualize the answers from the 23 students that voluntarily responded the pre and post survey (Figure 4).

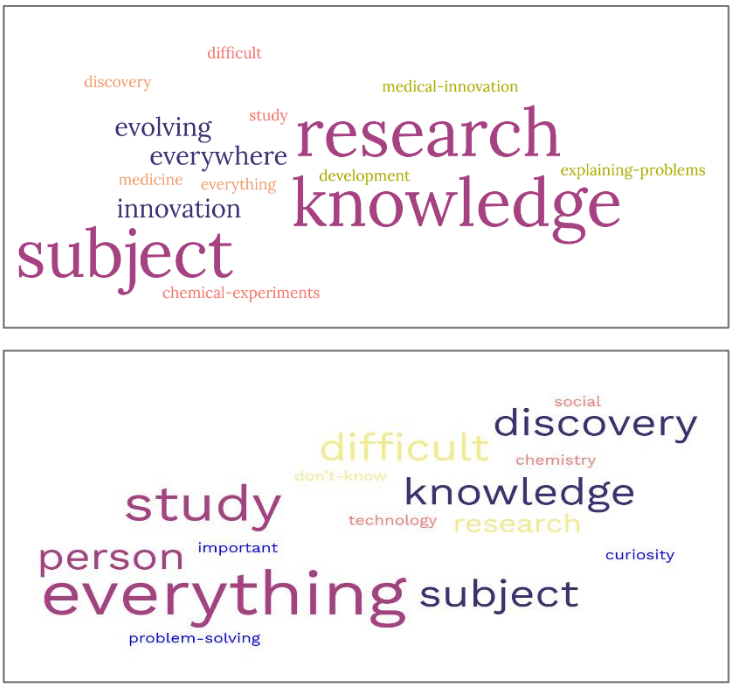

Figure 4. Pre (top) and post (bottom) surveys of students' views about what science is. In the word-clouds, the bigger the word the higher its frequency

From the start, students understood science alongside several lines. Theses understandings of science are diverse yet overlapping. After the 1st round of implementation, students saw science as a school's subject as well as a way of acquiring new knowledge through research. We notice that after the 2nd round of missions, their view of science appears to broaden, as they prominently see science as 'everything'. They also point out the omnipresence of science that is embedded in our daily lives and realities and that science is difficult yet important to the future.

Further analysis of the students' interview accounts allows us to conclude that the OSS immersion into science influenced students' relations to, and perception of, science in different ways. We find that the key factor that influenced the extent and nature of students' science perception transformation was their initial attitude to – interest in science.

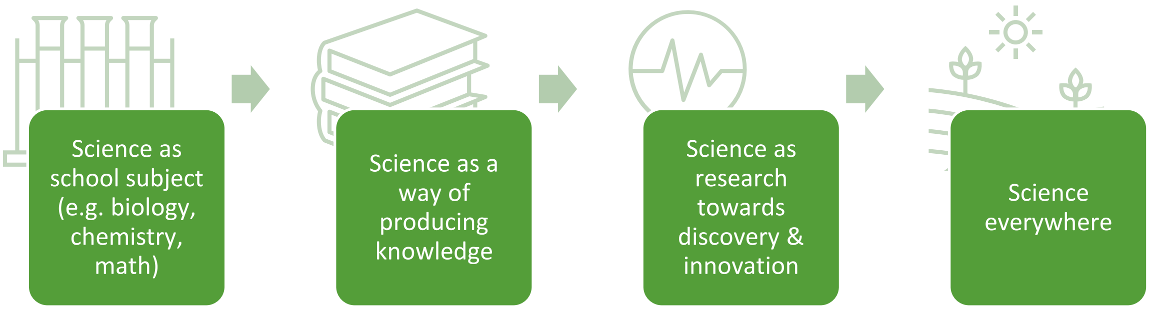

Figure 5. Students' Image of science in flux

Those students who joined the project *already being interested in science* did not report perception change – as they say they joined the project with interest in science and they leave it with the interest in science (Slovenian student A, Interview). However, for some of those interested in science in the beginning, the project participation contributed to development of their perception of science in a form of seeing how science can be harnessed to advance career and strengthening motivation to study science and become a scientist:

> *The only way that it might have changed is it evolved. It made me more motivated to do things concerning science and they made me more motivated to pursue my own career in science. because I found out that the ideas that I had about my future, they were facilitated through this mission because I got to see what work I was going to have to deal with in the future if I was to work in a biology-based field and Lab work and so on. (…) And not to leave the other students aside, I think a lot of them got motivated in the same way as well. (Lithuanian Student, Interview)*

> *Throughout the project, I became more motivated to become a scientist. (Romanian Student, Interview)*

Image of science evolved – “I like it more”.

To better understand students´ perception and their level of connection with their concept of what is a scientist, we asked students in the pre and post survey to identify how they saw themselves as a scientist. For this, we used a graphical representation of the Professional Identity Overlapping scale (McDonald, Zeigler-Hill, Vrabel & Escobar, 2019; Aron, Aron & Smollan, 1992), see Figure 6.

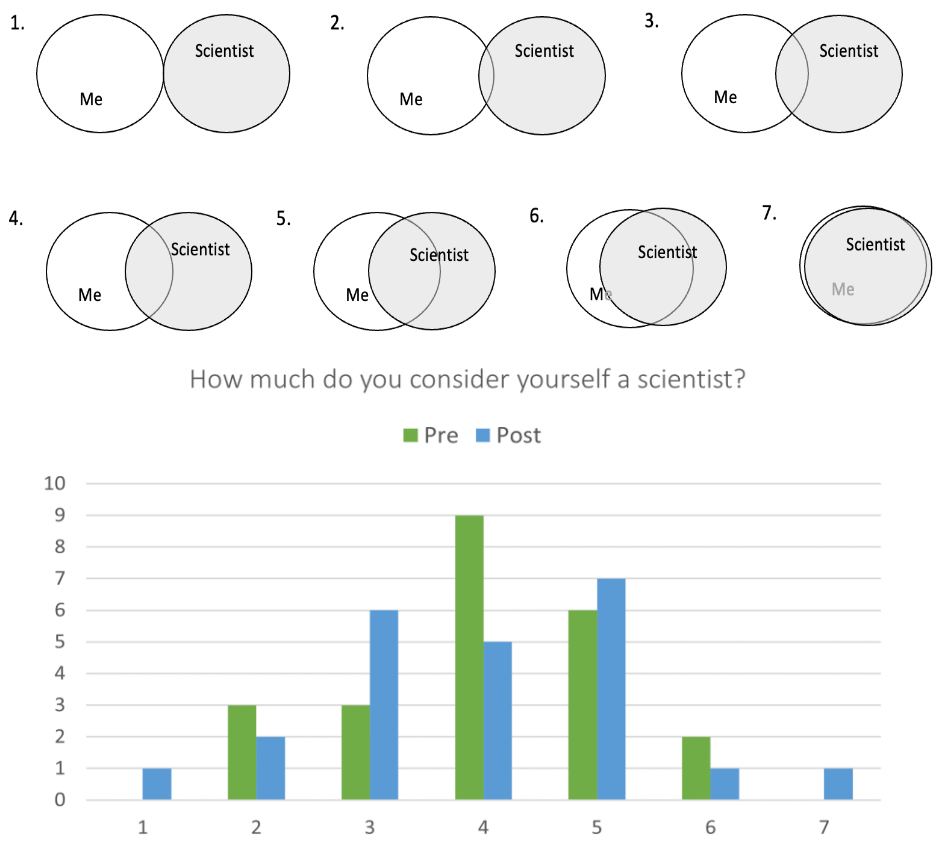

Figure 6. Students’ self-perception as a scientist reported in the pre- and post- surveys

The students reported different degrees of self-perception as a scientist as the project progressed, including for one student the realisation that they did not identify with being as scientist at all, while for another student they identified with being a scientist almost entirely in the post-survey. Furthermore, the qualitative interview data shows evidence that in some cases students who joined the project with an aversive attitude to science, complete transformation of their attitude could be observed, as one student reported:

> *When I start this project, I hate science and now I love science (Spanish Student, Interview)*

Mostly, however, the students reported moderate change of their attitude to science as a result of participation in the project:

> *I feel like it's changed it a little bit. (Swedish Student B, Interview) Because we haven't talked that much about the global warming, we were not talking that much about biology. But now, yes, our idea about science changed. (Swedish Student A, Interview)*

What is evident in the above students' quotes is that the attitude change towards science in their case was mediated by the emphasis of the climate change as a topic science can help to address.

Interestingly, it is significant that very few students interpreted the question about their attitude towards science during the interviews along the gender lines – for example, seeing science as more for girls or more for boys. Only some expressed it in their interview answers saying that that entered the project believing science is equality for boys and girls and they leave the project with the same notion *(Swedish Student A, Interview)*. We do not have more accounts on gendered perception of science and its project mediated transformations.

It is important to highlight that the methodology was reported to be beneficial for all participating students (girls and boys). The teachers reported the following

> *But I think we've opened their eyes a bit towards science, like focusing on the variety of science. I think they've got their straight idea of what science is, it's physics, chemistry, biology, but that it can be much more. And then this way of learning is a very good way for them. It's not like learn these facts and concepts and discuss and analyse and then a standardized test in the end. (Swedish Teacher A, Interview)*

> *Because I did three laboratory practices and my opinion of science change because now I like science. (Spanish Student, Interview)*

> *And also, the boys can see themselves somethings within professions that has science in them while girls don't. But that's changing and I think this project has really been eye-opening for some girls, to see how much science they actually is. (Swedish Teacher A, Interview)*

IN terms of how female students' academic identity changes when they encounter science through OSS focused on climate change and the factors that mediate this change, during the first empowerment mobility (online) in 2021 before the 1st round of missions' implementation, we carried out a workshop exploring the expectations and restrictions that the students perceived boys and girls have in society. We also asked them to what it meant for them to engage in science. The activity was implemented interactively using a Jamboard. Here we present the results.

Figure 7. Students' perception regarding socialised behaviours of girls and boys

Figure 7 shows the perceived behaviour that is acceptable for girls and boys as reported by the participating students. The students' inputs indicate very gendered views on the behaviour that girls and boys should have in society, including girls should 'be pretty' and shouldn't 'play with cars' whereas boys should 'do sports' and shouldn't 'wear makeup'.

Regarding students' societal perceptions about their views on what it meant to do something as a 'girl' (Figure 8). This relates to the academic identity that the female students may attach to the concept of 'doing science' or 'being scientist' under the societal assumptions that they recognise in their societal context.

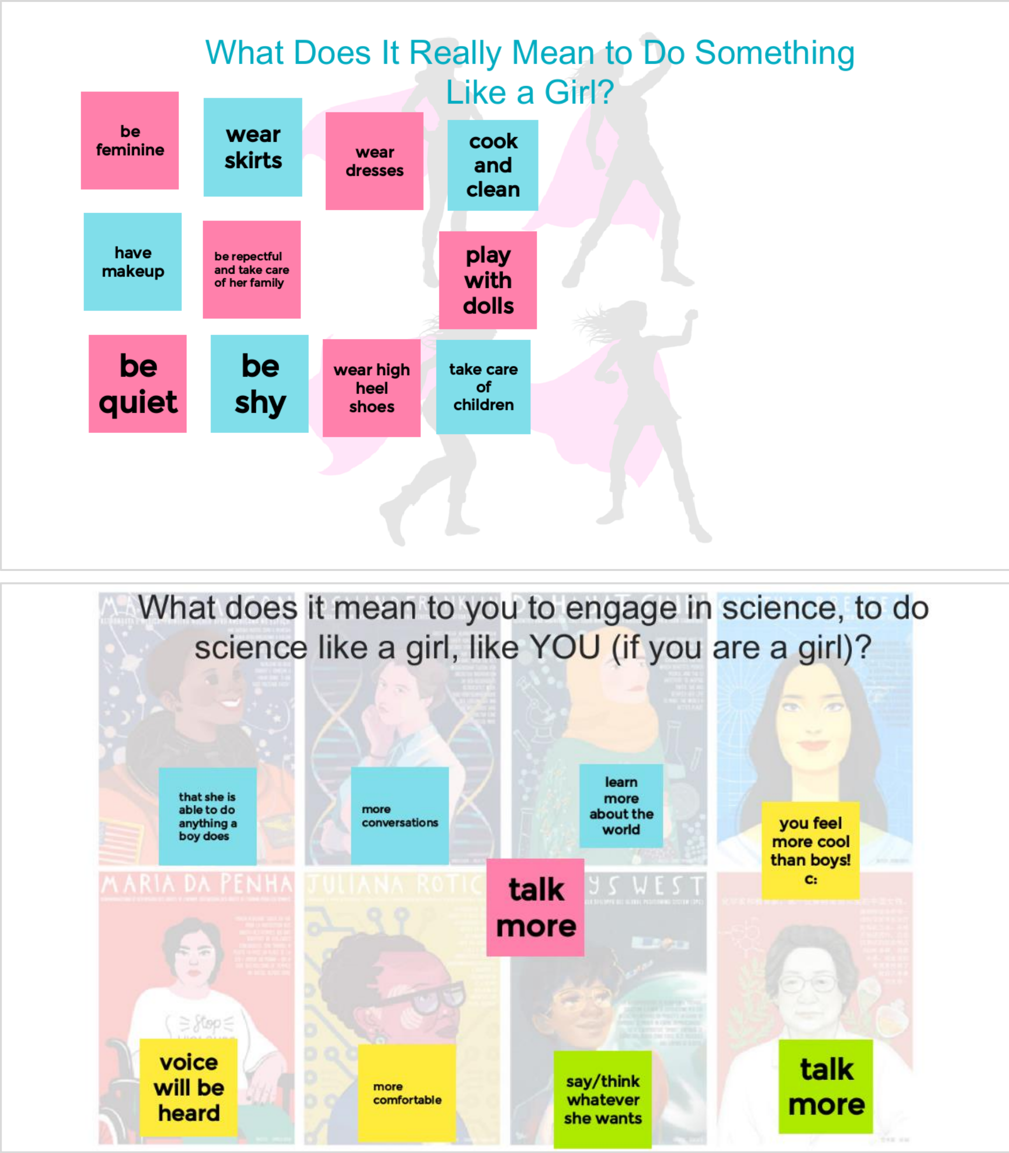

Figure 8. Students' perception regarding what it meant to engage with science as a 'girl'

As the project progressed, our data shows that all the national teams' teachers and students reported increased girls' mission engagement and motivation from mission 1 to mission 2. As our evidence suggests it was primarily linked to the progressive design of the project which itself promotes increased engagement due to better understanding of and immersion in the mission as it develops. On the other hand, we also found that in some partners' cases the second mission was compounded with lifting COVID-19 restrictions. This enabled full implementation of the OSS – learning outside of school and with the communities.

Immersive learning experience as mediating factor.

The surveys' data show that the self-perception of scientific knowledge changed as the students' involvement in the project activities progressed (see Figure 9). The interview data revealed that working in mission 2 was in general more attractive and interesting to girls because the idea of mission and their role in it became clearer for them.

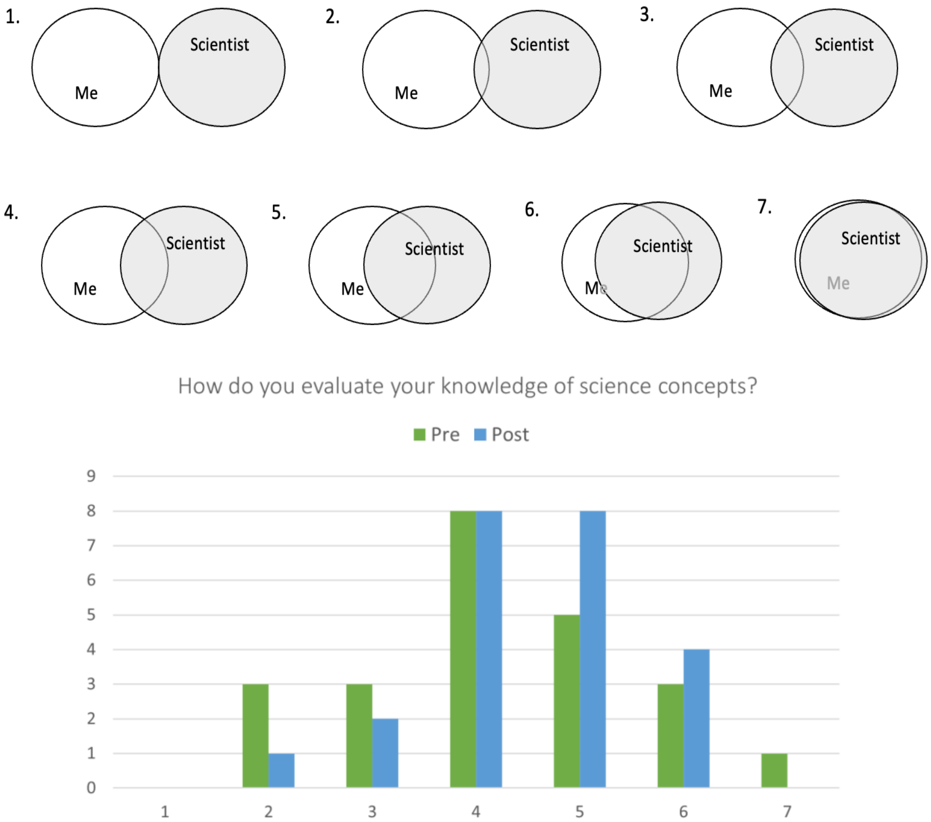

Figure 9. Students' self-perception of scientific knowledge reported in the pre- and post-surveys

Increased motivation and interest translated into bigger effort the students were willing to put in the mission activities:

> *(...) the motivation, the interest and the effort was increased significantly bigger and higher. (Romanian Teacher B, Interview)*

> *We have noticed a big difference. The students in Mission two are more motivated and they are understanding more, and they are doing more work, they had been like a bit hesitant in the beginning to do work and do extra time and do anything that took a bit of effort. They were really motivated, I think. What motivated them the most in this part now is both that they can see the end of the goal at the end of the project because for them this one and half two years' timeline, it's such a long time when you're 13 or 14, it's like forever. (Swedish Teacher B, Interview)*

External factors as mediators.

In some teams' cases, it was the external factors that played a role mediating students' mission engagement. Transition from mission 1 to mission 2 was coupled in some countries with lessening of the COVID-19 restrictions for the schools and communities. It meant returning to face-to-face teaching and being able to conduct activities outside of school – one of the key features of the OSS climate change missions that is a significant driver of students' engagement in science learning (as also presented previously):

> *The engagement started to grow. (...) We noticed a change in interest in every way actually because they were in reach of the hand, we could go to the classroom, talk*

to them and it was face to face, and definitely easier also to them. (Slovenian Teacher A, Interview)

Comparing the two missions, the second one was more attractive for girls because they get into the area, it wasn't online anymore. And the compared to the first one, their motivation, their efforts, their interests, all these were higher than being only online. (Romanian Teacher B, Interview)

From the students' pre- and post-surveys (n=24 respectively) as well as from the parents' survey (n=36) we also identify the students' perceptions related to the question *How do you think your parents/ care givers consider you a scientist?,* compared to the answers provided by the parents to the question *How much do you consider your child a scientist? "Me" indicates your child* (Figure 10). No correlation between the students' and parents' opinions was identified.

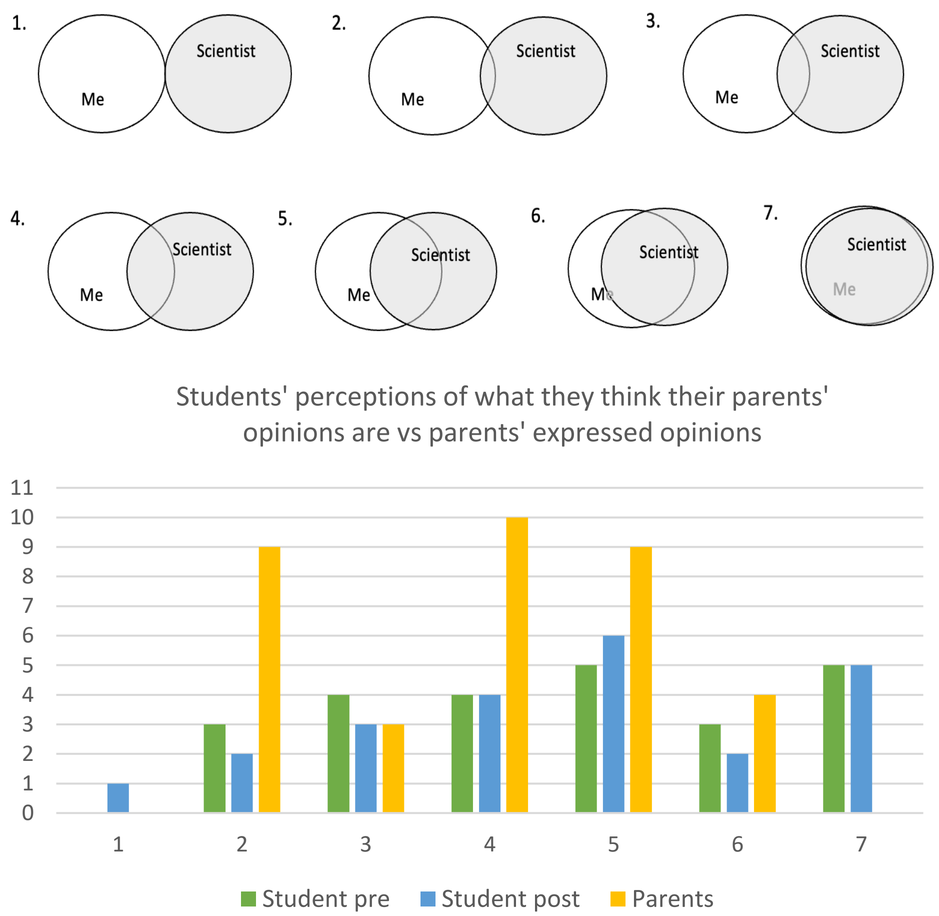

Figure 10. Students' perceived ideas about how they parents consider them as scientist

♦ The findings indicate that the students' perception and image of science evolved as the project progressed. The students became more self-aware of how they saw themselves as scientists and possessing scientists' knowledge. There was no correlation between how they perceived their parents thought of them as scientists and the actual parents' perception report.

♦ Several factors mediated the evolution of students' image of science including the immersiveness of the learning experience and external societal conditions that supported or hindered such immersivenness.

DISCUSSION

The collected data generally highlights the effectiveness of the open science schooling methodology combined with climate change related community missions towards supporting the engagement and motivation of female students in science learning.

In relation to the implementation of learning experiences using as a main topic climate change to develop missions under the open science schooling methodology that advantages in using a transdisciplinary topic to foster motivation. Seen from the **expectancy-value theory lens**, students find intrinsic value in tackling issues that are relevant for their local community as well as in a global scale. The effort that they 'invest' (learning new concepts, developing extracurricular activities, etc.) is well offset by the high benefits of the rewarding outcomes (solving a practical issue of major significance). The climate change topic also resonates with their own interests and values, which in turn enhances motivation, as it was noted that increased motivation and interest translated into bigger effort the students were willing to put into their mission activities.

Furthermore, teachers' survey indicated that they considered the OSS methodology suitable for tackling issues of gender stereotype and for engaging girls in science learning. Nevertheless, when asked about the boys' and girls' interests in science, the teachers seem to be in tacit agreement that is it boys who are more scientific (STEM) and technical, while girls more humanistic sciences (non-STEM) oriented and caring. The division of science interests, STEM and non-STEM, seems to overlap with the boys and girls gender divide lines as some quotes demonstrate:

The teaching experience shows that girls are more attractive to non-scientific fields while boys make connections easier technically, especially when talking about technique. Girls are more attractive to fields like languages. We called them a humanistic domain or humanistic fields. And boys always have been more technical and more inclined towards science. That's their way of being a man. Men are stronger and more technically involved than women in everything, including in a household and all sorts of painting a fence or repairing something in the house. (Romanian teacher B, Interview)

I generally find that boys have a stronger interest in science than girls, and I think that's also in boys and girls interests of things… Because I think boys are more exposed to science when they grow up. They play with more technical toys, they perhaps get a little science kit where they get to conduct investigations rather than girls. (Swedish Teacher A, Interview)

Boys' engagement, it depends on the upbringing, like for example, a lot of depends on the family. What I can make a conclusion. (Lithuanian Teacher A, Interview)

The teachers explain the boys' stronger (than girls') interest in science referring to the way boys' **socialisation and upbringing styles** that foster their early interactions with science. This socialisation was also observed in the data collected from students' perception of what girls and boys should and should not do as acceptable behaviour in society. Furthermore, according to a Slovenian teacher, it is not only the boys' and girls' gender stereotypical socialization styles that shape boys' and girls' interest in science in the future **but gendered science inclination it is also written in their genes**, sparkling the age-old debate of nature versus nurture:

We didn't find any specific values for the boys, their motivation in science. I believe it's in their DNA somehow. They(boys) are just interested more. (Slovenian Teacher A, Interview)

From our research we can not make any concrete conclusions about this particular matter. We can, nevertheless, present the teachers personal views on the gender divide when engaging boys and girls in science learning (Table 2), since the personal believes influence at subconscious level how people relate to one another. In this case unconscious bias in educational context (Dee & Gershenson, 2017).

Table 2. Teachers' perception regarding the inherent characteristics of boys and girls that may influence their interest in science learning

Girls' characteristics	Boys' characteristics	Source
Girls are more accurate. They need more time probably to think, to reflect too.	Boys are quicker in producing the ideas, the finding out the solutions	Lithuanian Teacher A, Interview
Girls are more responsible	Boys tend to forget and lose things	Lithuanian Teacher A, Interview
Girls thinking based on feelings on memories	Boys have more like critical way of thinking	Lithuanian Teacher A, Interview
Girls are more detailed and attentive	Boys are fast	Lithuanian Teacher B, Interview
Girls are more receptive and eager to get involved	x	Romanian Teacher B, Interview
Girls are reliable and take initiative	Boys give technical support	Slovenian Teacher B, Interview
Girls are persistent	Boys give ideas	Slovenian Teacher B, Interview
Girls are more responsible and studious, ambitious	Boys are more curious but less effective at work	Spanish Teacher A, Interview
Girls have a caring nature	Boys are practical, fixing building, organizing nature	Swedish Teacher A, Interview
Girls maybe studying harder	Boys have more of a go-and-try attitude	Swedish Teacher B, Interview

The gendered view of the issue was not apparent form the perspective of the students, who thought there should not be such a distinction. This was apparent in the student's answers to the question w*ho is more interested in science: boys or girls?* Some students confirmed that the girls' and boys' interests in science are equal but what makes the **difference is what we call the science interests' means and ends – in the students' words it simply means that boys' and girls' interests in science are manifested and used in different ways**:

Boys show interest in video games so that they learn about computers and how computers work. But the girls on the other hand, if you take the traditional approach of more interest in cooking, there are also cooking in science, by science cooking. (Slovenian Student A – Interview)

So, as for equal interest, I think, interest is generally equal, it's just that it's outsourced to different things often times. But that doesn't mean that those interests are entirely different, they could be correlated quite closely. (Lithuanian Student, Interview)

Teachers also reported that **when boys and girls work together**, as they do in climate change OSS missions, the **gender lines in defining competencies are blurred** as the various boys' and girls' skills and attitudes **complement each other**:

> *(…) when they are all together it's very good because they can supplement each other, it's better. (Lithuanian Teacher B, Interview)*

> *But then both of them, when they do research, and they do make conclusion based on the research and knowledge they got. (Lithuanian Teacher A, Interview)*

Here we could also see how from the students' perspective the expected value of the outcome (e.g., strong mission development and implementation) can motivate the investment of initial resources (e.g., participants' discomfort in mixed groups). This is also apparent in the following student's statement:

> *There is not just one facet of girls and one facet of boys. I think there's a mixture of both in terms of interest in science. There's not just that all girls are interested in one thing and all boys are interested in the other. It's more like a distribution that allows for a discussion and common interests among both genders. (Lithuanian Student, Interview)*

When it comes to the facilitation of female engagement in science data shows that the immersive quality of developing missions in the community is a salient factor of open science schooling on the topic of climate change. This alongside the relevance of the topic brings forward the added value of the learning activity in the form of a positive outcome for the community. Furthermore, as student teams work and learn at their own pace, pooling their capabilities and strengths, from the **self-determination theory** tenets' perspective we can see how intrinsic motivation can then be boosted: students have the freedom to choose the topic of interest as well as the solutions that they would like to pursue. Furthermore, as the competences that each student brings are acknowledged and recognized, while additional competences are developed as the mission progresses, there is further opportunity for motivation to be fostered. This is apparent in the reports from teachers and students that engagement increased from the first to the second round of mission. The intrinsic design of the learning activities through open science schooling also supports the sense of belonging and community in the students as the missions are carried out in groups. 21st century skills such as communication, empathy, cultural understanding, critical thinking and curiously have also the opportunity to be developed in the process.

The students' perspectives of and image about what science is, its importance in society and who can be a scientist also evolved during the project. During the students' mobility in Lisbon, 2022, in the mid of their 2nd round of climate change missions, students were tasked to represent a scientist through drawing. The idea was to explore the views of the students about how they kind of people they saw as scientist (Figure 11 and Figure 12). Also during the TPM III at the end of the project, Oct. 2022, students had the opportunity to present their drawings of how they saw science before and after the project. Representative images are shown in Figure 13.

Figure 11. Draw-A-Scientist-Test – collection of students' scientist drawings, Lisbon Mobility 2022. The layout of the drawings is how we interpreted them: historical male scientists are positioned in the center, they are circled around by male scientist drawings (as derived from the historical scientist male models), further away circle depicts female scientists and on the 'outskirts' of the composition we have a cross-gender scientist and those drawings where we could not specify the gender.

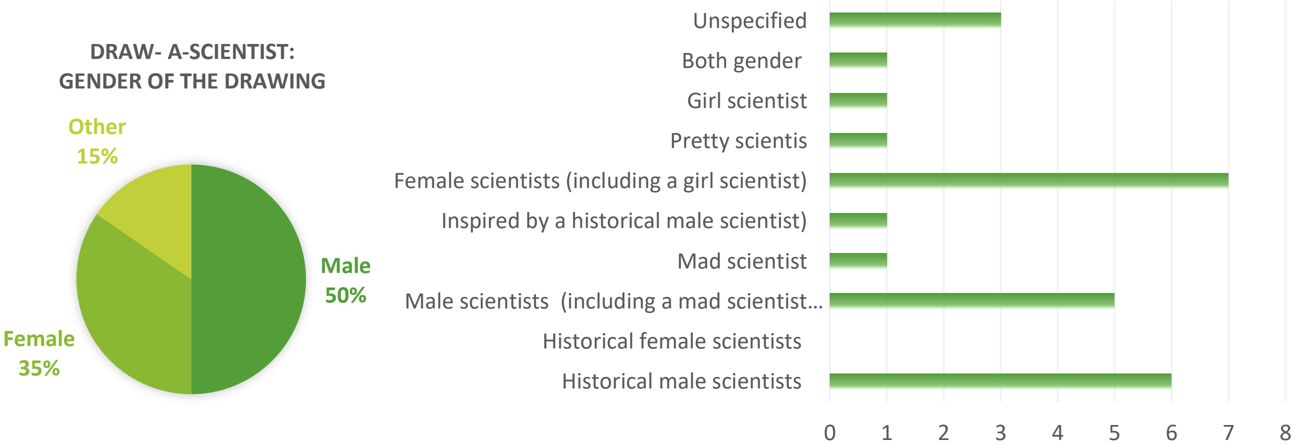

Figure 12. Gender composition of the identified scientist's types produced during the Draw a scientist activity (Lisbon Mobility, 2022)

Figure 13. Representative students' drawings on their views of science before and after the project (female student at the top). TPM III drawing activity, Oct. 2022. The students generally expressed their broader view of science in terms of what science is, and who can do science. A palpable evolution on these perspectives is the understanding that science is found in everyday life and can be carried out by 'anybody who wants to discover things'.

It would be too bold to conclude that the result is more gender-balanced because of the project. Instead, we may suggest that it is a very plausible explanation, and that deeper research can be done to closely investigate how explicit addressing gender stereotypes in learning (and focus on climate change) affects more gender-balanced view of who can be a 'scientist'. In addition, we see that the scientist representation changes with age (source: researchers' observations and discussion with the students). Younger students tend to portray scientist that resemble their own characteristics (i.e., girl scientist), a personally close scientist representation, whereas older students of both genders tend to depict a personally 'distant' scientist representation like a historical scientist model. We also observe that, in some instances, girls who already consider a possible career in science would draw a scientist woman that 'could be me'. However, this observation is not sustained across all participants and hence further research is needed to confirm this and to understand it.

At first, I never thought I could be like a scientist or something I paused that interest. But then through this project, I felt like maybe I can be a scientist one day. Slovenian Student B, Interview)

Yes, I would like go to university and study science and graduate in that science. (...) I think that if in the future I will become a scientist I would be a good scientist (Spanish Student, Interview)

So, I see myself as a scientist and every sense of the world because I implement the scientific methods into my personal life. (Lithuanian Student, Interview)

Yes, of course. I would like to study science and get a degree in science. I would really like to put my knowledge to the task and save millions of lives along the way. (Lithuanian Student, Interview)

I actually do want to study with science. And I want to work with the global warming and how that affects and how to solve it. (Swedish Student B, Interview)

I would like see myself as a scientist because I am a fighter and I like to help the community. (Romanian Student, Interview)

RECOMMENDATIONS

We can summarise the following recommendations from the experiences in the project and the data collected:

Increase Science's Learning Attractiveness

- Showing science 'behind scenes' by exposing students to practical views of science careers and experts in their workplace
- Making science learning a hands-on experience, showing the purpose of science

Re-engage All Students through Innovative Pedagogy

- Implementing methodlogies such as OSS and interdicisplinary topics of relevence and impact such as climate change is an excellent example of an approach to develop engaging learning experiences for girls and boys

Foster Teachers' Own Professional Development

- It is fundamental for teachers to become aware of their own as well as other societal biases so that they are able to identify and tackle them efficiently in their classrooms

In the teachers' words:

For girls, I think they need to see the connection to the society that the science has and how it's used in our society, how they can work within areas when they are older. (Swedish Teacher A, Interview)

And I think it's very important to see that the science is fundamental for the life. So if the science teachers emphasize to the classroom that science is very important for the life. Perhaps they will have more curiosity for little things about our environment. (Spanish Teacher A, Interview)

I think the part that we could do more obvious like giving the girls more or all the students more, getting them to see more what's behind those degrees and what's behind those professions. (...) So, I think that's something they need to be able to see what it would lead to. (Swedish Teacher B, Interview)

To make science more attractive to girls, more engaging and get girls more interested in the subject, the way of teaching science in school should imply more lab experiments. That is to let them gain more experience and the scientific knowledge through the practical applications, through going to the lab and getting involved in different activities and identifying different problems which may appear in science in general. (Romanian Teacher B, Interview)

When we talk about this, we can raise their curiosity, stimulate their curiosity through examples of big women scientists, for example, we have Marie Curie. We also spoke about that. And this could empower them to follow, let's say leading by example, but giving these examples. (Romanian Teacher A, Interview)

I think there are misconceptions within science. I think that the girls come with the idea that this is boring while boys come with the idea that it is fun and exciting. Finally, we get to put things together and test things. (...) And also, the boys can see themselves somethings within professions that has science in them while girls don't. (Swedish Teacher A, Interview)

(...) because students don't want to learn from textbooks anymore and I think it's normal and we can understand them. I myself can understand them because we don't live in those days anymore. (Romanian Teacher B, Interview)

We noticed that, for example, after we collected from the field, girls were happy and crazy going to test and to see, to implement, to study once they came back from the field. They (the teachers) could see a result on the spot, and this empowered them. (Romanian Teacher A, Interview)

Starting from examples from real life, from the everyday life, it can attract more girls to science. So, if all the girls can work in such or get involved in such experiments, they of course can get easily involved in these experiments. (Romanian Teacher B, Interview)

I started developing, and I am proud to say that why I am in the Erasmus Plus project, because I wanted to develop myself as a person, as a teacher, as a professional, as a mother, as a, I don't know, advisor to some of my students and my family and so on. Because you know me, a few years ago before taking part in the project and me today are two different people. I have developed a lot. I have learned a lot. I have changed a lot because even my family, they say that I have changed as a person. I have learned a lot of nice things. I joined the nice groups. I talked to many people. Then when I learned myself, I also become wiser as a teacher during the lesson because I have more answers to them, to give, I am educated because I have been educating myself during the project also. (Lithuanian Teacher 1, Interview)

CONCLUSIONS

This research study investigated the effectiveness of implementing learning activities related to community missions on climate change topics under an open science schooling methodology to re-engage female students in science learning. The data collected was rich and authentic in the form of surveys, interviews, drawings, pictures and observations. We identified 4 factors that support the effectiveness of open science schooling for developing science missions tackling climate change as a meaningful and relevant issue affecting society: *importance of the topic locally and globally*, *student-centred learning*, *role of community collaboration and immersiveness of the learning experience*. All the evidence we collected links features of research, experimentation and solution identification to increased motivation in learning science both in case of male and female students. Nevertheless, based on our research we are unable to disentangle the effects of the 4 factors to establish if the immersive research inquiry feature of OSS has special effect on the girls' engagement in science or if this effect was stronger or weaker depending on the students' gender. However, based on our findings we can claim that practice-orientation of the OSS focused on climate change may be regarded as a significant factor modulating female students' motivation and interest in pursuing science learning.

The research also showed that the image of science evolved in the participating students as the project progressed. Furthermore, for the students, the division between the boys' and girls' interests in science seemed superficial and in incongruity to how they see the world: they saw diversity instead of division, they saw distribution instead of opposition, they saw discussion and commonality of interest instead of girls' underrepresentation in science.

Based on the teachers' accounts, we may conclude that the OSS supports the conditions in which the students' gendered science interests and capacities stop to play a disadvantageous role for girls. In the OSS the different students' competences and resources are not put against each other, instead they are paired. We conclude that the OSS enables to tap into the variety of the individual students' talents, abilities and the approaches they take towards science. The OSS not only blurs the gender divisions of students' skills and competencies, but it makes it invalid; and it takes place without overtly challenging the gender norms and stereotypes in which those divisions are rooted.

Research is yet to establish the impact of role-models in influencing students' perception. I this study only one male student admitted being inspired to career in science after having met science professionals (the only male student interviewed). Female respondents did not report being motivated to career in science upon meeting the experts. Therefore, we suggest that further and more systematic research is needed to verify the extent of the role of meeting experts on students' career choices in science when gender is the key variable (both of the students and the experts).

This research provides practical evidence that demonstrates that only an unbiased approach to teaching is able to tap in the richness of the students' diverse abilities – capitalising putting them in collaboration and communication and not in opposition and competition.

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ANNEXES

STUDENTS' SURVEY

1. What is a scientist, in your opinion?

2. What kind of work does a scientist do?

3. Choose from the following professions the ones that you consider to be science professions.

Artist Firefighter Engineer School teacher Sociologist Computer scientist
Computer Programmer Environmental scientist Game developer
Translator Lawyer Surgeon Architect Dentist CEO
Physician Preschool or kindergarten teacher Human resources manager
Social worker Education administrator Registered nurse Clothes Designer
Industrial Designer Graphic Designer Other:

4. What kind of job would you like to have in the future? (for example, you can tell us what kind of work you are interested in)

5. Do you consider that kind of work to be a science profession (related to science)?

6. What is science in your opinion?

7. How does science help you in your daily life? (How can you use science in your life?)

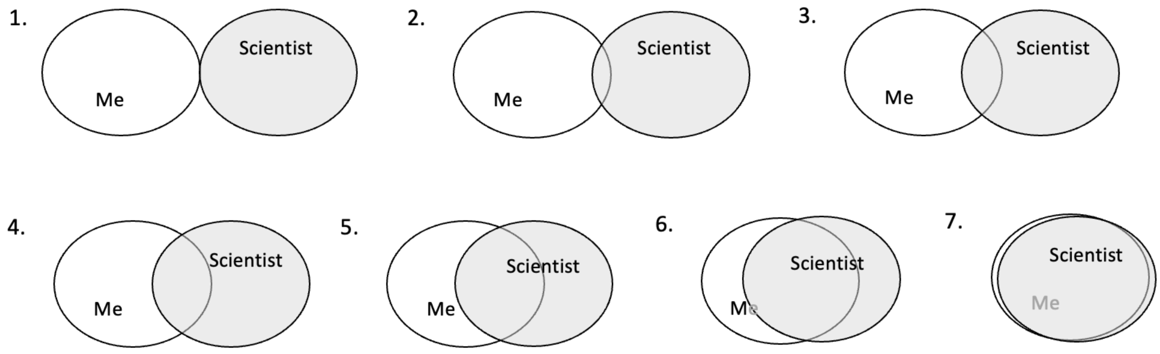
8. Why do you study science? Choose the statements that best describe your motivation to study science from most relevant to less relevant (multiple answers possible). In other words, organize the statements in order of how important it is to you. (1-6, where 1 means the most important and the 6 the least important)
I study science ...

- Because science is one of the subjects at school and I must study it.
- Because science is interesting.
- Because I would like to become a scientist.
- Because my parents want me to study science.
- Because my teacher makes science fun and interesting.
- Other reason:

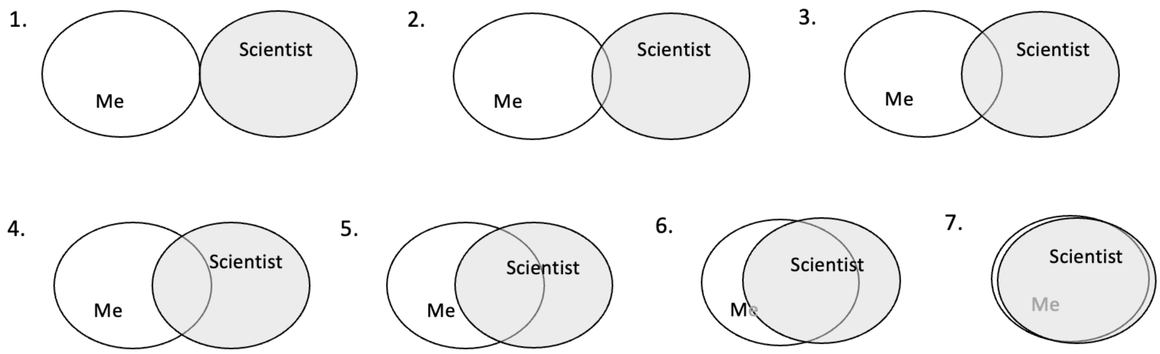
9. Which sentence best describes your feelings and thoughts towards science? Please choose one.

- I find science interesting and would like to pursue a career in science.
- I find science interesting as a subject but not as a career opportunity.
- I find science interesting and would like to be a scientist, but I am not sure how science could be a career. I find science interesting and I am good at it, but I am not motivated to become a scientist
- I would like to be a scientist, but I do not know how people become scientists.
- Science seems interesting to me, but I find it difficult at times.

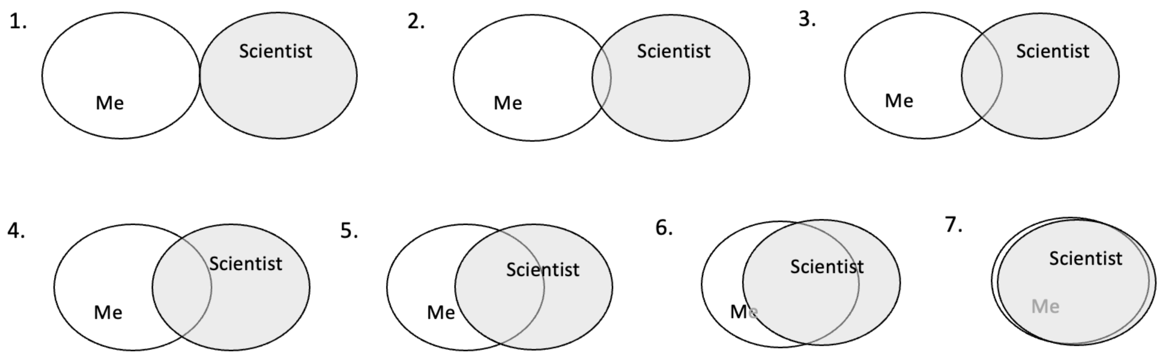
10. How much do you consider yourself a scientist? Choose the picture number (1-7) that you best identify with.



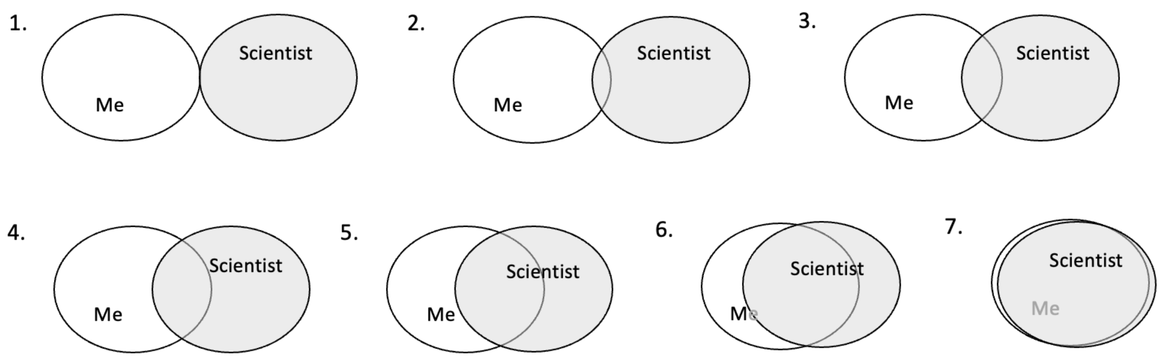
11. How do you evaluate your knowledge of science concepts? (How well do you do you remember basic scientific facts and can you use them that knowledge? Science concepts include Observing, Comparing, Classifying, Measuring, Communicating, Inferring, Predicting, cause and effect, scale, variation, change, diversity, and organization and systems). Answer by choosing the picture number.



12. What is your capacity to use science skills in public? (Using science skills in public may include giving science presentations, performing experiments, talking about science). Answer by choosing the picture number.



13. How do you think others (a. teachers, b. parents/ care givers, c. friends) consider you a scientist? Answer by choosing the picture number.



	1	2	3	4	5	6	7
Teachers *	○	○	○	○	○	○	○
Parents/ caregivers *	○	○	○	○	○	○	○
Friends *	○	○	○	○	○	○	○

14. How much do you agree with the following sentences?	Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree
• Science is for girls.					
• Science is for boys.					
• Science is for everyone, girls and boys.					
• Boys are better at science than girls.					
• Girls are better at science than boys.					
• Boys and girls are equally good at science.					
• Boys are encouraged more to be scientists (by teachers, parents, family) than girls.					
• Girls are encouraged more to be scientists (by teachers, parents, family) than boys.					
• Girls and boys are equally encouraged (by teachers, parents, family) to be scientists.					
• Teachers give the impression as if they believe that girls are better at science.					
• Teachers give the impression as if they believe boys are better at science.					
• Teachers give the impression as if they believe that boys and girls are equally good at science.					

15. Which of the following professions do you consider are more suitable for boys, more suitable for girls or equally suitable for both boys and girls?

	More suitable for boys	More suitable for girls	Equally suitable for both boys and girls
• Artist			
• Firefighter			
• Engineer			
• School teacher			
• Sociologist			
• Computer scientist			
• Computer Programmer			
• Environmental scientist			
• Game developer			

- Translator
- Lawyer
- Surgeon
- Architect
- Dentist
- CEO
- Physician
- Preschool or kindergarten teacher
- Human resources manager
- Social worker
- Education administrator
- Registered nurse
- Clothes Designer
- Industrial Designer
- Graphic Designer

16. Would you be more motivated to study science if the teacher was of the same gender (man or woman) as you?

- ○ Yes
- ○ No
- ○ I don't know
- ○ Explain your answer: __________

17. How important is it to use science to address problems that are related to climate change?

- ○ Very important
- ○ Not more important than other measures (i.e., good social policies, responsible consumer behav ior, etc.)
- ○ Not important
- ○ I don't know

18. If science focuses on finding solutions to climate change problems, then I feel that :

- ○ It would not affect my interest in science as I do not like science.
- ○ It would not affect my interest in science as I already like science.
- ○ It would amplify (make stronger) my interest in science, as I already like science.
- ○ It would help me develop an interest in science as I do not like science.

19. Would you like to become a scientist who is focused on climate change issues?

- ○ Yes
- ○ No
- ○ It depends... (elaborate) ______

20. Personally, how important are each of the following goals o you?

	Extremely important	Important	Somewhat important	Neither important nor unimportant	Somewhat unimportant	Unimportant	Not at all important

- serving community (help other in your community)
- working with people
- power (you want to have power like a boss)
- altruism (sacrifice yourself for others work-free)
- self-promotion (brag about yourself)
- achievement (being successful)
- helping others
- independence (wok on your own)
- recognition connecting with others
- serving humanity
- competition status
- demonstrating skill
- attending to others
- success
- focus on the self (take care of yourself first)
- individualism (prefer to work by yourself)
- financial reward get bonus money)
- caring for others
- self-direction (be your own boss)
- spirituality (affects your spirit/soul)
- mastery (be like an expert)
- intimacy (being close to others)
- seeking new experiences and excitement

TEACHERS' SURVEY

. TEACHER'S GENDER STEREOTYPES- AND BIASES AWARENESS

How much do you agree with the following statements	Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

- I understand what are gender stereotypes and biases in science.
- I understand how can gender stereotypes in science affect girls' self-efficacy (perception of their ability and mastery) in science and their possible science career choices.
- I don't think teachers should address gender stereotypes and biases in science, it is not their job.*
- I can notice gender stereotypes and biases (regarding science and in general) both in the school textbooks and in the behaviour of the students and teachers.
- I can notice my own gender stereotypical and biased thoughts and behaviour in the context of own teaching (my work as a teacher).

TEACHER'S SELF-EFFICACY IN ADDRESSING GENDER STEREOTYPES AND BIASES IN TEACHING

Questions in this section concern teachers' perceived ability (self-efficacy) to address and counteract gender stereotypical behaviours in the context of teaching as well as gender biased depictions of women and men in educational materials.

I know how to counteract gender stereotypes and biases in behaviour of students and teachers as well as in educational materials (both in the context of science and in general).

Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

In my work as teacher, I have already (successfully) addressed gender stereotypical behaviour of students and/or teachers

- ◯ I strongly agree
- ◯ I agree
- ◯ I neither agree nor disagree
- ◯ I disagree
- ◯ I strongly disagree
- ◯ I have not come across such situation(s)

In my work as teacher, I have already (successfully) addressed gender stereotypical depictions in school books (both in science and in general).

- ◯ I strongly agree
- ◯ I agree
- ◯ I neither agree nor disagree
- ◯ I disagree
- ◯ I strongly disagree
- ◯ I have not come across such situation(s)

If you have addressed gender stereotypical behavior or women/men depictions (in the context of education in general), please tell about this experience.

How do I perceive my own ability (efficacy/mastery) in dealing with gender stereotypes and biases in education (in science and in general)?

- ◯ Very good
- ◯ Good
- ◯ Neither good nor bad
- ◯ Not good
- ◯ Not good at all

The following question (.a) is addressed specifically to the teachers who take part in Science4Girls project. If you don't take part in the project, the survey will take you to the next question.

.a. How do I evaluate my ability to address gender stereotypes and biases in science and in general before the Science4Girls project and now as the project draws to the end.

	Very good	Good	Neither good nor not good	Not good	Not good at all
Before the project *	◯	◯	◯	◯	◯
Now *	◯	◯	◯	◯	◯

I need more support (from peers, training etc.) in order to address gender stereotypes in science and in general in my work*.

Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

OPEN SCIENCE SCHOOLING (OSS) METHODOLOGY AND STUDENTS' INTEREST IN SCIENCE.

In this section, the survey participants are asked to evaluate the effectiveness of the Open Science Schooling methods in making science more attractive and interesting - as subject and career to students, particularly girl students.

I find the OSS methodology an effective tool in addressing gender stereotypes in science.

Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

How can I use the OSS methodology to counteract gender stereotypes in my teaching, if applicable?

I can use the OSS to manage the differences between boys' and girls' styles of participation and engagement in the (science) classes.

Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

How can I use the OSS methodology to manage differences in styles of boys' and girls' engagement and participation in science classes, if applicable?

I can use OSS methodology to manage differences between boys' and girls' differences in styles of working and learning science?

Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

How can I use OSS methodology to manage differences between boys' and girls' differences in styles of working and learning science, if applicable?

I can use the OSS methodology to strengthen the girls' self-efficacy in science (perception of their abilities in science).

Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

How can I use the OSS methodology to strengthen the girls' self-efficacy in science, if applicable?

15. I can use the OSS methodology to nurture the boys' and girls' interest and curiosity in science.

Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree

How can I use the OSS methodology to nurture the boys' and girls' interest and curiosity in science, if applicable?

STUDENTS' (RE) ENGAGEMENT IN SCIENCE - TEACHER'S ROLE

This section is focused how do the teachers perceive their role in engaging students in science learning.

In your opinion, how important is the teacher's role in (re) engaging students in science - both as school subject and possible career?

- ◯ Very important
- ◯ Important
- ◯ Neither important nor not important
- ◯ Not important
- ◯ Not important at all

As a teacher, what can you do to engage the students in science (=make it more interesting)? Name at least three ideas.

What is beyond your influence in engaging students in science (=rendering science attractive and interesting)?

From your perspective, how important is students' active engagement and participation in designing learning activities (science missions) for their engagement in science?

- Very important
- Important
- Neither important nor not important
- Not important
- Not important at all

How would you evaluate the importance of student's active engagement in designing learning activities from the gender perspective?

- Very important
- Important
- Neither important nor not important
- Not important
- Not important at all

How would you evaluate the importance of student's active engagement in designing learning activities from the gender perspective?

You may elaborate on your answer in a field that follows the statement you chose.

- It has equally positive effect on boys' and girls' in terest and engagement in science
- It is more important for the boys' interest an d engagement in science
- It does not really matter for neither boys' no r girls' interest in science
- It is more important for the girls' interest an d engagement in science

How do you evaluate your capacity to actively involve students in designing the learning activities in your regular teaching?

- Very strong
- Strong
- Neither strong nor not strong
- Not strong
- Not strong at all

How likely it is that you will actively involve the students in designing the learning activities like it was in science4girls project when the project ends?

- Very likely
- Likely
- Neither likely nor unlikely
- Unlikely
- Very unlikely

PARENTS' SURVEY

What is a scientist, in your opinion?

What kind of work does a scientist do?

Which of the following professions do you consider to be a science profession?

- ☐ Artist
- ☐ Environmental scientist
- ☐ CEO
- ☐ Clothes Designer
- ☐ Firefighter
- ☐ Game developer
- ☐ Physician
- ☐ Industrial Designer
- ☐ Engineer
- ☐ Translator
- ☐ Preschool or kindergarten teacher
- ☐ Graphic Designer
- ☐ School teacher
- ☐ Lawyer
- ☐ Human resources manager
- ☐ Other:
- ☐ Sociologist
- ☐ Surgeon
- ☐ Social worker
- ☐ Computer scientist
- ☐ Architect
- ☐ Education administrator
- ☐ Computer Programmer
- ☐ Dentist
- ☐ Registered nurse

What is your profession?

Do you consider this profession a science profession?

○ Yes ○ No ○ I don't know

Would you like your child to become a scientist?

- ○ Yes
- ○ It is too early to say
- ○ No
- ○ Other answer: ______
- ○ I don't know

Why do you think your child studies science? *Choose the statements that best describes your child's motivation to study science from most relevant to less relevant (multiple answers possible). She/he studies science ...* *

- ☐ Because science is one of the subjects at school and he/she must study it.
- ☐ Because science is interesting for him/her.
- ☐ Because she/he would like to become a scientist.
- ☐ Because her/his parents want her/him to study science.
- ☐ Because his/her teacher makes science attractive and interesting.
- ☐ Other reason … ______

Do you encourage your child's interest to study science? *

- ○ Yes. Please, tell how: ______
- ○ No. Please, tell why: ______

How much you would like your child to become one of the following professionals:

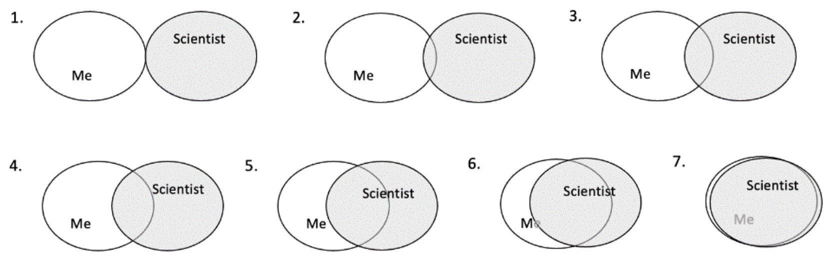
	Very interested	Interested	Neither interested nor uninterested	Not interested	Very uninterested
Mechanical engineer	○	○	○	○	○
Computer scientist	○	○	○	○	○
Aerospace engineer	○	○	○	○	○
Environmental scientist	○	○	○	○	○
Lawyer	○	○	○	○	○
Architect	○	○	○	○	○
Dentist	○	○	○	○	○
CEO	○	○	○	○	○
Physician	○	○	○	○	○
Preschool or kindergarten teacher	○	○	○	○	○
Human resources manager	○	○	○	○	○
Social worker	○	○	○	○	○
Education administrator	○	○	○	○	○
Registered nurse	○	○	○	○	○

Which one of the sentences you think best describes your child's relation to science? *(what your child thinks about science and how she/he feels about science)*

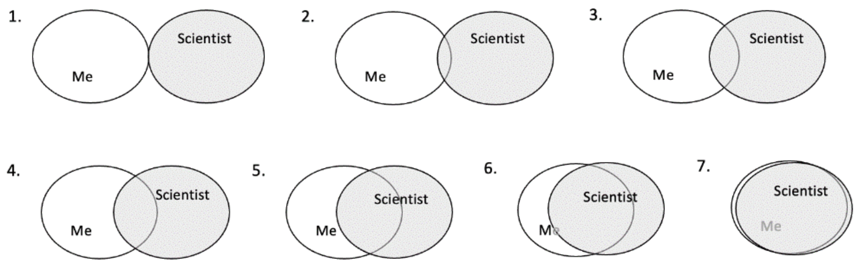
- ☐ He/she finds science interesting and would like to pursue a career in science.
- ☐ She/he finds science interesting as a subject but not as a career opportunity.
- ☐ She/he finds science interesting and would like to be a scientist, but he/she not sure how science could be a career.
- ☐ She/he finds science interesting and is good at it, but not motivated to become a scientist.
- ☐ He/she would like to be a scientist but does not know how people become scientists.
- ☐ Science seems interesting to him/her, but he/ she finds it difficult at times.
- ☐ Other reason … ________________

YOUR CHILD AS A SCIENTIST

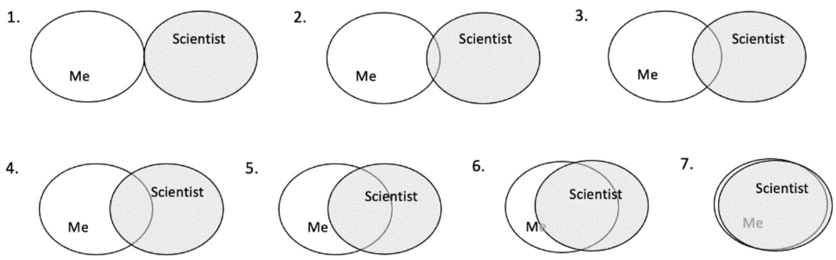
How much do you consider your child a scientist? *Answer by choosing the picture number. "Me" indicates your child.* *



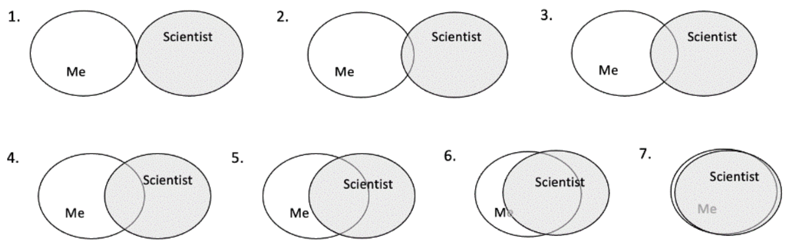
In your opinion, how much you think your child considers her/himself a scientist? *Answer by choosing the picture number. "Me" indicates your child.* *



How do you evaluate your child's knowledge of science concepts? *(How well does your child know the basic scientific concepts and can use them? (Science concepts include Observing, Comparing, Classifying, Measuring, Communicating, Inferring, Predicting, cause and effect, scale, variation, change, diversity, and organization and systems). Answer by choosing the picture number. "Me" indicates your child.* *



What is your child's capacity to use science skills in public? *(Using science skills in public may include giving science presentations, performing experiments, talking about science) Answer by choosing the picture number. "Me" indicates your child.* *



How do you think others (a. teachers, b. friends, c. other family members) consider your child a scientist?
Answer by choosing the picture number. "Me" indicates your child. *

	1	2	3	4	5	6	7
	☐	☐	☐	☐	☐	☐	☐
Teachers	☐	☐	☐	☐	☐	☐	☐
Friends	☐	☐	☐	☐	☐	☐	☐
Family	☐	☐	☐	☐	☐	☐	☐

SCIENCE AND GENDER

How much do you agree with the following sentences?

	Strongly agree	Agree	Neither agree nor disagree	Don't agree	Strongly disagree
Science is for girls. *	☐	☐	☐	☐	☐
Science is for boys. *	☐	☐	☐	☐	☐
Science is for everyone, girls and boys. *	☐	☐	☐	☐	☐
Boys are better at science than girls. *	☐	☐	☐	☐	☐
Girls are better at science than boys. *	☐	☐	☐	☐	☐
Boys and girls are equally good at science. *	☐	☐	☐	☐	☐
Boys are encouraged more to be scientists (by teachers, parents, family) than girls. *	☐	☐	☐	☐	☐
Girls are encouraged more to be scientists (by teachers, parents, family) than boys. *	☐	☐	☐	☐	☐
Girls and boys are equally encouraged (by teachers, parents, family) to be scientists. *	☐	☐	☐	☐	☐
Teachers give the impression as if they believe that girls are better at science. *	☐	☐	☐	☐	☐
Teachers give the impression as if they believe boys are better at science. *	☐	☐	☐	☐	☐
Teachers give the impression as if they believe that boys and girls are equally good at science. *	☐	☐	☐	☐	☐
Career in science is more suited for boys. *	☐	☐	☐	☐	☐
Career in science is more suited for girls. *	☐	☐	☐	☐	☐
Career in science is equally suited for girls and boys. *	☐	☐	☐	☐	☐

Which of the following professions do you consider are more suitable for boys, more suitable for girls or equally suitable for both boys and girls?

	More suitable for boys	More suitable for girls	Equally suitable for both boys and girls
Mechanical engineer *	◯	◯	◯
Computer scientist *	◯	◯	◯
Aerospace engineer *	◯	◯	◯
Environmental scientist *	◯	◯	◯
Lawyer *	◯	◯	◯
Architect *	◯	◯	◯
Dentist *	◯	◯	◯
CEO *	◯	◯	◯
Physician *	◯	◯	◯
Preschool or kindergarten teacher *	◯	◯	◯
Human resources manager *	◯	◯	◯
Social worker *	◯	◯	◯
Education administrator *	◯	◯	◯
Registered nurse *	◯	◯	◯