D5.2 EVALUATION REPORT

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EXECUTIVE SUMMARY

The ICSE Science Factory project addresses the shortage of scientists and scientifically literate citizens in Europe by engaging learners and communities in innovative, real-life-connected science activities. Implemented across five partner countries (Croatia, Cyprus, Germany, Portugal, and Turkey), the project builds sustainable cross-sectoral partnerships and delivers different activities involving schools, universities, enterprises, and community institutions.

The key findings of this project show a positive and consistent impact on students' attitudes and beliefs towards science, with both primary and secondary participants reporting high enjoyment of science and a strong interest in scientific experimentation. The activities also lead to significant improvements in scientific self-efficacy, as students gain confidence in applying scientific knowledge to real-world situations, communicating about science, and using scientific skills, demonstrating that ICSE Science Factory initiatives effectively support their perceived capability to succeed in STEM pathways. Among the different formats, lighthouse activities and open schooling activities generate the strongest learning outcomes and engagement, with lighthouse activities receiving the highest ratings and open schooling activities proving especially impactful in strengthening decision-making, problem-solving, and community engagement. Despite these positive outcomes, gender differences remain visible; although the activities help reduce stereotypes, long-term and systematic policy measures are still required to close the gap. The evaluation also reveals high variation between countries, underlining the importance of contextualizing interventions within national educational cultures. Finally, the project achieved large participation, with nearly 5000 pre-test and 6900 post-test questionnaires collected during the piloting and implementation phases.

The main policy implications highlight the need to integrate open schooling approaches into national STEM strategies, as open schooling activities show that collaboration between schools, researchers, enterprises, and community members substantially enhances science learning and civic scientific literacy. Policymakers should also prioritize real-life, challenge-driven, interdisciplinary science learning, since activities grounded in societal issues, such as the Green Deal, health, and digitalization, are particularly effective in raising engagement. Furthermore, long-term structural actions are essential to reduce gender disparities: evidence indicates that isolated activities are insufficient, and education systems should institutionalize female role-model programs, mentoring schemes, and stereotype-challenging interventions. The findings also underscore the importance of supporting sustainable cross-sectoral partnerships, as structured collaboration among schools, universities, enterprises, and NGOs improves activity quality and strengthens community-level scientific capacity. Finally, the development of streamlined and engaging evaluation systems is crucial; to sustain motivation and ensure high-quality data, policies should promote digital, adaptive, and non-repetitive assessment tools.

Some strategic recommendations include institutionalizing open schooling models and embedding them in national STEM policies to expand community-based science learning, as well as funding and maintaining science labs and collaborative learning spaces to scale the hands-on activities that have proven effective in lighthouse activities and open schooling activities. It is also advisable to create national frameworks for gender-inclusive STEM pathways that combine interactive career talks with long-term mentoring. Additionally, teacher professional development should be promoted in alignment with interdisciplinary, challenge-driven innovation and design research. Finally, ensuring sustained support for cross-sector partnerships is essential, as these collaborations are a core element enabling high-impact science learning across Europe.

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1. OBJECTIVE AND INTRODUCTION

The Deliverable 5.2 (D5.2) aims to present the results of the ICSE Science Factory project in terms of the evaluation of the different activities carried out. The document is organized into seven main sections: introduction, methodology, results, conclusion with recommendations, limitations, references, and appendix. The ICSE Science Factory supports the EU's endeavour to combat a shortfall of scientists and citizens versed in science. It does so by offering a unique combination of different measures, each of them tackling the issue from a different starting point, thereby leveraging impact. The unique features of the ICSE Science Factory are:

- New high-capacity cross-sectoral partnerships in five partner countries consisting of science researchers, science education researchers and non-formal education providers, supported by attached schools, enterprises and community institutions.
- Innovative concept to enlarge the number of scientists and scientific knowledge in the communities:
  1. To strengthen the partnerships, we organize local partnership conventions, where we share and apply research findings, and local public fairs to integrate communities in the scientific learning process.
  2. With the expertise of the local cross-sectoral partnership, in each country we offer collaborative and interdisciplinary lighthouse activities and open schooling activities for community members (on health, digitalization, Green Deal), supported by mentoring.
  3. All activities are complemented by a series of interactive career talks, focusing especially but not only on female role models in science and on overcoming stereotypes.
- An educational, research-backed concept for our lighthouse and open schooling activities which deliberately includes real-life problem-solving on issues relevant to society (including decision-making), and the concept of challenge-driven innovation, which integrates communities in overcoming challenges.
- The activities are supplemented by special features: The setting up of stimulating science labs in each country, a threefold system for encouraging mentoring across the partnership and a systematic approach to quality assurance by using design research, which strives for solutions tailored to local communities based on a joint European concept.

In a nutshell, the main objectives of the ICSE Factory project are:

- Promote access to science education through innovative, real-life-connected activities.

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- Address the shortage of scientists and scientifically literate citizens, fostering interest in STEM careers, especially among girls and women.
- Encourage cross-sector collaboration (researchers, schools, businesses, NGOs) to tackle real-world challenges in sustainability, health, and digitalization.

The duration of the project is from January 1, 2023 to February 28, 2026 and it is organized around six work packages (WP):

- WP1 – Management: led by Pädagogische Hochschule Freiburg, with the following objectives:
    1. To provide efficient administration and management to meet the projects' objectives and Grant obligations
    2. To facilitate involvement of all partners and foster open, active dialogue and to build trust among partners
    3. To maintain the link to the European Commission
- WP2 – Lighthouse activities and open schooling: led by Instituto de Educação da Universidade de Lisboa, with the following objectives:
    1. To offer communities members real-problem solving opportunities, contributing to lifelong learning
    2. To run lighthouse activities
    3. To encourage schools to run open schooling activities
    4. To continuously optimise activities in the sense of design research
- WP3 – Interactive career talks: led by Faculty of Science of the University of Zagreb, with the following objectives:
    1. To raise young persons' interest in science careers and science studies
    2. To particularly raise young women's interest in science careers and science studies
    3. To continuously optimise interactive career talks in the sense of design research
- WP4 – Sustainable cross-sectoral partnerships: led by Pädagogische Hochschule Freiburg, with the following objectives:
    1. To foster networking among different stakeholders and community members
    2. To create partnerships between teachers, science researchers, entrepreneurs, community members
    3. To run partnership conventions and local fairs

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4. To work on sustainability strategies for the partnership

- WP5 – Evaluation: led by University of Nicosia, with the following objectives:
  1. To ensure activities of the highest quality
  2. To measure the impact of the activities on participants to give advice to other people interested in open schooling, creating partnerships, providing activities for lifelong learning
- WP6 – Dissemination, Exploitation and Communication: led by Hacettepe Universitesi, with the following objectives:
  1. To raise awareness of the ICSE Science Factory among target groups and the wider public
  2. To win community members, teachers, students, etc. to participate in our activities and for our partnership
  3. To promote the ICSE Science Factory, its results and related themes across Europe and beyond project lifetime
  4. To communicate our main messages to target groups

The project has been materialized through three types of activities that have been developed in all participating countries:

- Interactive career talks (ICaT): Meetings for young people in the active phase of their career orientation, in which 2-3 role models (predominantly but not exclusively females) present their science careers and participants have the opportunity for exchange with those role models.
- Lighthouse activities (LHA): Collaboratively, local consortium members and enterprises run interdisciplinary workshops on real-life problems for community members, thus contributing to a lifelong learning continuum for all.
- Open schooling activities (OSA): Schools run open schooling activities in their communities, supported by mentors (provided by project partners) and guidelines. They can choose from a wide range of activities such as workshops, projects, round table discussions or a school market.

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2. METHODOLOGY

2.1. Evaluation phases and timeline

The evaluation of the project has three main phases distributed in three different tasks (T) (Appendix II):

- T5.1 Development of evaluation instruments (m1-14) (January 2023-February 2024)

  The instruments were piloted during m7-12 (July 2023-December 2024) and then refined.

  Role of participants: The country partners gave feedback to the evaluation instruments.

- T5.2 Data collection (m15-32) (March 2024-August 2025)

  Each country collected data after LHA and ICaT through the post-test, and before and after OSA through pre-test and post-test. Additionally, we conducted case studies on OSA. For collecting and evaluating the data we use a data protection compliant, digital, coded-anonymized system. This enables us to examine the participant behaviour and beliefs in compliance with the European (European Union, 2016) and national data protection acts (Federal Ministry of Justice, 2017).

  Role of participants: The country partners were responsible for the local data collection.

- T5.3 Data evaluation (m27-35) (March 2025-November 2025)

  The questionnaires were evaluated centrally by UNIC, whilst the case studies were evaluated in the respective country due to language reasons. Each country team wrote an individual country-case study. UNIC provided to the countries the templates for conducting, analysing and reporting the results of the case studies. Afterwards, UNIC evaluated the country-case studies internationally in order to write a cross-case study. The results of the evaluation were discussed in a validation workshop with the consortium. All results (from questionnaires and case studies) are summarized in this report.

  Role of participants: Country partners were responsible for writing their country-case studies. UNIC evaluated the questionnaires centrally and write the cross-case study.

2.2. Evaluation procedure

The questionnaires were tested during the piloting phase. After analysis of the data collected during the piloting phase, the instruments were modified, and the final questionnaires were used during the implementation phase. The piloting and implementation phases for each type of activity were as follows:

- **Lighthouse activities**

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- Piloting phase: from mid-November 2023 until the end of March 2024. At least three LHA per country.
- Implementation phase: until March 2025. At least 27 LHA.

- **Interactive career talks**
  - Piloting phase: from mid-November 2023 until the end of March 2024. At least 1-2 ICaT per country.
  - Implementation: from January 2023 to March 2024. At least eight ICaT per country.
- **Open schooling activities**
  - Piloting phase: from mid-November 2023 until the end of March 2024. Although it was not necessary to carry out OSA during the piloting phase, OSA could begin if the teachers felt ready.
  - Implementation: from March 2024 to February 2025. At least 40 per country.

The activities carried out during the implementation phase were evaluated through questionnaires and case studies (Table 1). ICaT and LHA were evaluated after the activity (post-test only). Observation Templates were also used during the LHA (Appendix VI). OSA were evaluated before and after the activity (pre-test and post-test) by means of the same questionnaire as for LHA and ICaT, and by case studies. The questionnaires were filled in by students (see Appendix I) as well as by adults (teachers, parents and scientists/experts) (see Appendix II). The case studies consisted of three initial interviews with teachers (see Appendix III), three retrospective interviews (see Appendix IV) with the same teachers and a retrospective focus group with students (see Appendix V). The number of activities and participants required for the project are shown in Table 2.

Table 1. Evaluation instruments used for each type of activity.

Type of activity	Pre-test	Post-test	Observation template	Initial individual interview	Retrospective individual interview	Retrospective focus group
Lighthouse activities	—*	Students Adults	During the activity	—	—	—
Interactive career talks	—	Students Adults	—	—	—	—
Open schooling activities	Students Adults	Students Adults	—	3 with teachers	3 with teachers	1 with students

Note. — = Not applicable

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Table 2. Number of activities and participants required.

Type of activity	Nº of activities/country	Nº of participants/activity	Nº of participants/country	Europe
Lighthouse activities	27	10-15	≈300	≈1500
Open schooling activities	40	5-8	≈250	≈1250
Interactive career talks	10	10-15	≈120	≈600
Local fairs	2	30-50	60-100	300-500

Note. Local fairs were also other activities held as part of the project, although these activities were not evaluated.

2.3. Distribution of the sample

The total number of questionnaires collected during the entire project (piloting and implementation phases) by type of activity and country are shown in Table 3. In the piloting phase the questionnaire for primary and secondary students was the same.

Table 3. Sample sizes by type of activity and country from the project.

			Croatia		Cyprus		Germany		Portugal		Turkey		Total	
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Piloting	**P+S**	**ICaT**	0	8	0	12	1	37	0	13	1	39	2	109
		LHA	24	163	0	33	4	44	0	0	34	32	62	272
		OSA	22	25	0	0	8	34	0	0	46	16	76	75
	A	**ICaT**	—	0	—	0	—	4	—	0	—	4	—	8
		LHA	—	7	—	0	—	22	—	12	—	71	—	112
		OSA	—	0	—	0	—	3	—	1	—	10	—	14
Implementation	**P**	**ICaT**	—	0	—	0	—	103	—	61	—	0	—	164
		LHA	—	22	—	289	—	2746	—	26	—	0	—	3083
		OSA	0	0	118	117	162	100	188	168	0	0	468	385
	S	**ICaT**	—	373	—	116	—	35	—	77	—	364	—	965
		LHA	—	138	—	32	2870*	270	—	219	—	298	2870	957
		OSA	177	41	63	28	313	153	421	89	546	289	1520	600
	A	**ICaT**	—	0	—	0	0	0	—	0	—	0	0	0
		LHA	—	5	—	0	0	7	—	109	—	0	0	121
		OSA	0	0	0	0	0	0	0	0	0	0	0	0
Project (Piloting + Implementation; P + S + A)		**ICaT**	0	381*	0	128	1	179	0	151	1	407	2	1246
		LHA	24	335	0	354	2874*	3089	0	366	34	401	2932	4545
		OSA	199*	66	181	145	483	290	609	258	592	315	2064	1074
Total Project (ICaT + LHA + OSA)			223	782	181	627	3358	3558	609	775	627	1123	4998	6865

Note. P = Primary; S = Secondary; A = Adults; — = Not applicable. *Some partners used pre-test before the LHA during the implementation phase for research purposes, although these questionnaires have not been considered for the evaluation of the LHA for the project, since LHA are only evaluated after the activity. *Numbers in green indicate that the country/project objective has been met. *Numbers in red indicate that the country/project objective has not been met.

In general, countries have met the objectives set in the project in terms of number of participants, with the exception of Croatia and Cyprus in the case of ICaT (Table 3). Although the number of participants in OSA met the objective of the project (2046 pre-tests collected), there were difficulties in collecting the post-tests in OSA. This may be due to the fact that students often find the task of answering the same questionnaire twice tedious, so many did not complete it.

As mentioned above, only the questionnaires from the implementation phase were used for the evaluation, since these are the final instruments developed. In addition, some participants had not completed the questionnaire in full, so cases in which none of the Likert-type items were answered were eliminated. Questionnaires that were completed incorrectly were also eliminated (for example, some adults answered the questionnaire for secondary or primary students). However, these questionnaires were used to count the number of participants, as they recorded their code, gender, age, and other personal information that allowed participation to be verified, even if they did not complete the Likert-type items. The number of questionnaires used for the analyses is shown in Table 4:

Table 4. Sample sizes by type of activity and country from the analysis.

		Croatia		Cyprus		Germany		Portugal		Turkey		Total	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Students (Primary + Secondary)	**ICaT**	—	296	—	116	—	128	—	133	—	275	—	948
	LHA	—	137	—	321	—	2825	—	234	—	295	—	3812
	OSA	129	41	181	145	475	232	529	244	425	237	1739	899
Adults	**ICaT**	—	0	—	0	—	0	—	0	—	0	—	0
	LHA	—	4	—	0	—	7	—	105	—	0	—	116
	OSA	0	0	0	0	0	0	0	0	0	0	0	0
Total	**ICaT**	—	296	—	116	—	128	—	133	—	275	—	948
	LHA	—	141	—	321	—	2832	—	339	—	295	—	3928
	OSA	129	41	181	145	475	232	529	244	425	237	1939	899
Total Project (ICaT, LHA and OSA)		129	478	181	582	475	3192	529	716	425	807	1939	5774

Note. — Not applicable.

2.4. Statistical analysis

As for the instrument, internal reliability was assessed using Cronbach's alpha coefficient and construct validity was assessed using Confirmatory Factor Analysis (CFA). Data analysis combined descriptive statistical methods (means and standard deviations) for each item to identify general trends and variability in responses. In terms of inferential analysis, given the non-normal distribution of the variables, the non-parametric Kruskal–Wallis test was used for comparisons between countries and types of activity, supplemented by pairwise comparisons using the Dwass–Steel–Critchlow–Fligner procedure. Similarly, the Wilcoxon signed-rank test was used to perform analyses

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between paired samples (pre-test and post-test of the same participant). In the case of statistically significant differences, the effect size (ε^2) was calculated to estimate the magnitude of these differences.

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3. RESULTS

This section presents the findings derived from the evaluation of the project activities through questionnaires and case studies, as well as the results of the validity and reliability analyses of the questionnaires (see subsection 3.1). The subsection on questionnaires (3.2) is organised into several subsections presenting the pre-test and post-test results for each group, as well as the results by gender and pre-post comparisons. Each of these subsections also includes comparative analyses between countries and types of activity and the results of the statistical tests carried out. The subception about the case studies (3.3) is organised into three main points that show the results on teachers' initial interviews, teachers' retrospective interviews and students' focus groups.

3.1. Validity and reliability

This section presents the results of the validity and reliability analyses of the questionnaires collected during the implementation phase. The statistical analyses performed on the questionnaires from the piloting phase can be found in a previous report (Deliverable 5.1). Separate analyses were performed for pre-test (OSA only; 468 questionnaires) and post-test (ICaT, LHA and OSA; 1271 questionnaires) for the different samples (primary, secondary and adults). Table 6 shows the reference values for interpreting the results of Cronbach's alpha coefficient and CFA.

Table 5. Summary of reference values for interpreting the goodness of fit of the Cronbach's alpha coefficient and the adjustment indices for the CFA (Byrne, 1994; Costa & Sarmento, 2019; Hu & Bentler, 1998; 1999).

	Very good	Good/acceptable	Suffering/questionable	Bad/unacceptable
Cronbach's alpha	≥ 0.9	0.89 – 0.70	0.69 – 0.60	≥ 0.59
χ^2/df	≤ 1	1 – 2	2 – 5	> 5
CFI	≥ 0.95	0.9 – 0.95	0.8 – 0.9	< 0.8
TLI	≥ 0.95	0.9 – 0.95	0.8 – 0.9	< 0.8
SRMR	≤ 0.08	0.08 – 0.09	0.09 – 0.10	> 0.10
RMSEA	≤ 0.05/0.06	0.05/0.06 – 0.08	0.08 – 0.10	> 0.10

Note. The symbols in green and red illustrate the qualitative global evaluation for each range.

3.1.1. Pre-test

The results of the reliability and validity analyses are shown in Table 7. The results show good internal consistency for both questionnaires, although the secondary questionnaire does not perform well in terms of its dimensional structure.

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Table 6. Cronbach's alpha coefficient and CFA results for the pre-test (only OSA) for primary and secondary.

	Primary (N=468)	Secondary (N=1271)
Cronbach's alpha	.778*	.889
Cronbach's alpha DB	—	.849
Cronbach's alpha DC	—	.656*
Cronbach's alpha DD	—	.678
Qualitative global evaluation	▬	▬
Confirmatory Factor Analysis		
Chi-square		
χ^2	—	1159
df	—	74
p-value	—	<.001
Adjustment measures		
CFI	—	.887
TLI	—	.861
SRMR	—	.050
RMSEA	—	.107
Global evaluation	—	▬

Note. — = Not applicable. *Green numbers indicate adequate values. *Red numbers indicate inadequate values.

3.1.2. Post-test

Regarding the results of the post-test, analyses were performed for primary, secondary and adults' questionnaires separately. In the case of secondary questionnaires, independent analyses were performed for each type of activity since the dimension E (Evaluation of the activity) was different for each activity (Table 7). The results show good internal consistency for the three questionnaires, although the secondary questionnaire does not perform well in terms of its dimensional structure.

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Table 7. Cronbach's alpha coefficient and CFA results for the post-test.

		Primary (N=3632)	Secondary (N=2027)	Adults (N=116)
	Cronbach's Alpha	.860*	—	.879
	Cronbach's alpha ICaT (N=784)	—*	.901	—
	Cronbach's alpha LHA (N=729)	—	.882	—
	Cronbach's alpha OSA (N=514)	—	.936	—
	Global evaluation	●	●	●
ICaT	χ^2	—	1489*	—
	df	—	129	—
	p-value	—	<.001	—
	Adjustment measures			
	CFI	—	.799	—
	TLI	—	.761	—
	SRMR	—	.072	—
	RMSEA	—	.116	—
	Global evaluation	—	▬	▬
LHA	χ^2	—	1011	—
	df	—	146	—
	p-value	—	<.001	—
	Adjustment measures			
	CFI	—	.862	—
	TLI	—	.839	—
	SRMR	—	.053	—
	RMSEA	—	.090	—
	Global evaluation	—	▬	▬
OSA	χ^2	—	1247	—
	df	—	269	—
	p-value	—	<.001	—
	Adjustment measures			
	CFI	—	.869	—
	TLI	—	.854	—
	SRMR	—	.084	—
	RMSEA	—	.079	—
	Global evaluation	—	▬	▬

Note. — = Not applicable. *Green numbers indicate adequate values. *Red numbers indicate inadequate values.

In summary, analyses show that the questionnaires generally have good internal consistency. In the case of the primary and adult questionnaires, which did not establish dimensions between items, Cronbach's alpha coefficient values are high, indicating adequate homogeneity between items and high reliability of scores. However, in the secondary questionnaires, although the reliability coefficients were mostly good or excellent, the CFA showed insufficient fit to the proposed theoretical structure. For this reason, and in order to avoid potentially erroneous interpretations derived from an unstable factor structure, overall means for the questionnaires are not reported.

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However, we do consider it appropriate to make comparisons of items between different countries, always bearing in mind that they are compared and expressed individually, and do not form higher-level constructs.

3.2. Results of the questionnaires

The questionnaires (see Appendix II) were applied as a pre-test (only for OSA, in primary and secondary) and post-test (for ICaT, LHA, and OSA, in primary, secondary, and adults). The primary questionnaire consists of three different parts/dimensions: A. Demographic information (five questions); B. Attitudes and beliefs towards science (11 Likert-scale items in the pre-test and 12 in the post-test); and two open-ended questions. The adult questionnaire consists of two different parts/dimensions: A. Demographic information (five questions); and B. Evaluation of the activity (5 Likert-scale items). The secondary questionnaire consists of five different parts/dimensions: A. Demographic information (seven questions); B. Attitudes and beliefs towards science (five Likert-scale items); C. Self-efficacy towards science (five Likert-scale items); D. Interest in science studies and science career (four Likert-scale items); and E. Evaluation of the activity. Dimension E was different for ICaT (four Likert-scale items), LHA (five Likert-scale items) and OSA (11 Likert-scale items). In all cases, the Likert scale for the items has five levels, where the value “1” expresses the lowest degree of agreement with the item and “5” expresses the highest degree of agreement.

3.2.1. Pre-test

As explained above, the only activities that had a pre-test were OSA. The results of the pre-test for the OSA by group (primary, secondary, and adults) are shown below.

3.2.1.1. Primary

Primary pre-tests were only collected in Cyprus, Germany, and Portugal (Appendix I.1). The results show mostly positive scores (Figure 1), with the highest values in the items *I like to experiment* (M = 4.02; SD = 1.03) and *I can carry out scientific experiments independently* (M = 3.97; SD = 1.06). The items with the lowest means are *What I learned today is important for my future career* (M = 3.05; SD = 1.19) and *I am interested in today's topic* (M = 3.08; SD = 1.14). The standard deviations (slightly above 1 for all items) show moderate variability.

Regarding the differences between countries (Figure 2), Portugal stands out with the highest means and lowest standard deviations in almost all items, reflecting positive scores and homogeneity in the responses. Items such as *I like to experiment* (M = 4.83; SD = 0.43) and *I can carry out scientific experiments independently* (M = 4.92; SD = 0.37) stand out in particular. Germany shows moderately high results with wider deviations, suggesting more diverse perceptions within the group. Cyprus

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shows the lowest scores and the highest standard deviations on almost all items (e.g. *I like natural sciences*, M = 3.01; SD = 1.50; and *The workshop helped me learn new things*, M = 2.83; SD = 1.43).

The Kruskal-Wallis test (Table 8) showed that there are statistically significant differences between countries on all items in the questionnaire except one (*I would like to find out more about this topic*), indicating that participants' perceptions of science, technology, and the workshop experience differ depending on the national context. Four items show a very large effect size, four show medium or large effects, and three show medium or small effects. This suggests that, although differences between countries are widespread, their practical impact is particularly relevant in certain items of the questionnaire. The results of items related to autonomy and scientific experimentation stand out, such as *I can carry out scientific experiments independently* ($\chi^2 = 167.14$; $p < .001$; $\varepsilon^2 = 0.360$) and *I like to experiment* ($\chi^2 = 142.46$; $p < .001$; $\varepsilon^2 = 0.306$). Pairwise tests[1] showed that Cyprus was the country with more statistical differences with the rest of the countries.

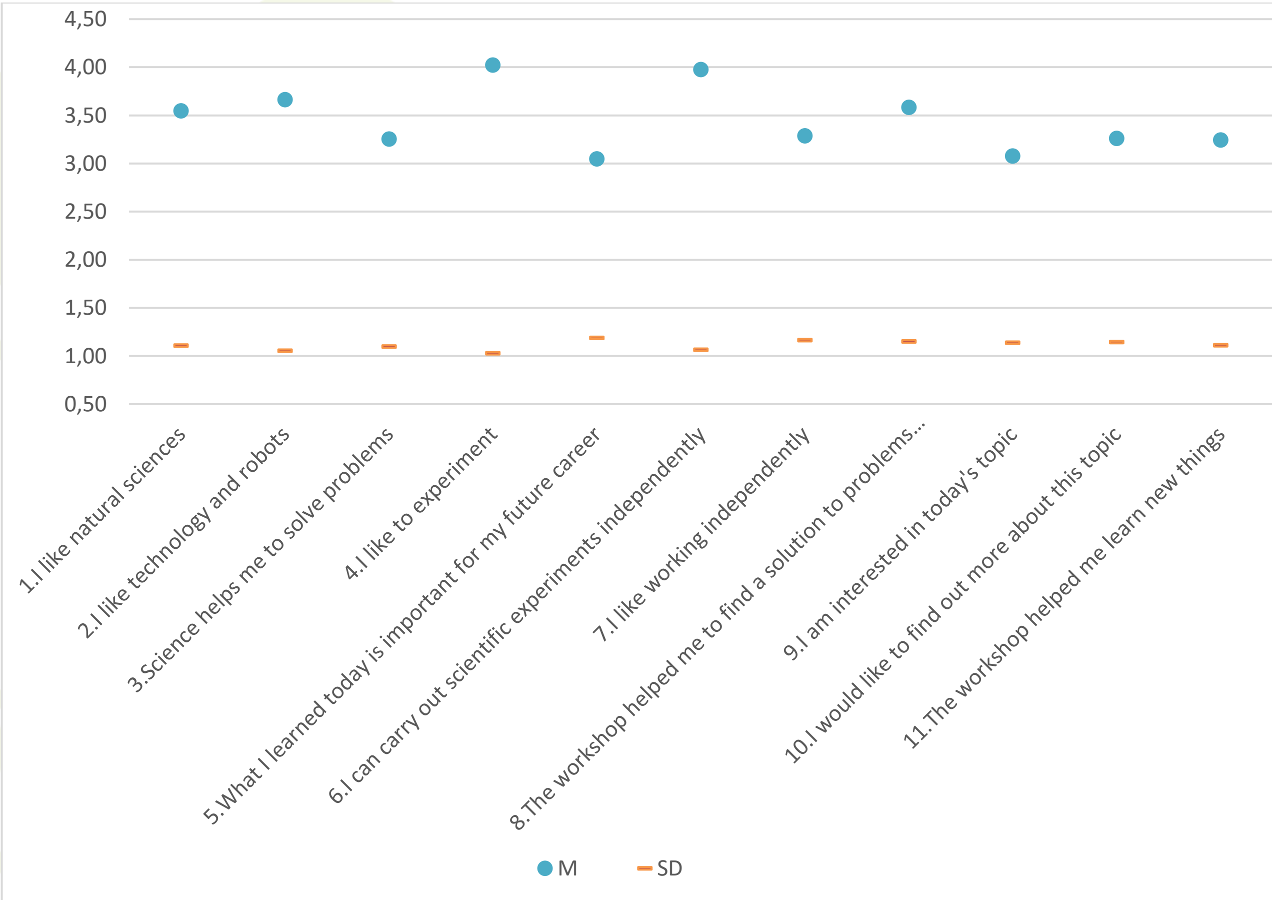

Figure 1. Mean and standard deviation of primary pre-tests.

[1] Peer testing was performed using the Dwass-Steel-Critchlow-Fligner post-hoc test. Not all results from this test have been included due to the large volume of tables obtained. Only the values for the most notable results are shown.

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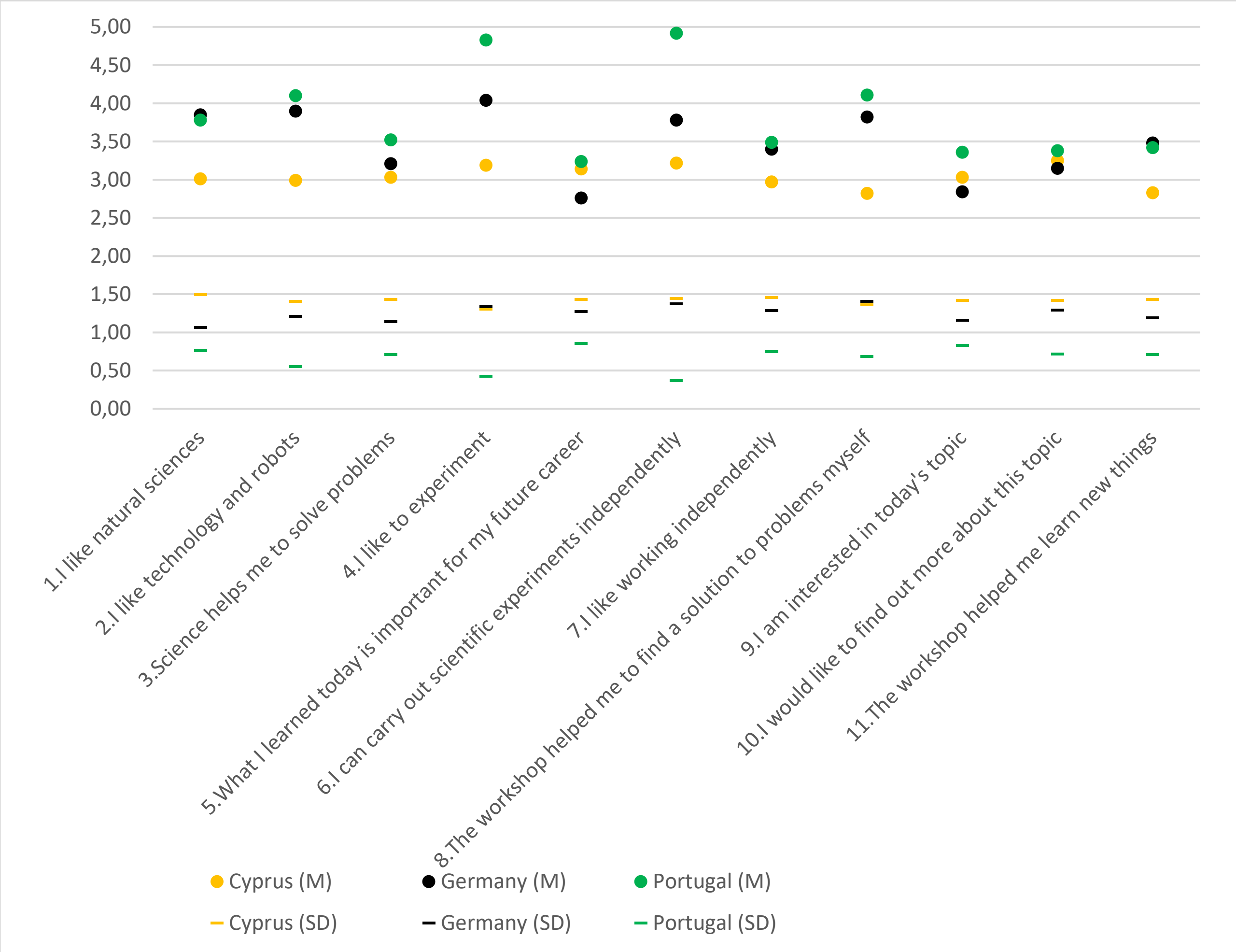

Figure 2. Mean and standard deviation of primary pre-tests by country.

Table 8. Results of the Kruskal-Wallis test for the primary pre-tests.

Item	χ^2	df	p	ε^2
1.I like natural sciences	26.74	2	<.001	0.057
2.I like technology and robots	51.10	2	<.001	0.109
3.Science helps me to solve problems	10.42	2	0.005	0.022
4.I like to experiment	142.46	2	<.001	0.306
5.What I learned today is important for my future career	15.10	2	<.001	0.033
6.I can carry out scientific experiments independently	167.14	2	<.001	0.360
7.I like working independently	8.75	2	0.013	0.019
8.The workshop helped me to find a solution to problems myself	64.39	2	<.001	0.139
9.I am interested in today's topic	17.85	2	<.001	0.038
10.I would like to find out more about this topic	1.77	2	0.413	0.004
11.The workshop helped me learn new things	19.90	2	<.001	0.043

Note. χ^2 = chi-square; df = degrees of freedom; p = p-value; ε^2 = effect size[2].

[2] Interpretation: $\varepsilon^2 < 0.01$, small; $0.01 \le \varepsilon^2 < 0.06$, medium; $0.06 \le \varepsilon^2 < 0.14$, large; $\varepsilon^2 \ge 0.14$, very large (Cohen, 1988)

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3.2.1.2. Secondary

Secondary pre-tests were collected in all the countries (Appendix I.2). The results show mostly positive scores, with moderate differences between the various items (Figure 3). The highest mean values are found in dimension B (Attitudes and beliefs towards science), especially in the items *Science is interesting* (M = 3.98; SD = 1.07) and *I enjoy learning science* (M = 3.78; SD = 1.16). In dimension C (Self-efficacy towards science), items such as *I can learn and use scientific skills* (M = 3.38; SD = 1.13) and *I can apply scientific knowledge to real-world situations* (M = 3.41; SD = 1.08) also had relatively high scores, and the lowest means were observed in items in dimension D (Interest in science studies and science career), particularly *A family member of mine works in a science-related field* (M = 2.72; SD = 1.62) and *I am interested in careers that use science, mathematics, or technology* (M = 3.48; SD = 1.33). In terms of dispersion, standard deviations range from approximately 1.0 to 1.6 across all items, reflecting moderate variability in the responses. Items with lower means, especially in dimension D (Interest in science studies and science career), also tend to show greater variability.

The results show differences between countries (Figure 4). Portugal stands out with the highest means and lowest standard deviations in almost all items, reflecting positive and homogeneous scores among participants. Items such as *I like to experiment* (M = 4.83; SD = 0.43) and *I can carry out scientific experiments independently* (M = 4.92; SD = 0.37) stand out in particular. Germany has moderately high results, although with wider standard deviations, suggesting more diverse perceptions. Cyprus, on the other hand, shows the lowest scores and highest standard deviations on almost all items (e.g., *I like natural sciences*, M = 3.01; SD = 1.50; and *The workshop helped me learn new things*, M = 2.83; SD = 1.43), indicating a lower overall assessment of the activities and greater heterogeneity in responses.

The Kruskal-Wallis test (Table 9) showed that there are statistically significant differences between countries in all items. Four items show a very large effect size, four show large or medium effects, and three show medium or small effects. Particularly noteworthy are the results of items related to dimension B (Attitudes and beliefs towards science), such as *I can communicate effectively about scientific topics with others* ($\chi^2 = 303.2$; $p < .001$; $\varepsilon^2 = 0.240$) and *I can apply scientific knowledge to real-world situations* ($\chi^2 = 205.7$; $p < .001$; $\varepsilon^2 = 0.163$), both with very large effect sizes. Pairwise comparisons showed that Germany was the country that presented the most differences with respect to the others, especially in items in dimension C (Self-efficacy towards science), such as *I can learn and use scientific skills*, where comparisons with Portugal ($W = 13.114$; $p < .001$), Turkey ($W = 12.053$; $p < .001$), and Croatia ($W = -10.638$; $p < .001$) were statistically significant. Cyprus also differed on several items, especially when compared to Germany and Portugal. In contrast, Turkey and Croatia showed fewer significant differences between themselves and with the other countries, suggesting more homogeneous perceptions among their participants.

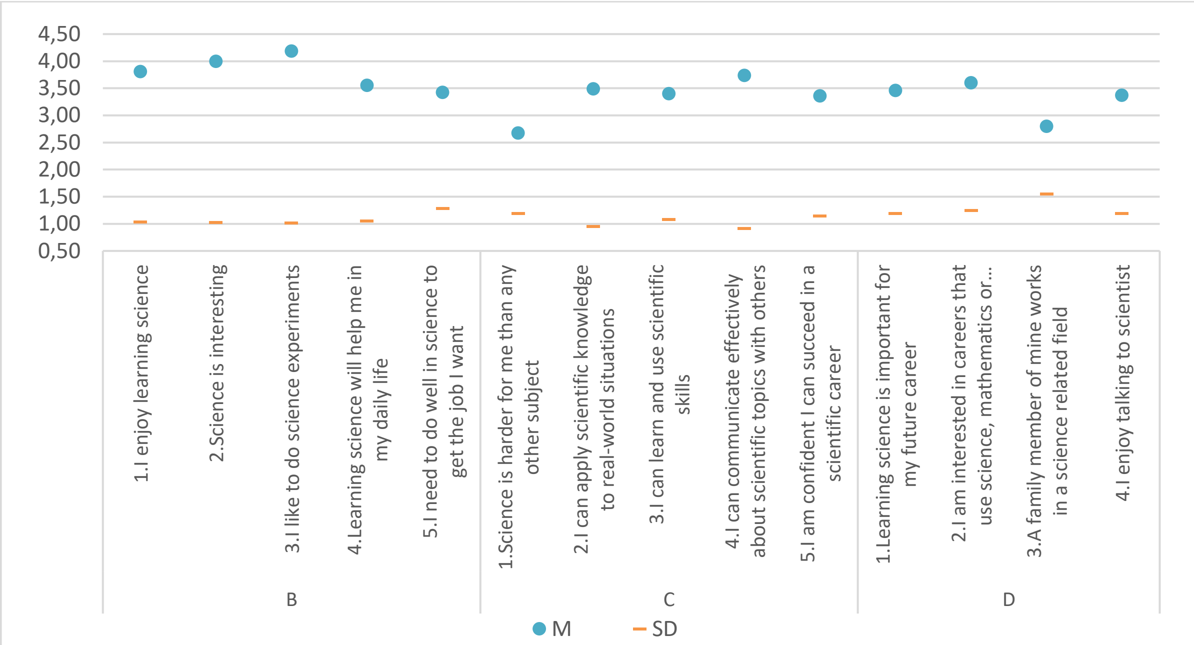

Figure 3. Mean and standard deviation of secondary pre-tests.

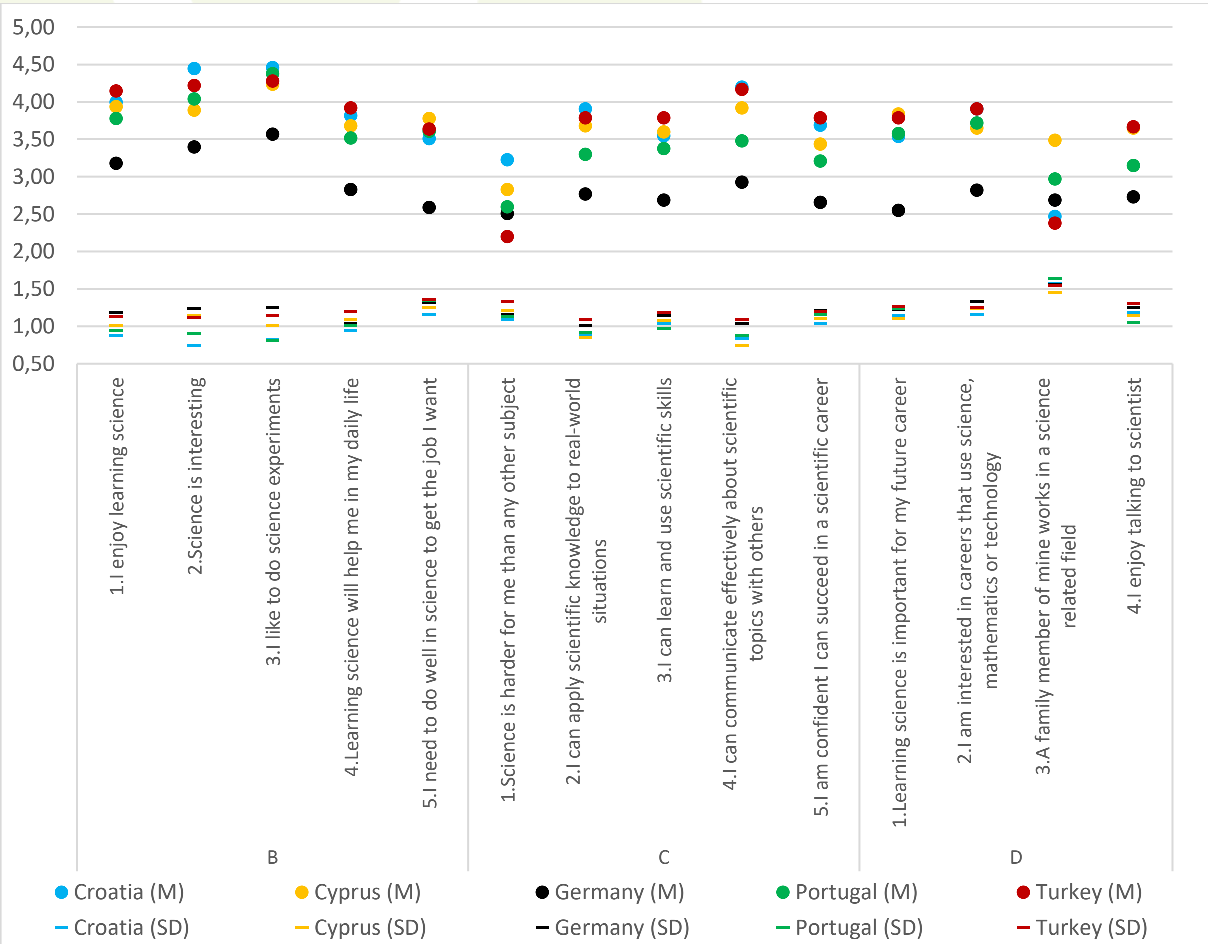

Figure 4. Mean and standard deviation of secondary pre-tests by country.

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Table 9. Results of the Kruskal-Wallis test for the secondary pre-tests.

Dimension	Item	χ²	df	p	ε²
B	**1.I enjoy learning science**	159.3	4	<.001	0.125
	2.Science is interesting	135.4	4	<.001	0.107
	3.I like to do science experiments	116.4	4	<.001	0.092
	4.Learning science will help me in my daily life	187.2	4	<.001	0.148
	5.I need to do well in science to get the job I want	130.7	4	<.001	0.103
C	**1.Science is harder for me than any other subject**	88.1	4	<.001	0.070
	2.I can apply scientific knowledge to real-world situations	205.7	4	<.001	0.163
	3.I can learn and use scientific skills	162.0	4	<.001	0.128
	4.I can communicate effectively about scientific topics with others	303.2	4	<.001	0.240
	5.I am confident I can succeed in a scientific career	159.8	4	<.001	0.127
D	**1.Learning science is important for my future career**	177.8	4	<.001	0.142
	2.I am interested in careers that use science, mathematics or technology	134.3	4	<.001	0.107
	3.A family member of mine works in a science related field	43.9	4	<.001	0.035
	4.I enjoy talking to scientist	122.6	4	<.001	0.098

Note. χ² = chi-square; df = degrees of freedom; p = p-value; ε² = effect size.

3.2.2. Post-test

3.2.2.1. Primary

Primary post-tests were collected in Croatia, Cyprus, Germany, and Portugal (Appendix I.3). The results show generally positive scores (Figure 5), although some cross-country differences can be observed. The highest mean values are observed in Germany and Portugal for the items *I like to experiment* (Germany: M = 4.53; SD = 0.91; Portugal: M = 4.95; SD = 0.32) and *I like technology and robots* (Germany: M = 4.29; SD = 1.02; Portugal: M = 4.29; SD = 0.55). Conversely, the lowest mean values appear mainly in Croatia and Cyprus for the item *What I learned today is important for my future career* (Croatia: M = 3.00; SD = 1.16; Cyprus: M = 3.67; SD = 1.23). Standard deviations remain moderate, generally around 1 point, which reflects consistent responses within each country.

The results show differences between the countries (Figure 6). Germany and Portugal stand out with the highest means and the lowest standard deviations in most items, reflecting positive scores and consistency in the participants' responses. Cyprus shows moderately positive results, with intermediate means and slightly higher dispersion (e.g., *Science helps me to solve problems*, M = 3.80; SD = 1.26), indicating greater variability. Croatia, on the other hand, presents the lowest scores on most items (e.g., *I like natural sciences*, M = 2.32; SD = 1.25).

The Kruskal-Wallis test (Table 10) showed that there are statistically significant differences between countries on all items in the questionnaire except one (*The workshop helped me to find a solution to problems myself*). Four items show a large effect size, while most of the remaining items show small to medium effects. The most pronounced differences are observed in *I like to experiment* (χ^2 = 375.26; $p < .001$; ε^2 = 0.105) and *I liked the topic today* (χ^2 = 318.75; $p < .001$; ε^2 = 0.080). Pairwise

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tests showed that Cyprus was the country with the greatest number of statistically significant differences compared with the others, particularly with Germany and Portugal, which systematically presented the highest mean scores.

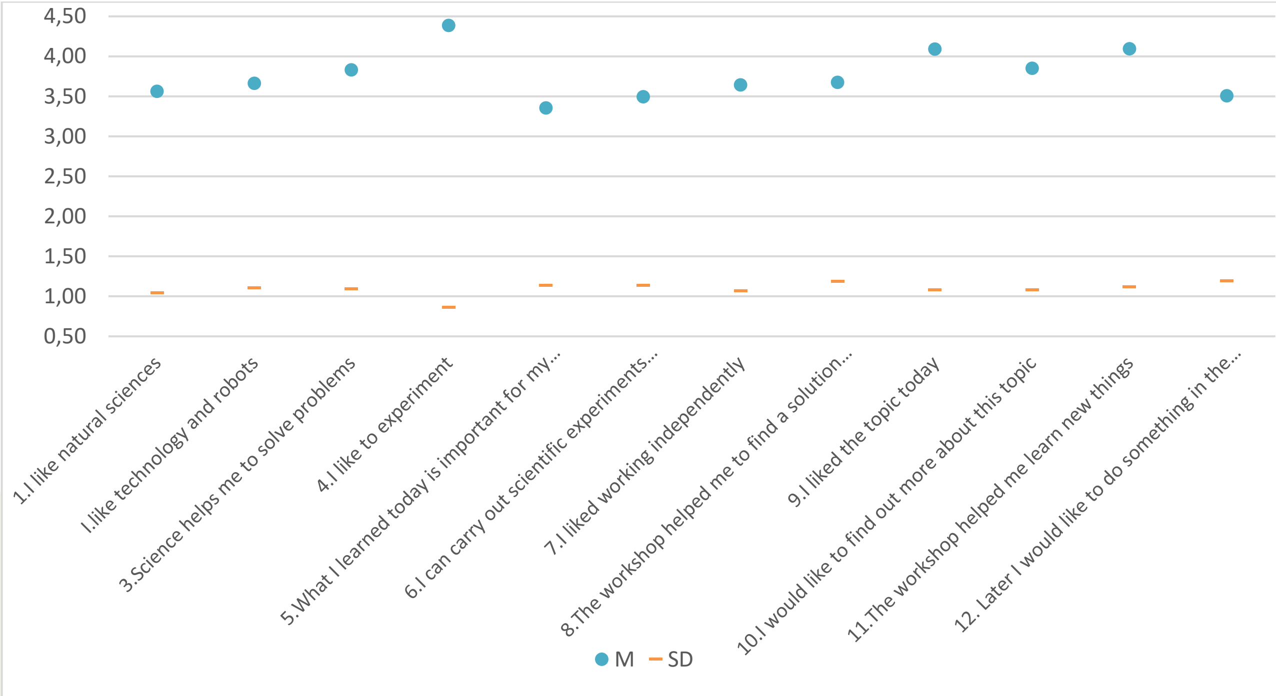

Figure 5. Mean and standard deviation of primary post-tests for all countries.

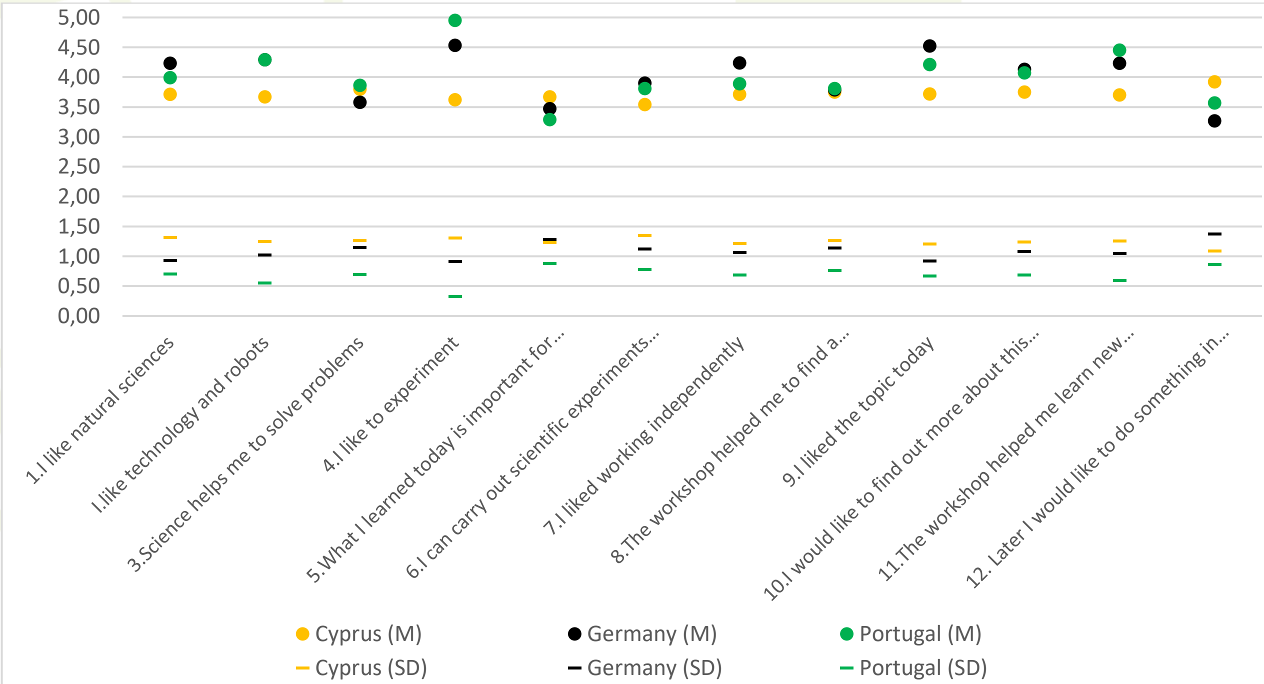

Figure 6. Mean and standard deviation of primary post-tests by country.

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Table 10. Results of the Kruskal-Wallis test for the primary post-tests.

Item	χ^2	df	p	ε^2
1.I like natural sciences	123.84	3	<.001	0.035
2.I like technology and robots	155.92	3	<.001	0.044
3.Science helps me to solve problems	31.96	3	<.001	0.009
4.I like to experiment	375.26	3	<.001	0.105
5.What I learned today is important for my future career	25.92	3	<.001	0.007
6.I can carry out scientific experiments independently	46.88	3	<.001	0.013
7.I like working independently	179.05	3	<.001	0.052
8.The workshop helped me to find a solution to problems myself	2.63	3	0.452	7.59e-4
9.I am interested in today's topic	318.75	3	<.001	0.080
10.I would like to find out more about this topic	53.70	3	<.001	0.015
11.The workshop helped me learn new things	79.33	3	<.001	0.022
12. Later I would like to do something in the natural sciences	62.73	3	<.001	0.018

Note. χ^2 = chi-square; df = degrees of freedom; p = p-value; ε^2 = effect size.

Regarding the different types of activities (Figure 7), the results show that LHA had the highest means in almost all items, with values close to or above 4.0, such as in *I like to experiment* (M = 4.48; SD = 0.93) and *I like working independently* (M = 4.21; SD = 1.05). In the case of OSA, high scores were also recorded, although accompanied in some cases by slightly higher standard deviations, suggesting greater variability in responses. For their part, ICaT had the lowest means on most items, such as *What I learned today is important for my future career* (M = 3.00; SD = 1.20) and *I am interested in today's topic* (M = 3.10; SD = 1.15), along with a more marked dispersion.

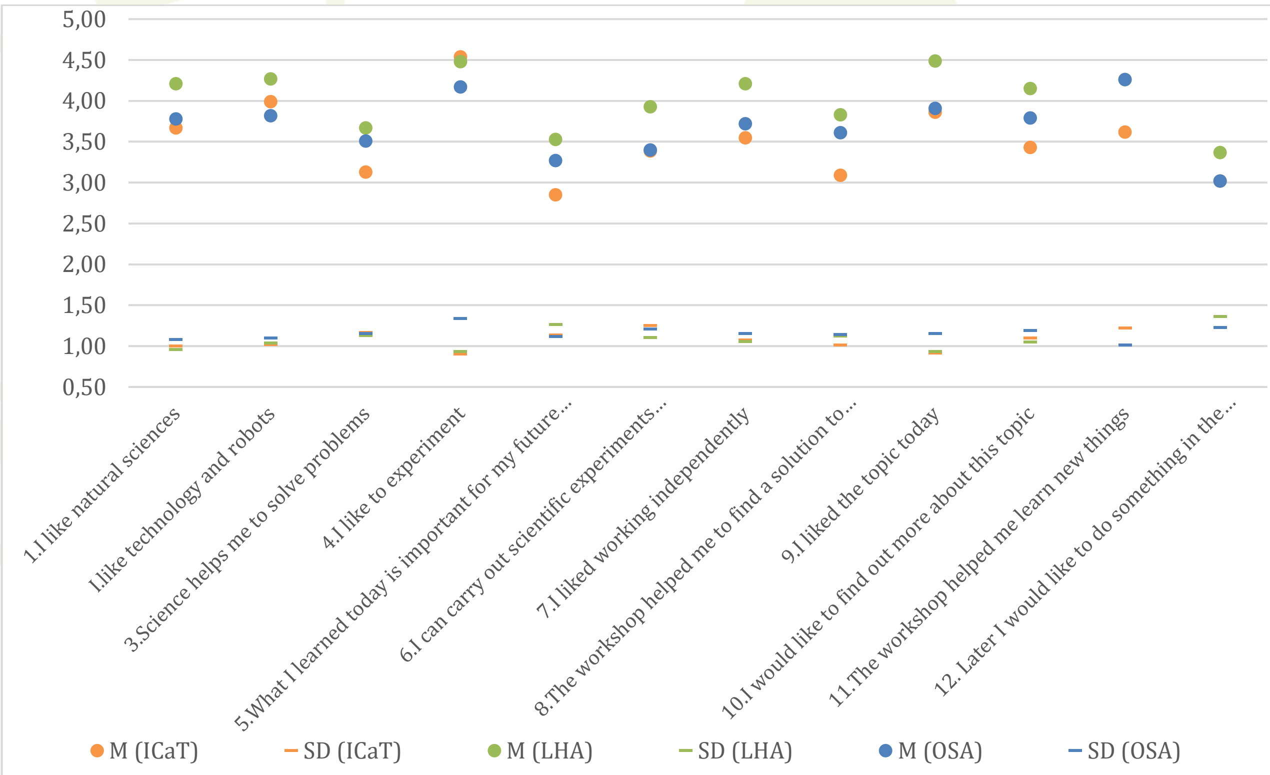

Figure 7. Mean and standard deviation of primary post-tests by type of activity.

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The Kruskal-Wallis test (Table 11) showed that there are statistically significant differences between activities on all items. Four items show a large effect size, while most of the remaining items show small to medium effects. The most pronounced differences are observed in *I liked the topic today* (χ^2 = 252.50; p < .001; ε^2 = 0.071) and *I liked working independently* (χ^2 = 133.40; p < .001; ε^2 = 0.038). Pairwise tests showed that LHA was the group with the greatest number of statistically significant differences compared with the others (particularly with ICaT), which generally obtained the highest mean scores.

Table 11. Results of the Kruskal-Wallis test for the primary post-tests by type of activity.

Item	χ^2	df	p	ε^2
1.I like natural sciences	118.1	2	<.001	0.033
2.I like technology and robots	105.0	2	<.001	0.030
3.Science helps me to solve problems	35.8	2	<.001	0.010
4.I like to experiment	10.1	2	0.006	0.003
5.What I learned today is important for my future career	63.8	2	<.001	0.018
6.I can carry out scientific experiments independently	95.6	2	<.001	0.027
7.I like working independently	133.4	2	<.001	0.039
8.The workshop helped me to find a solution to problems myself	63.1	2	<.001	0.018
9.I am interested in today's topic	252.5	2	<.001	0.071
10.I would like to find out more about this topic	112.0	2	<.001	0.032
11.The workshop helped me learn new things	99.3	2	<.001	0.028
12. Later I would like to do something in the natural sciences	12.8	2	0.002	0.004

Note. χ^2 = chi-square; df = degrees of freedom; p = p-value; ε^2 = effect size.

3.2.2.2. Secondary

The results from the secondary post-tests are shown in Appendix I.4. There are generally positive scores, being the highest mean values found in dimension B (Attitudes and beliefs towards science), particularly in *I like to do science experiments* (M = 4.15; SD = 0.98) and *Science is interesting* (M = 3.97; SD = 0.94). In contrast, the item *I need to do well in science to get the job I want* (M = 3.49; SD = 1.23) shows a slightly lower mean. In dimension C (Self-efficacy towards science), the results also show moderately positive scores, with higher means in *I can communicate effectively about scientific topics with others* (M = 3.73; SD = 0.95) and lower in *Science is harder for me than any other subject* (M = 2.78; SD = 1.16). Regarding dimension D (Interest in science studies and science career), students report positive scores about future professional possibilities related to science, as shown in *I am interested in careers that use science, mathematics or technology* (M = 3.63; SD = 1.17), while items such as *A family member of mine works in a science related field* (M = 3.02; SD = 1.49) obtain lower values.

Finally, dimension E (Evaluation of the activity) presents overall positive scores across all types of activity. The items *Was fascinating* (E-LHA: M = 4.14; SD = 0.94; E-OSA: M = 3.98; SD = 1.04) and *The guest speaker(s) clearly presented their career path and I learned something new about their* *profession* (E-ICaT: M = 4.08; SD = 0.84) show particularly high means. Conversely, items such as *Required that I collaborate with people from industry* (M = 2.84; SD = 1.25) present the lowest scores.

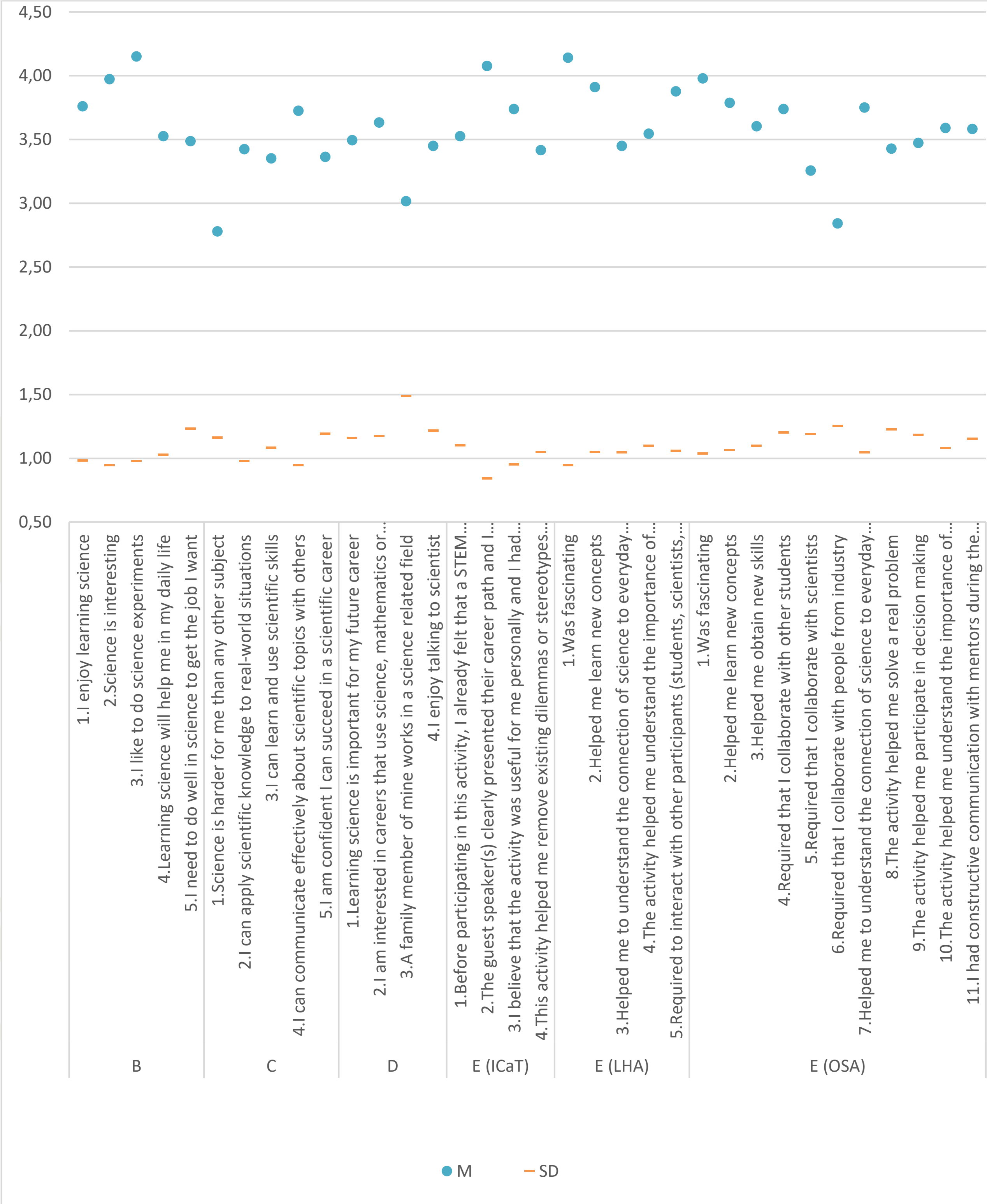

Figure 8. Mean and standard deviation of secondary post-test (dimensions B, C and D).

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Portugal and Cyprus stand out with the highest means and the lowest standard deviations in most items, reflecting generally positive scores and consistency in the responses. For instance, Portuguese students show particularly high values in the item *The guest speaker(s) clearly presented their career path and I learned something new about their profession* (ICaT, M = 4.68; SD = 0.53). Cyprus also exhibits high and stable scores (e.g. the item *Was fascinating* in LHA —M = 4.50; SD = 0.67— and *Required to interact with other participants* —M = 4.38; SD = 0.55—). Germany and Turkey show moderately positive scores, with intermediate means and greater dispersion (e.g., *I can apply scientific knowledge to real-world situations* —Germany M = 2.79; SD = 1.00, and Turkey M = 3.67; SD = 1.21—), reflecting more variability in the responses. Croatia presents the lowest scores in most items (e.g., *Science is harder for me than any other subject*, M = 3.34; SD = 1.17).

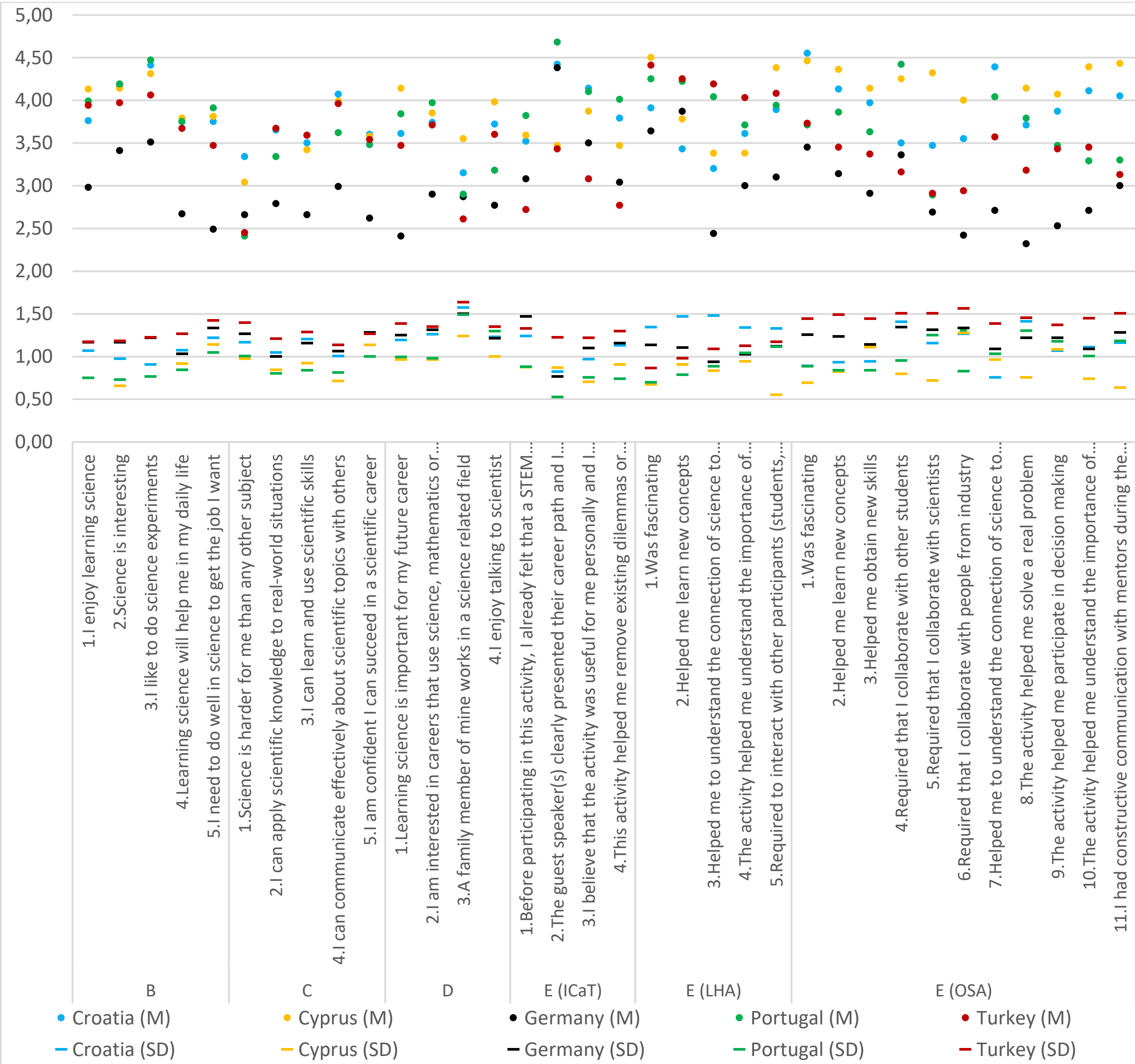

Figure 9. Mean and standard deviation of secondary students' post-test by country.

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The Kruskal-Wallis test (Table 11) showed that there are statistically significant differences between countries on all items. Five items show a large effect size, while the rest of them show small to medium effects. The most pronounced differences are observed in *I can communicate effectively about scientific topics with others* ($\chi^2 = 216.00$; $p < .001$; $\varepsilon^2 = 0.108$) and *Learning science is important for my future career* ($\chi^2 = 204.10$; $p < .001$; $\varepsilon^2 = 0.102$). Other items with large effect sizes include *Science is harder for me than any other subject* ($\chi^2 = 178.20$; $p < .001$; $\varepsilon^2 = 0.089$*), Learning science will help me in my daily life* ($\chi^2 = 168.90$; $p < .001$; $\varepsilon^2 = 0.083$), and *I need to do well in science to get the job I want* ($\chi^2 = 165.30$; $p < .001$; $\varepsilon^2 = 0.082$). Pairwise tests showed that Germany was the country with the greatest number of statistically significant differences compared with the others (particularly with Portugal and Cyprus), which systematically presented the highest mean scores across most items.

Table 11. Results of the Kruskal-Wallis test for the secondary post-tests by country.

Dimension	Item	χ^2	df	p	ε^2
B	**1.I enjoy learning science**	155.3	4	<.001	0.0767
	2.Science is interesting	88.3	4	<.001	0.0436
	3.I like to do science experiments	137.0	4	<.001	0.0676
	4.Learning science will help me in my daily life	168.9	4	<.001	0.0834
	5.I need to do well in science to get the job I want	165.3	4	<.001	0.0816
C	**1.Science is harder for me than any other subject**	178.2	4	<.001	0.0887
	2.I can apply scientific knowledge to real-world situations	152.3	4	<.001	0.0758
	3.I can learn and use scientific skills	118.8	4	<.001	0.0591
	4.I can communicate effectively about scientific topics with others	216.0	4	<.001	0.1075
	5.I am confident I can succeed in a scientific career	105.0	4	<.001	0.0522
D	**1.Learning science is important for my future career**	204.1	4	<.001	0.1018
	2.I am interested in careers that use science, mathematics or technology	95.7	4	<.001	0.0477
	3.A family member of mine works in a science related field	61.9	4	<.001	0.0309
	4.I enjoy talking to scientist	132.1	4	<.001	0.0659

Note. χ^2 = chi-square; df = degrees of freedom; p = p-value; ε^2 = effect size.

The results show that LHA obtained the highest means in most items, with values close to or above 4.0, such as *I like to do science experiments* (M = 4.30; SD = 0.96) and *Science is interesting* (M = 4.15; SD = 0.95) (Figure 10). The ICaT also presents relatively high scores, as seen in *I like to do science experiments* (M = 4.14; SD = 1.08) and *I enjoy learning science* (M = 3.78; SD = 1.00). In contrast, OSA shows more moderate values in several items, particularly in Learning science will help me in my daily life (M = 3.36; SD = 1.31) and *I need to do well in science to get the job I want* (M = 3.32; SD = 1.43). Overall, the dispersion of responses is moderate across all activities, with standard deviations around 1, reflecting a generally consistent perception among participants, though slightly greater variability in OSA.

There also are statistically significant differences between activities on all items, except in the item *I am confident I can succeed in a scientific career* (Table 12). Five items show a medium effect size, while the rest show small effects. The most pronounced differences are in the items *Science is* *harder for me than any other subject* (χ^2 = 55.02; p < .001; ε^2 = 0.027), *I can learn and use scientific skills* (χ^2 = 24.66; p < .001; ε^2 = 0.012), and *Learning science will help me in my daily life* (χ^2 = 24.36; p < .001; ε^2 = 0.012). Other items with notable differences are *I enjoy learning science* (χ^2 = 20.92; p < .001; ε^2 = 0.010), and *Learning science is important for my future career* (χ^2 = 18.02; p < .001; ε^2 = 0.009). Pairwise tests showed that the LHA was the one with the greatest number of statistically significant differences compared to ICaT and OSA. In general, ICaT systematically presented the highest mean scores across most items, while OSA showed lower averages.

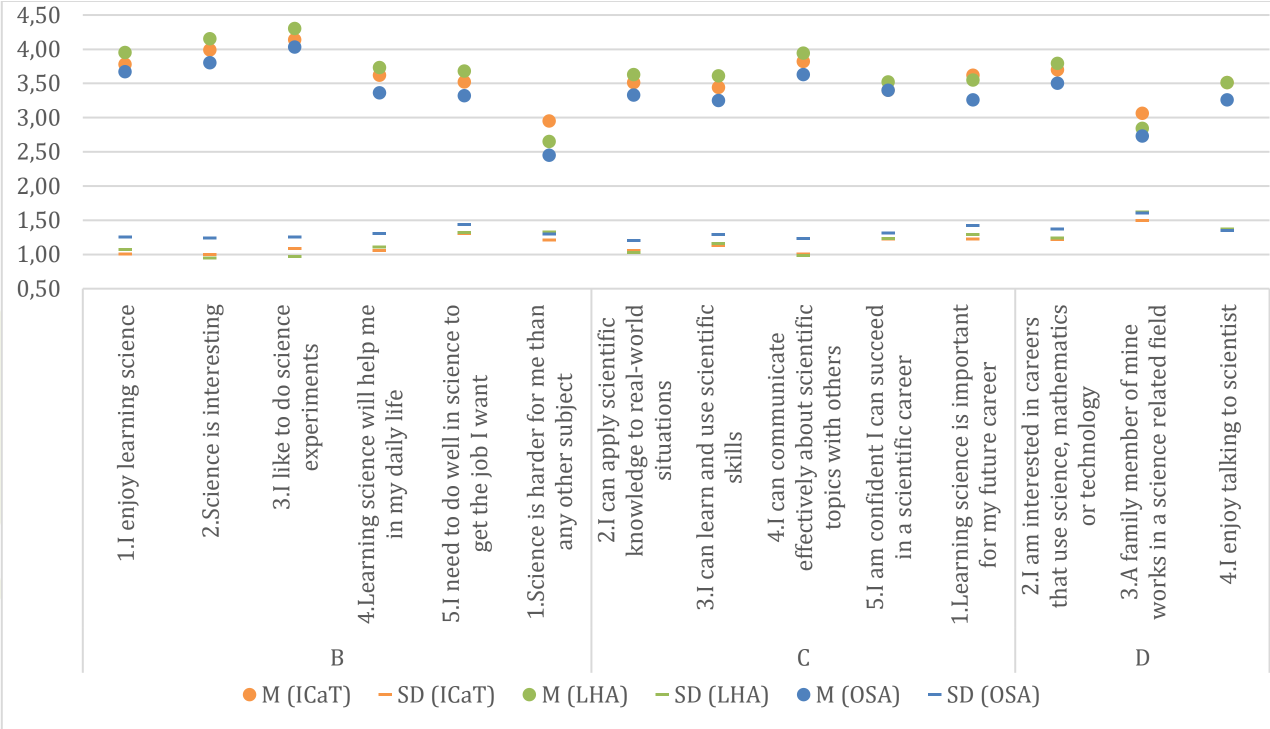

Figure 10. Mean and standard deviation of secondary students' post-test by type of activity.

Table 12. Results of the Kruskal-Wallis test for the secondary post-tests by type of activity.

Dimension	Item	χ^2	df	p	ε^2
B	1.I enjoy learning science	20.92	2	<.001	0.010
	2.Science is interesting	23.56	2	<.001	0.012
	3.I like to do science experiments	11.60	2	0.003	0.006
	4.Learning science will help me in my daily life	24.36	2	<.001	0.012
	5.I need to do well in science to get the job I want	20.70	2	<.001	0.010
C	1.Science is harder for me than any other subject	55.02	2	<.001	0.027
	2.I can apply scientific knowledge to real-world situations	17.43	2	<.001	0.009
	3.I can learn and use scientific skills	24.66	2	<.001	0.012
	4.I can communicate effectively about scientific topics with others	15.71	2	<.001	0.008
	5.I am confident I can succeed in a scientific career	3.44	2	0.179	0.002
D	1.Learning science is important for my future career	18.02	2	<.001	0.009
	2.I am interested in careers that use science, mathematics or technology	14.14	2	<.001	0.007
	3.A family member of mine works in a science related field	12.49	2	0.002	0.006
	4.I enjoy talking to scientist	19.97	2	<.001	0.010

3.2.2.3. *Adults*

Adults' post-tests were collected in Croatia, Germany, and Portugal (Appendix I.5) and only after LHA. The results show generally positive scores and standard deviations remain generally low (Figure 11). However, the very high mean scores observed in Croatia (M = 5.00 in all items) and the overall positive results in Portugal should be interpreted considering the extremely small sample size in both countries (Croatia, N = 4; Portugal, N = 7). This reduces the representativeness of these results and limit the validity of direct comparisons between countries. Regarding the differences between the countries (Figure 12), as mentioned before, although Croatia and Portugal display the highest means across most items, these results are not fully comparable to those from Germany due to substantial differences in sample size.

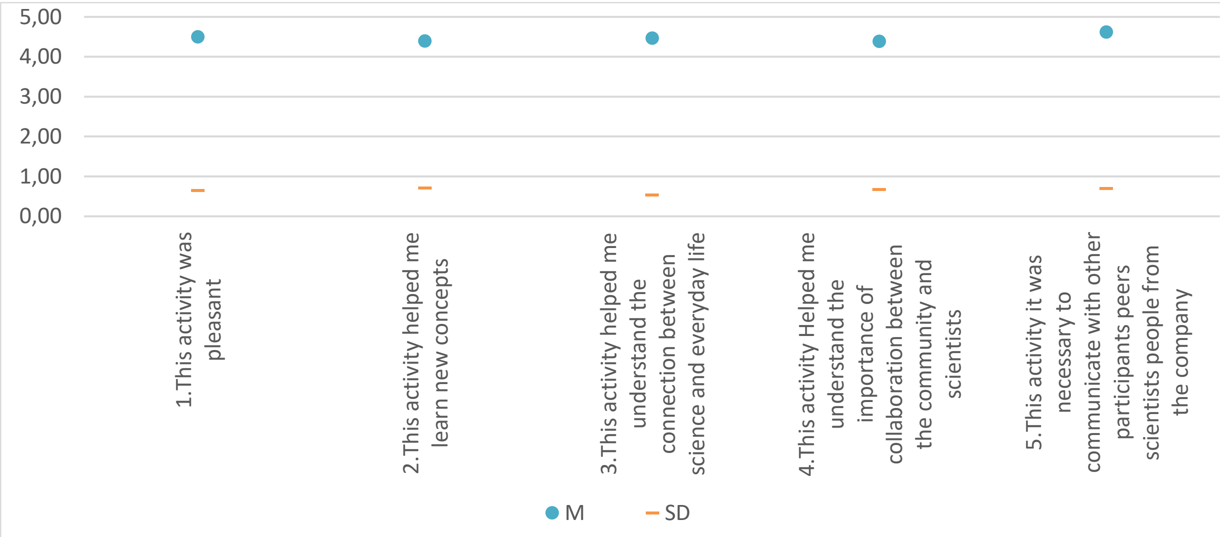

Figure 11. Mean and standard deviation of adults' post-test for all countries.

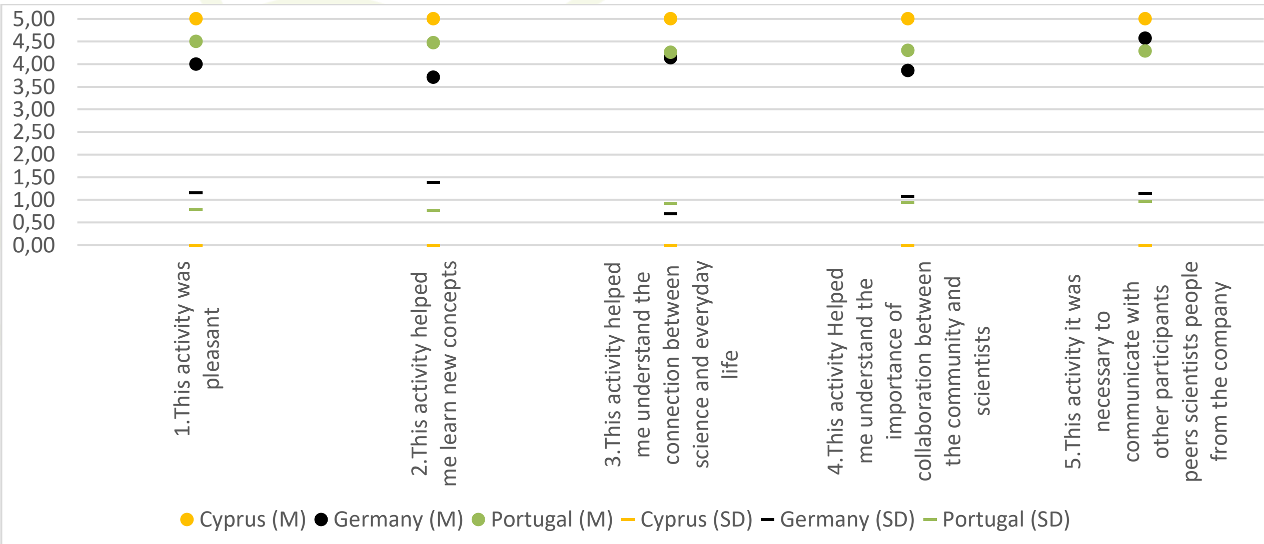

Figure 12. Mean and standard deviation of adults' post-test by country.

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The Kruskal–Wallis test showed that there was only one statistically significant difference between countries, found in *This activity helped me learn new concepts* ($\chi^2 = 6.06$; $p = .048$; $\varepsilon^2 = 0.053$). However, these differences disappear when performing pair tests. Therefore, the results do not support consistent cross-country comparisons in adults' questionnaires.

3.2.3. Results by gender

The response options for the variable "Gender" included the options "Female", "Male" and "Diverse." Since very few participants selected the option "Diverse", this data has not been represented in the tables and graphs. One primary student and five secondary students marked this option in OSA. Gender differences among adult participants were not studied, as this was not an objective of the project.

3.2.3.1. Primary

- ICaT

The results from the primary post-tests for ICaT are shown in Table 13, while Figure 11 shows the mean and standard deviation by gender. Overall, both girls and boys expressed positive scores, with the item *I like to experiment* receiving the highest average score among both groups (M = 4.51 girls; M = 4.57 boys). Girls reported slightly higher levels of interest in natural sciences than boys (Item 1; M = 3.73 girls, M = 3.61 boys), and a greater appreciation of the workshop's educational value (Item 11; M = 3.76 girls; M = 3.45 boys). Conversely, boys showed a notably stronger interest in technology and robots (Item 2; M = 4.29 boys; M = 3.71 girls) and a slightly higher inclination to consider a future in natural sciences (Item 12; M = 3.06 boys; girls M = 2.96). Perceptions of autonomy were relatively similar across genders, although girls scored higher in *I liked working independently* (M = 3.69 girls; M = 3.39 boys). Standard deviations were generally moderate, indicating some variability, particularly among boys in items such as enjoyment of independent work (Item 7; SD = 1.23) and perceived learning (Item 11; SD = 1.28). The Mann-Whitney U test (Table 14) showed that there are no significant differences for the gender variable except for the item 2, in which boys showed more interest in technology and robots.

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Table 13. Sample size, lost values, mean and standard deviation of primary post-tests for each item and gender in ICaT.

	Female				Male			
	N	Lost	Mean	SD	N	Lost	Mean	SD
1.I like natural sciences	84	0	3.73	1.02	79	0	3.61	0.98
2.like technology and robots	83	1	3.71	1.10	79	0	4.29	0.85
3.Science helps me to solve problems	83	1	3.19	1.19	77	2	3.06	1.14
4.I like to experiment	84	0	4.51	1.02	77	2	4.57	0.77
5.What I learned today is important for my future career	79	5	2.81	1.12	75	4	2.89	1.16
6.I can carry out scientific experiments independently	80	4	3.39	1.26	77	2	3.40	1.26
7.I liked working independently	58	26	3.69	0.90	51	28	3.39	1.23
8.The workshop helped me to find a solution to problems myself	61	23	3.11	0.97	51	28	3.06	1.09
9.I liked the topic today	82	2	3.91	0.86	77	2	3.79	0.96
10.I would like to find out more about this topic	83	1	3.47	1.08	78	1	3.37	1.12
11.The workshop helped me learn new things	76	8	3.76	1.15	75	4	3.45	1.28
12. Later I would like to do something in the natural sciences	83	1	2.96	1.17	77	2	3.06	1.29

Note. N = sample size; Lost = Lost data; SD = Standard deviation.

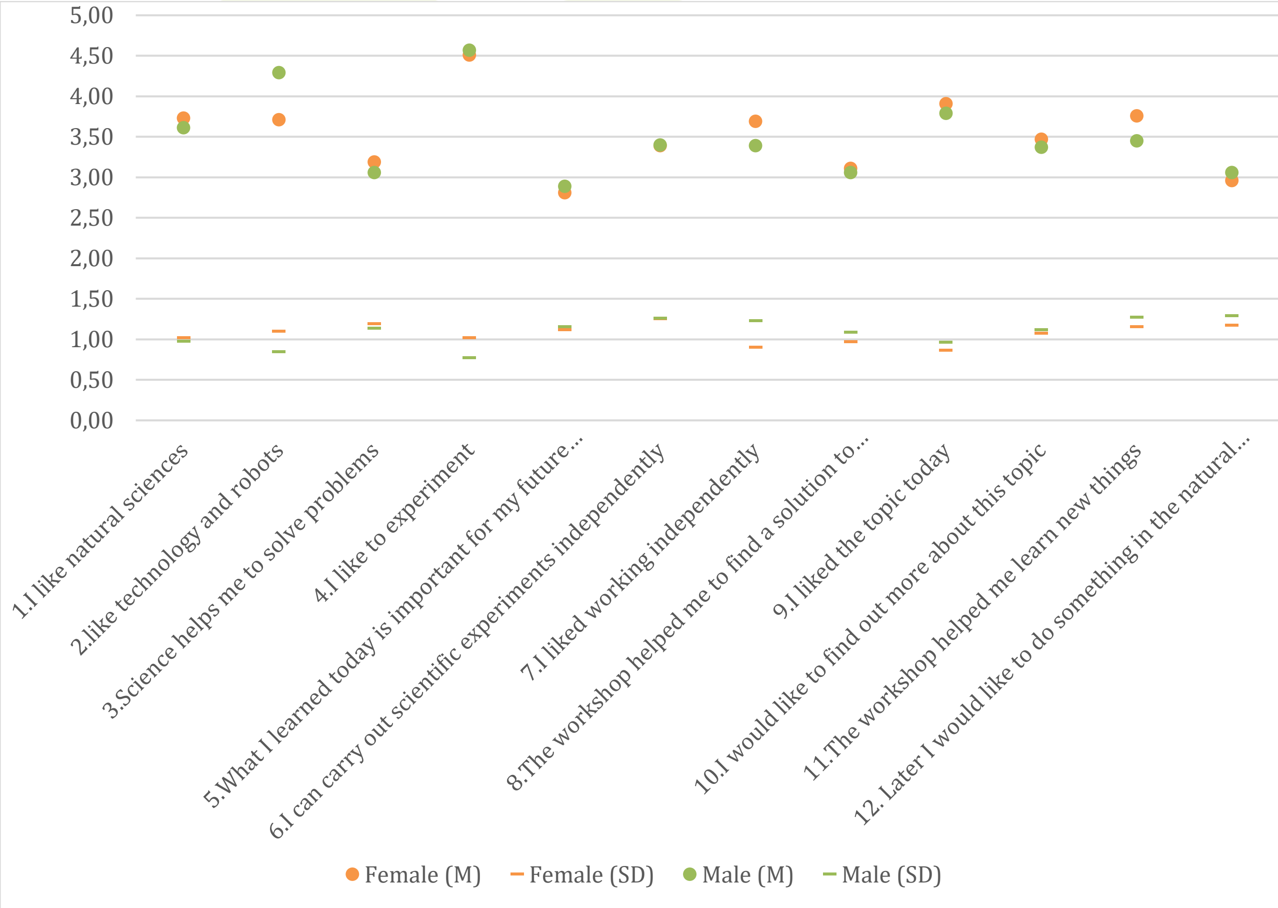

Figure 13. Mean and standard deviation of primary post-test by gender in ICaT.

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Table 14. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for primary post-tests in ICaT.

	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
				U	p
1.I like natural sciences	3.73	3.61	<.001	3059	0.363
2.like technology and robots	3.71	4.29	<.001	2245	<.001
3.Science helps me to solve problems	3.19	3.06	<.001	2940	0.365
4.I like to experiment	4.51	4.57	<.001	3179	0.814
5.What I learned today is important for my future career	2.81	2.89	<.001	2810	0.566
6.I can carry out scientific experiments independently	3.39	3.40	<.001	3065	0.958
7.I liked working independently	3.69	3.39	<.001	1318	0.297
8.The workshop helped me to find a solution to problems myself	3.11	3.06	<.001	1488	0.674
9.I liked the topic today	3.91	3.79	<.001	2998	0.562
10.I would like to find out more about this topic	3.47	3.37	<.001	3120	0.674
11.The workshop helped me learn new things	3.76	3.45	<.001	2469	0.143
12. Later I would like to do something in the natural sciences	2.96	3.06	<.001	2979	0.447

Note. p = p-value; U = U statistic.

- LHA

The results from the primary post-tests for LHA are shown in Table 15, while Figure 14 shows the mean and standard deviation by gender. The item *I like to experiment* received the highest average score across both groups (M = 4.53 girls; M = 4.46 boys), closely followed by *I liked the topic today* (M = 4.53 girls; M = 4.46 boys). Girls showed slightly higher average score in items related to general interest in science and perceived learning outcomes (e.g. *The workshop helped me learn new things* —M = 4.32 girls; M = 4.23 boys— and *I like natural sciences* —M = 4.25 girls; M = 4.19 boys— although the differences are relatively minor. Boys, on the other hand, scored significantly higher in their interest in technology and robots (Item 2; M = 4.50 boys; M = 4.06 girls). Both genders reported strong levels of autonomy and self-efficacy, particularly in items such as *I can carry out scientific experiments independently* (M ≈ 3.9–4.0) and *I liked working independently* (M ≈ 4.2), with very similar values across the groups. Both girls and boys scored equally in their intention to pursue something in the natural sciences in the future (M = 3.39). Standard deviations were moderate, indicating relatively consistent responses among participants. In the same way as for the ICaT, the Mann-Whitney U test (Table 16) showed that there are no significant differences for the gender variable except for the item 2, in which boys showed more interest in technology and robots.

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Table 15. Sample size, lost values, mean and standard deviation of primary post-tests for each item and gender in LHA.

	Female				Male			
	N	Lost	Mean	SD	N	Lost	Mean	SD
1.I like natural sciences	1536	33	4.25	0.92	1455	19	4.19	0.99
2.like technology and robots	1523	46	4.06	1.09	1449	25	4.50	0.92
3.Science helps me to solve problems	1525	44	3.68	1.09	1444	30	3.69	1.15
4.I like to experiment	1543	26	4.53	0.91	1447	27	4.46	0.93
5.What I learned today is important for my future career	1507	62	3.53	1.24	1421	53	3.56	1.29
6.I can carry out scientific experiments independently	1514	55	3.91	1.09	1428	46	3.97	1.09
7.I liked working independently	1504	65	4.24	1.04	1433	41	4.20	1.06
8.The workshop helped me to find a solution to problems myself	1521	48	3.82	1.10	1427	47	3.87	1.14
9.I liked the topic today	1530	39	4.53	0.90	1435	39	4.46	0.94
10.I would like to find out more about this topic	1523	46	4.19	1.01	1435	39	4.15	1.08
11.The workshop helped me learn new things	1527	42	4.32	0.98	1444	30	4.23	1.03
12. Later I would like to do something in the natural sciences	1519	50	3.39	1.34	1433	41	3.39	1.37

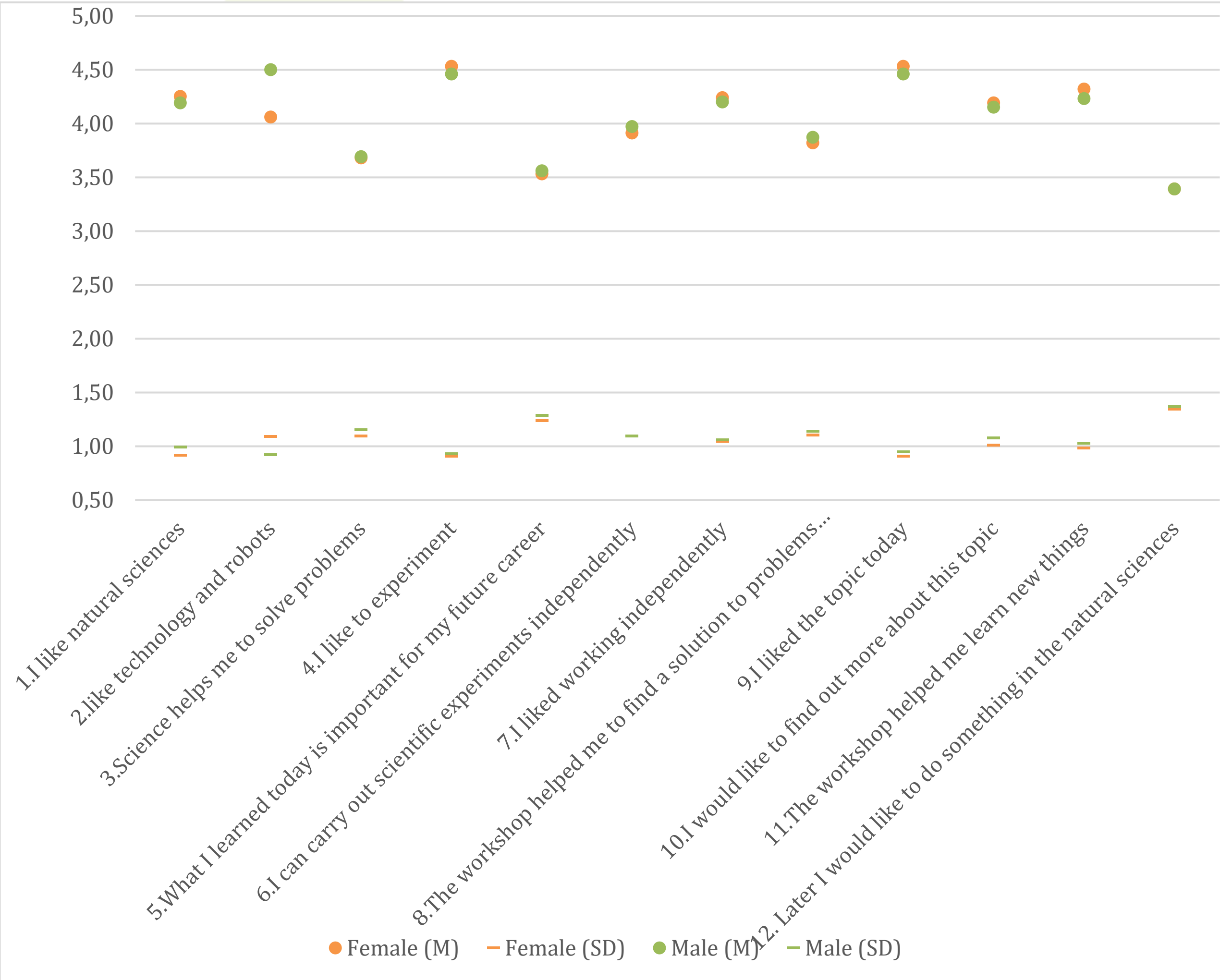

Figure 14. Mean and standard deviation of primary post-test by gender in LHA.

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Table 16. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for primary post-tests in LHA.

	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
				Z	p
1.I like natural sciences	4.25	4.19	<.001	1.09e+6	0.199
2.like technology and robots	4.06	4.50	<.001	818274	<.001
3.Science helps me to solve problems	3.68	3.69	<.001	1.08e+6	0.445
4.I like to experiment	4.53	4.46	<.001	1.06e+6	0.002
5.What I learned today is important for my future career	3.53	3.56	<.001	1.05e+6	0.275
6.I can carry out scientific experiments independently	3.91	3.97	<.001	1.04e+6	0.077
7.I liked working independently	4.24	4.20	<.001	1.05e+6	0.185
8.The workshop helped me to find a solution to problems myself	3.82	3.87	<.001	1.05e+6	0.120
9.I liked the topic today	4.53	4.46	<.001	1.05e+6	0.007
10.I would like to find out more about this topic	4.19	4.15	<.001	1.09e+6	0.862
11.The workshop helped me learn new things	4.32	4.23	<.001	1.05e+6	0.017
12. Later I would like to do something in the natural sciences	3.39	3.39	<.001	1.09e+6	0.917

Note. p = p-value; U = U statistic.

- OSA pre-test

The results from the primary pre-tests for OSA are shown in Table 17 and Figure 15 shows the mean and standard deviation by gender. Both genders showed high interest in experimentation, with *I like to experiment* being among the top-rated items (M = 3.98 girls; M = 4.16 boys). Boys reported slightly higher levels of confidence in their ability to conduct experiments independently (Item 6; M = 4.28 boys; M = 3.99 girls), and also showed greater interest in technology and robots (Item 2; M = 3.72 boys; M = 3.55 girls). Girls, meanwhile, demonstrated slightly stronger interest in the topic presented that day (Item 9; M = 3.25 girls; M = 3.13 boys), though both groups rated it moderately. Attitudes toward science as a tool for solving problems were similar across genders (Item 8; M ≈ 3.25–3.28), and both boys and girls have similar scores about what they learned was important for their future (Item 5; M ≈ 3.14–3.20). One of the lowest-rated items for both groups was the desire to find out more about the topic (Item 10; M = 3.22 girls; M = 3.34 boys). Standard deviations across items were generally around 1.1–1.3, indicating a fair degree of response variability. The Mann-Whitney U test (Table 18) showed that there are no significant differences for the gender variable.

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Table 17. Sample size, lost values, mean and standard deviation of primary pre-tests for each item and gender in OSA.

	Female				Male			
	N	Lost	Mean	SD	N	Lost	Mean	SD
1.I like natural sciences	170	0	3.40	1.19	179	0	3.51	1.18
2.like technology and robots	170	0	3.55	1.21	179	0	3.72	1.12
3.Science helps me to solve problems	169	1	3.25	1.11	179	0	3.28	1.08
4.I like to experiment	170	0	3.98	1.37	179	0	4.16	1.23
5.What I learned today is important for my future career	169	1	3.14	1.14	178	1	3.20	1.13
6.I can carry out scientific experiments independently	170	0	3.99	1.47	177	2	4.28	1.22
7.I liked working independently	170	0	3.32	1.13	179	0	3.19	1.16
8.The workshop helped me to find a solution to problems myself	170	0	3.47	1.32	179	0	3.67	1.25
9.I liked the topic today	169	1	3.25	1.09	179	0	3.13	1.15
10.I would like to find out more about this topic	170	0	3.22	1.10	178	1	3.34	1.08
11.The workshop helped me learn new things	170	0	3.17	1.13	179	0	3.16	1.09

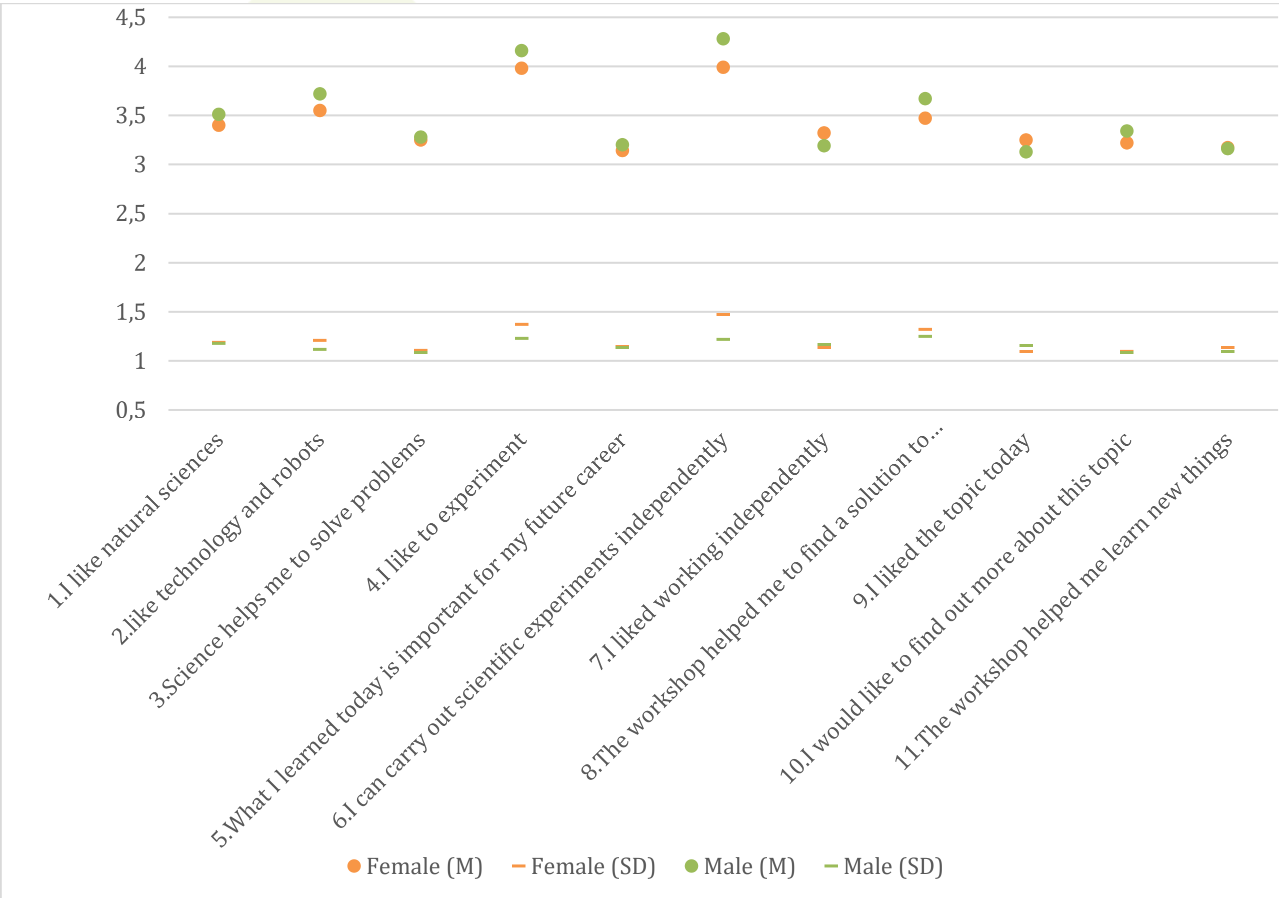

Figure 15. Mean and standard deviation of primary pre-test by gender in OSA.

Table 18. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for primary pre-tests in OSA.

	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
				U	p
1.I like natural sciences	3.40	3.51	<.001	14438	0.391
2.like technology and robots	3.55	3.72	<.001	14037	0.180
3.Science helps me to solve problems	3.25	3.28	<.001	14980	0.872
4.I like to experiment	3.98	4.16	<.001	14402	0.339
5.What I learned today is important for my future career	3.14	3.20	<.001	14579	0.609
6.I can carry out scientific experiments independently	3.99	4.28	<.001	13681	0.088
7.I liked working independently	3.32	3.19	<.001	14281	0.303
8.The workshop helped me to find a solution to problems myself	3.47	3.67	<.001	13956	0.163
9.I liked the topic today	3.25	3.13	<.001	14108	0.260
10.I would like to find out more about this topic	3.22	3.34	<.001	14070	0.238
11.The workshop helped me learn new things	3.17	3.16	<.001	15047	0.853

Note. p = p-value; U = U statistic.

- OSA post-test

The results from the primary post-tests for OSA are shown in Table 19, while Figure 16 shows the mean and standard deviation by gender. Both groups rated *I like to experiment* highly (M = 3.98 girls; M = 4.24 boys). Boys tended to score slightly higher on items related to problem-solving and autonomy, such as *Science helps me to solve problems* (M = 3.62 boys; M = 3.41 girls) and *I liked working independently* (M = 3.71 boys; M = 3.56 girls). Girls, on the other hand, showed marginally higher interest in learning outcomes and topic engagement (e. g., *I would like to find out more about this topic* —M = 3.78 girls; M = 3.71 boys— and *The workshop helped me learn new things* —M = 3.80 girls; M = 3.84 boys—). Interest in natural sciences was moderate for both genders (Item 1; M ≈ 3.7), and while boys reported a stronger interest in technology and robots (Item 2; M = 3.87 boys: M = 3.70 girls), the difference was relatively small. Both groups rated the workshop's effectiveness in promoting problem-solving similarly (Item 8; M ≈ 3.56). Standard deviations across items were moderate. The Mann-Whitney U test (Table 20) showed that there are no significant differences for the gender variable.

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Table 19. Sample size, lost values, mean and standard deviation of primary post-tests for each item and gender in OSA.

	Female				Male			
	N	Lost	Mean	SD	N	Lost	Mean	SD
1.I like natural sciences	163	0	3.75	1.06	177	0	3.66	1.14
2.like technology and robots	163	0	3.70	1.11	177	0	3.87	1.08
3.Science helps me to solve problems	163	0	3.41	1.18	176	1	3.62	1.11
4.I like to experiment	163	0	3.98	1.47	177	0	4.24	1.31
5.What I learned today is important for my future career	162	1	3.37	1.04	176	1	3.19	1.15
6.I can carry out scientific experiments independently	163	0	3.37	1.24	177	0	3.37	1.22
7.I liked working independently	163	0	3.56	1.17	177	0	3.71	1.12
8.The workshop helped me to find a solution to problems myself	161	2	3.57	1.21	176	1	3.55	1.08
9.I liked the topic today	162	1	3.84	1.18	177	0	3.89	1.13
10.I would like to find out more about this topic	163	0	3.78	1.23	176	1	3.71	1.15
11.The workshop helped me learn new things	163	0	3.80	1.27	177	0	3.84	1.21
12. Later I would like to do something in the natural sciences	99	64	3.44	0.92	122	55	3.37	1.04

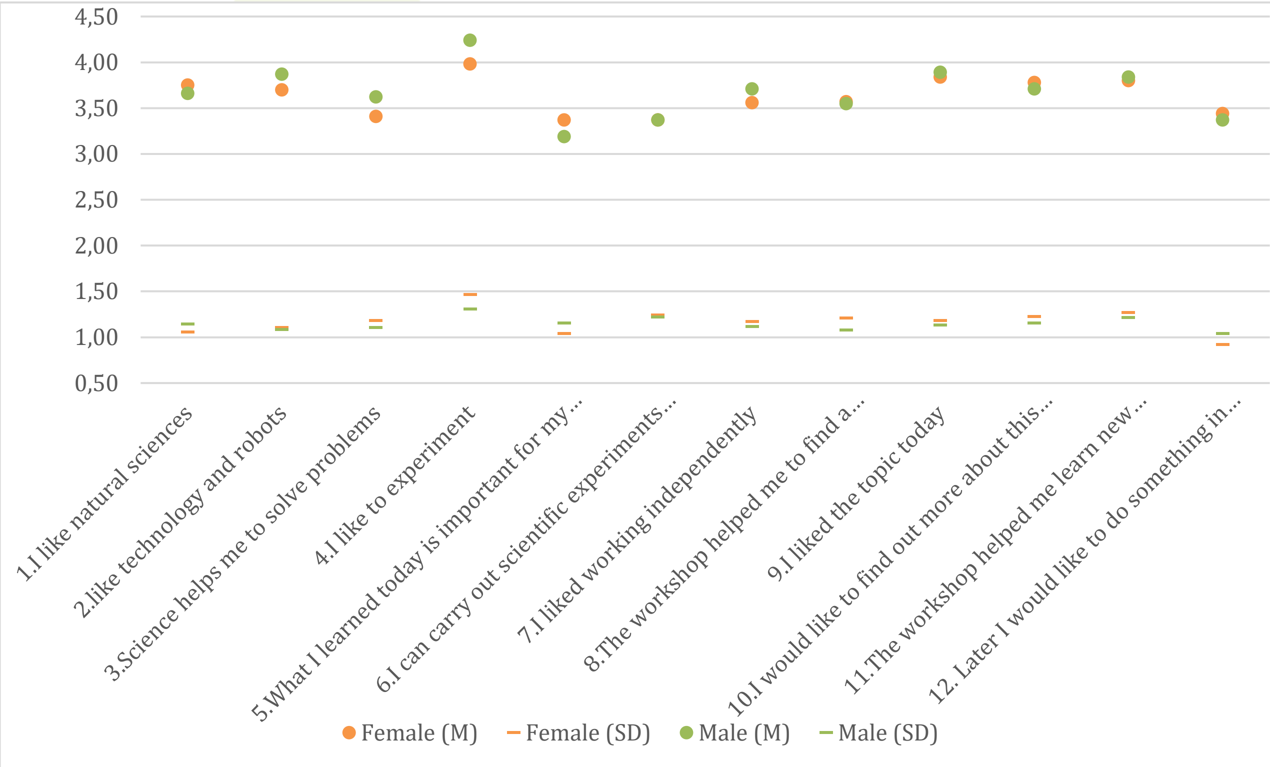

Figure 16. Mean and standard deviation of primary post-test by gender in OSA.

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Table 20. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for primary post-tests in OSA.

	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
				U	p
1.I like natural sciences	3.75	3.66	<.001	13899	0.538
2.like technology and robots	3.70	3.87	<.001	13086	0.112
3.Science helps me to solve problems	3.41	3.62	<.001	12909	0.097
4.I like to experiment	3.98	4.24	<.001	13059	0.078
5.What I learned today is important for my future career	3.37	3.19	<.001	12939	0.129
6.I can carry out scientific experiments independently	3.37	3.37	<.001	14335	0.917
7.I liked working independently	3.56	3.71	<.001	13414	0.242
8.The workshop helped me to find a solution to problems myself	3.57	3.55	<.001	13742	0.619
9.I liked the topic today	3.84	3.89	<.001	14157	0.833
10.I would like to find out more about this topic	3.78	3.71	<.001	13562	0.363
11.The workshop helped me learn new things	3.80	3.84	<.001	14279	0.865
12. Later I would like to do something in the natural sciences	3.44	3.37	<.001	5865	0.695

Note. p = p-value; U = U statistic.

3.2.3.2. Secondary

- ICaT

The results from the secondary post-tests for ICaT are shown in Table 21, while Figure 17 shows the mean and standard deviation by gender. In dimension B (Attitudes and beliefs towards science), both girls and boys reported high enjoyment and interest in science, particularly in items such as *I like to do science experiments* (M = 4.16 girls; 4.13 boys) and *Science is interesting* (M = 4.00 girls; M = 3.99 boys). Boys reported slightly higher enjoyment in learning science (Item B1; M = 3.85 boys; M = 3.71 girls) and greater agreement with the item *I need to do well in science to get the job I want* (Item 5B; M = 3.55 boys; M = 3.48 girls). In dimension C (Self-efficacy towards science), boys consistently scored slightly higher, particularly in *I can apply scientific knowledge to real-world situations* (Item C2; M = 3.56 boys; M = 3.45 girls), *I can learn and use scientific skills* (Item C3; M = 3.48 boys; M = 3.39 girls), and *I am confident I can succeed in a scientific career* (Item C5; M = 3.51 boys; M = 3.30 girls). However, both genders rated *I can communicate effectively about scientific topics* quite positively (Item C4; M = 3.92 boys; M = 3.72 girls). In dimension D (Interest in science studies and science career), boys again scored slightly higher across all items. The largest gap was in *I am interested in careers that use science, mathematics or technology* (Item D2; M = 3.88 boys; M = 3.53 girls). In dimension E (Evaluation of the activity), both genders rated the activities positively, with strong agreement on the clarity of the guest speakers (Item E2; M = 4.00 girls; M = 3.90 boys) and the usefulness of the activity (Item E3; M = 3.67 girls; M = 3.74 boys). Notably, boys expressed a slightly higher baseline interest in STEM careers prior to the activity (Item E4; M = 3.48 boys; M = 3.06 girls). The Mann-Whitney U test (Table 22) showed significant differences for the gender variable in items B1, C4, C5, all the items in dimension D and E1.

Table 21. Sample size, lost values, mean and standard deviation of primary post-tests for each item and gender in ICaT.

		Female				Male			
Dimension	Item	N	Lost	Mean	SD	N	Lost	Mean	SD
B	1.I enjoy learning science	404	0	3,71	0,89	379	0	3,85	1,11
	2.Science is interesting	404	0	4,00	0,87	379	0	3,99	1,12
	3.I like to do science experiments	404	0	4,16	0,98	379	0	4,13	1,18
	4.Learning science will help me in my daily life	404	0	3,61	0,99	379	0	3,63	1,12
	5.I need to do well in science to get the job I want	404	0	3,48	1,28	379	0	3,55	1,34
C	1.Science is harder for me than any other subject	398	6	2,95	1,15	377	2	2,95	1,28
	2.I can apply scientific knowledge to real-world situations	398	6	3,45	1,01	377	2	3,56	1,11
	3.I can learn and use scientific skills	398	6	3,39	1,13	377	2	3,48	1,12
	4.I can communicate effectively about scientific topics with others	398	6	3,72	0,99	377	2	3,92	1,02
	5.I am confident I can succeed in a scientific career	398	6	3,30	1,18	377	2	3,51	1,28
D	1.Learning science is important for my future career	397	7	3,53	1,20	376	3	3,71	1,26
	2.I am interested in careers that use science, mathematics or technology	397	7	3,53	1,22	376	3	3,88	1,19
	3.A family member of mine works in a science related field	397	7	2,95	1,50	376	3	3,17	1,49
	4.I enjoy talking to scientist	397	7	3,40	1,38	376	3	3,63	1,35
E (ICaT)	1.Before participating in this activity, I already felt that a STEM career would be a good choice for me	394	10	3,06	1,25	374	5	3,48	1,26
	2.The guest speaker(s) clearly presented their career path and I learned something new about their profession from their presentation	394	10	4,00	1,10	374	5	3,90	1,10
	3.I believe that the activity was useful for me personally and I had the opportunity to actively participate in the discussion	394	10	3,67	1,15	374	5	3,74	1,10
	4.This activity helped me remove existing dilemmas or stereotypes about STEM careers and encouraged me to further consider choosing a STEM profession	394	10	3,34	1,22	374	5	3,43	1,25

Note. N = sample size; Lost = Lost data; SD = Standard deviation.

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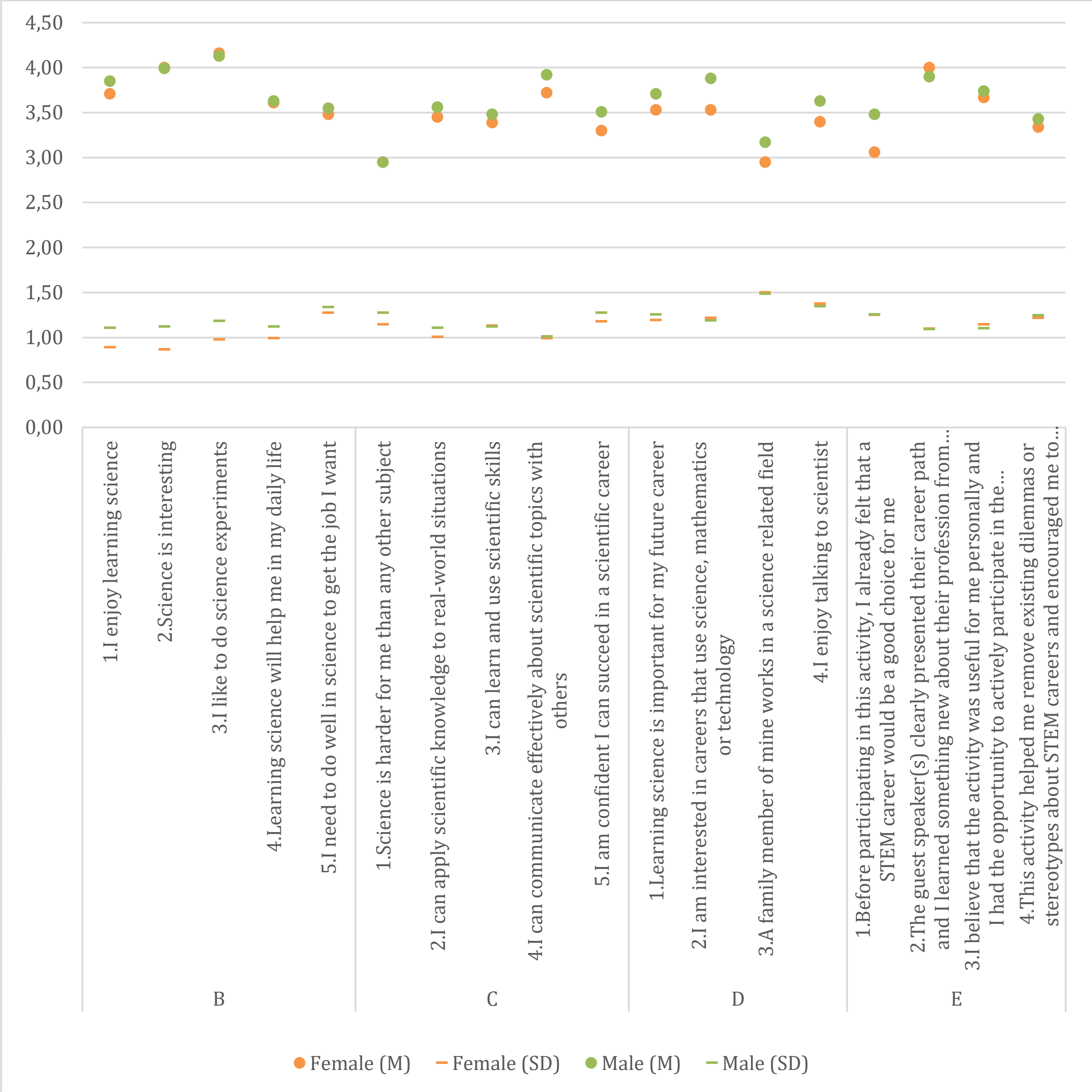

Figure 17. Mean and standard deviation of primary post-test by gender in ICaT.

Table 22. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for secondary post-tests in ICaT.

Dimension	Item	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
					U	p
B	1.I enjoy learning science	3,71	3,85	<.001	66732	0.001
	2.Science is interesting	4,00	3,99	<.001	71792	0.108
	3.I like to do science experiments	4,16	4,13	<.001	74010	0.383
	4.Learning science will help me in my daily life	3,61	3,63	<.001	74409	0.479
	5.I need to do well in science to get the job I want	3,48	3,55	<.001	73486	0.316
C	1.Science is harder for me than any other subject	2,95	2,95	<.001	74363	0.828
	2.I can apply scientific knowledge to real-world situations	3,45	3,56	<.001	69469	0.062
	3.I can learn and use scientific skills	3,39	3,48	<.001	71844	0.290
	4.I can communicate effectively about scientific topics with others	3,72	3,92	<.001	65090	<.001
	5.I am confident I can succeed in a scientific career	3,30	3,51	<.001	66704	0.006
D	1.Learning science is important for my future career	3,53	3,71	<.001	67232	0.014
	2.I am interested in careers that use science, mathematics or technology	3,53	3,88	<.001	62180	<.001
	3.A family member of mine works in a science related field	2,95	3,17	<.001	68497	0.042
	4.I enjoy talking to scientist	3,40	3,63	<.001	67322	0.015
E (ICaT)	1.Before participating in this activity, I already felt that a STEM career would be a good choice for me	3,06	3,48	<.001	59204	<.001
	2.The guest speaker(s) clearly presented their career path and I learned something new about their profession from their presentation	4,00	3,90	<.001	69568	0.159
	3.I believe that the activity was useful for me personally and I had the opportunity to actively participate in the discussion	3,67	3,74	<.001	71951	0.558
	4.This activity helped me remove existing dilemmas or stereotypes about STEM careers and encouraged me to further consider choosing a STEM profession	3,34	3,43	<.001	70751	0.325

Note. p = p-value; U = U statistic.

- LHA

The results from the secondary participants' post-tests for LHA by gender are shown in Table 23, while Figure 18 shows the mean and standard deviation by gender. In dimension B (Attitudes and beliefs towards science), both genders expressed very favorable views. Boys scored slightly higher than girls in almost every item, particularly in *Science is interesting* (Item B2; M = 4.23 boys; M = 4.09 girls) and *I like to do science experiments* (Item B3; M = 4.33 boys; M = 4.28 girls). In dimension C (Self-efficacy towards science), both boys and girls rated themselves positively, with boys again showing marginally higher confidence in nearly all areas. For example, boys reported greater confidence in their ability to use scientific skills (Item C3; M = 3.69 boys; M = 3.53 girls), to communicate about science (Item C4; M = 3.99 boys; M = 3.90 girls), and to succeed in a scientific career (Item C5; M = 3.60 boys; M = 3.44 girls). In dimension D (Interest in science studies and science career), boys showed higher interest in STEM careers (Item D2; M = 3.86 boys; M = 3.73 girls) and greater enjoyment when engaging with scientists (Item D4; M = 3.77 boys; M = 3.50 girls).

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Interestingly, girls reported more frequently having a family member working in a science-related field (Item D3; M = 2.99 girls; M = 2.67 boys), though this item had the largest variability in both groups (SD ≈ 1.6). Dimension E (Evaluation of the activity) shows highly favorable evaluations from both genders. Both girls and boys agreed that the activity was *fascinating* (Item E1; M = 4.18 girls; M = 4.24 boys), *helped them learn new concepts* (Item E2; M ≈ 4.06–4.07), and *fostered understanding of the relevance of science in everyday life* (Item E3). Boys reported slightly higher gains in understanding *the importance of cooperation between community and scientists* (Item E4; M = 3.85 boys; M = 3.70 girls), and in *being required to interact with other participants* (Item E5; M = 4.07 boys; M = 3.87 girls). The Mann-Whitney U test (Table 24) showed significant differences for the gender variable in items B2, C3, D3 and D4, and items E3 and E5.

Table 23. Sample size, lost values, mean and standard deviation of secondary post-tests for each item and gender in LHA by gender.

		Female				Male			
Dimension	**Item**	**N**	**Lost**	**Mean**	**SD**	**N**	**Lost**	**Mean**	**SD**
B	**1.I enjoy learning science**	390	1	3,91	1,09	338	0	4,00	1,05
	2.Science is interesting	391	0	4,09	0,95	338	0	4,23	0,94
	3.I like to do science experiments	391	0	4,28	0,98	338	0	4,33	0,94
	4.Learning science will help me in my daily life	390	1	3,72	1,09	338	0	3,76	1,14
	5.I need to do well in science to get the job I want	390	1	3,66	1,37	338	0	3,70	1,26
C	**1.Science is harder for me than any other subject**	387	4	2,66	1,30	338	0	2,64	1,37
	2.I can apply scientific knowledge to real-world situations	387	4	3,63	0,96	338	0	3,64	1,10
	3.I can learn and use scientific skills	387	4	3,53	1,15	338	0	3,69	1,16
	4.I can communicate effectively about scientific topics with others	387	4	3,90	0,96	338	0	3,99	1,01
	5.I am confident I can succeed in a scientific career	387	4	3,44	1,23	338	0	3,60	1,23
D	**1.Learning science is important for my future career**	387	4	3,52	1,33	338	0	3,59	1,25
	2.I am interested in careers that use science, mathematics or technology	387	4	3,73	1,26	338	0	3,86	1,22
	3.A family member of mine works in a science related field	387	4	2,99	1,62	338	0	2,67	1,61
	4.I enjoy talking to scientist	387	4	3,50	1,18	338	0	3,77	1,22
E (LHA)	**1.Was fascinating**	386	5	4,18	1,01	337	1	4,24	0,92
	2.Helped me learn new concepts	347	44	4,07	1,08	336	2	4,06	1,06
	3.Helped me to understand the connection of science to everyday life	347	44	3,76	1,22	336	2	3,94	1,17
	4.The activity helped me understand the importance of cooperation between community and scientists	347	44	3,70	1,16	337	1	3,85	1,15
	5.Required to interact with other participants (students, scientists, people from the industry)	347	44	3,87	1,20	337	1	4,07	1,16

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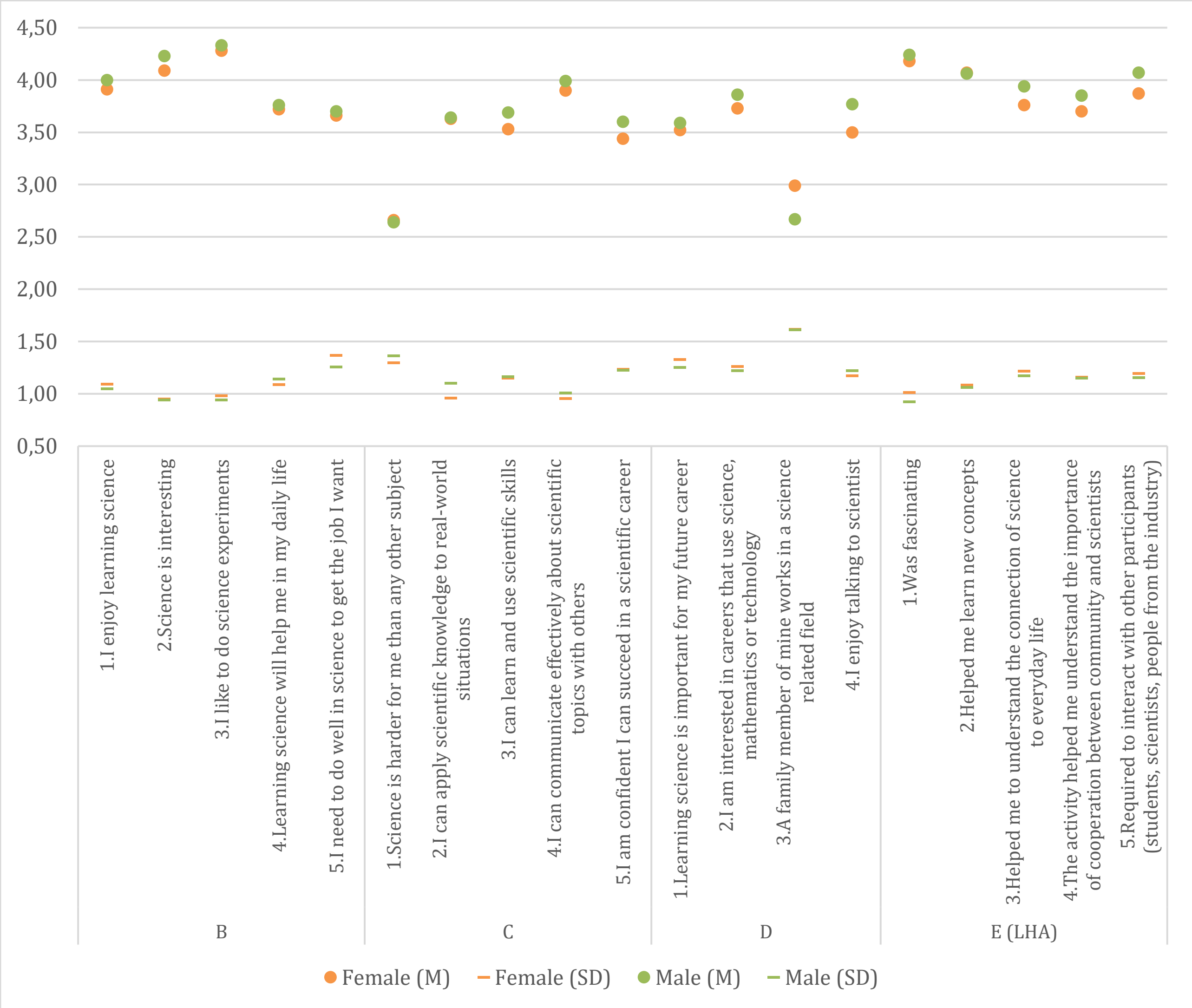

Figure 18. Mean and standard deviation of secondary post-test by gender in LHA.

Table 24. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for secondary post-tests in LHA.

Dimension	Item	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
					U	p
B	1.I enjoy learning science	3,91	4,00	<.001	62790	0.246
	2.Science is interesting	4,09	4,23	<.001	59836	0.018
	3.I like to do science experiments	4,28	4,33	<.001	64684	0.584
	4.Learning science will help me in my daily life	3,72	3,76	<.001	63730	0.424
	5.I need to do well in science to get the job I want	3,66	3,70	<.001	65889	0.994
C	1.Science is harder for me than any other subject	2,66	2,64	<.001	64495	0.741
	2.I can apply scientific knowledge to real-world situations	3,63	3,64	<.001	63524	0.485
	3.I can learn and use scientific skills	3,53	3,69	<.001	59722	0.037
	4.I can communicate effectively about scientific topics with others	3,90	3,99	<.001	60880	0.091
	5.I am confident I can succeed in a scientific career	3,44	3,60	<.001	60647	0.081
D	1.Learning science is important for my future career	3,52	3,59	<.001	63979	0.602
	2.I am interested in careers that use science, mathematics or technology	3,73	3,86	<.001	61567	0.154
	3.A family member of mine works in a science related field	2,99	2,67	<.001	57830	0.005
	4.I enjoy talking to scientist	3,50	3,77	<.001	56234	<.001
E (LHA)	1.Was fascinating	4,18	4,24	<.001	64111	0.719
	2.Helped me learn new concepts	4,07	4,06	<.001	57599	0.773
	3.Helped me to understand the connection of science to everyday life	3,76	3,94	<.001	52786	0.025
	4.The activity helped me understand the importance of cooperation between community and scientists	3,70	3,85	<.001	53645	0.052
	5.Required to interact with other participants (students, scientists, people from the industry)	3,87	4,07	<.001	52381	0.013

Note. p = p-value; U = U statistic.

- OSA pre-test

The results from the secondary pre-tests for OSA by gender are shown in Table 25, while Figure 19 shows the mean and standard deviation by gender. In dimension B (Attitudes and beliefs towards science), both girls and boys reported strong enjoyment of *doing science experiments* (Item B3; M = 4.19 for girls, 4.10 for boys), and high agreement with the idea that *science is interesting* (Item B2; M = 3.96 and 3.99, respectively). While boys reported slightly higher interest overall, girls tended to perceive *science as more useful in everyday life* (Item B4; M = 3.60 vs. 3.43). In dimension C (Self-efficacy towards science), responses were very closely aligned across genders. Both girls and boys showed moderate confidence in their ability to *apply scientific knowledge* (Item C1; M = 3.41), *learn and use scientific skills* (Item C2; M ≈ 3.36–3.39), and *communicate about science effectively* (Item C3; M ≈ 3.66–3.68). The item *Science is harder for me than any other subject* (Item C4) received low ratings from both groups (M ≈ 2.50). In dimension D (Interest in science studies and science career), boys reported slightly more interest in *careers involving science, mathematics, or technology* (Item D1; M = 3.68 vs. 3.48). Girls, however, were somewhat more likely to report *having a family member working in a science-related field* (Item D2; M = 2.72 vs. 2.64). The Mann-Whitney U test (Table 26) showed significant differences for the gender variable in items B4, and D2.

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Table 25. Sample size, lost values, mean and standard deviation of secondary pre-tests for each item and gender in OSA by gender.

		Female				Male			
Dimension	**Item**	**N**	**Lost**	**Mean**	**SD**	**N**	**Lost**	**Mean**	**SD**
B	**1.I enjoy learning science**	656	0	3,77	1,12	615	0	3,80	1,15
	2.Science is interesting	656	0	3,96	1,10	615	0	3,99	1,14
	3.I like to do science experiments	656	0	4,19	1,08	615	0	4,10	1,14
	4.Learning science will help me in my daily life	655	1	3,60	1,14	615	0	3,43	1,17
	5.I need to do well in science to get the job I want	656	0	3,37	1,40	614	1	3,36	1,39
C	**1.Science is harder for me than any other subject**	652	4	2,54	1,24	611	4	2,50	1,25
	2.I can apply scientific knowledge to real-world situations	652	4	3,41	1,10	611	4	3,41	1,06
	3.I can learn and use scientific skills	652	4	3,36	1,18	611	4	3,39	1,17
	4.I can communicate effectively about scientific topics with others	652	4	3,66	1,11	611	4	3,68	1,11
	5.I am confident I can succeed in a scientific career	652	4	3,33	1,27	610	5	3,32	1,23
D	**1.Learning science is important for my future career**	645	11	3,41	1,36	607	8	3,40	1,28
	2.I am interested in careers that use science, mathematics or technology	645	11	3,48	1,36	608	7	3,68	1,30
	3.A family member of mine works in a science related field	645	11	2,72	1,61	608	7	2,64	1,59
	4.I enjoy talking to scientist	645	11	3,31	1,25	608	7	3,29	1,29

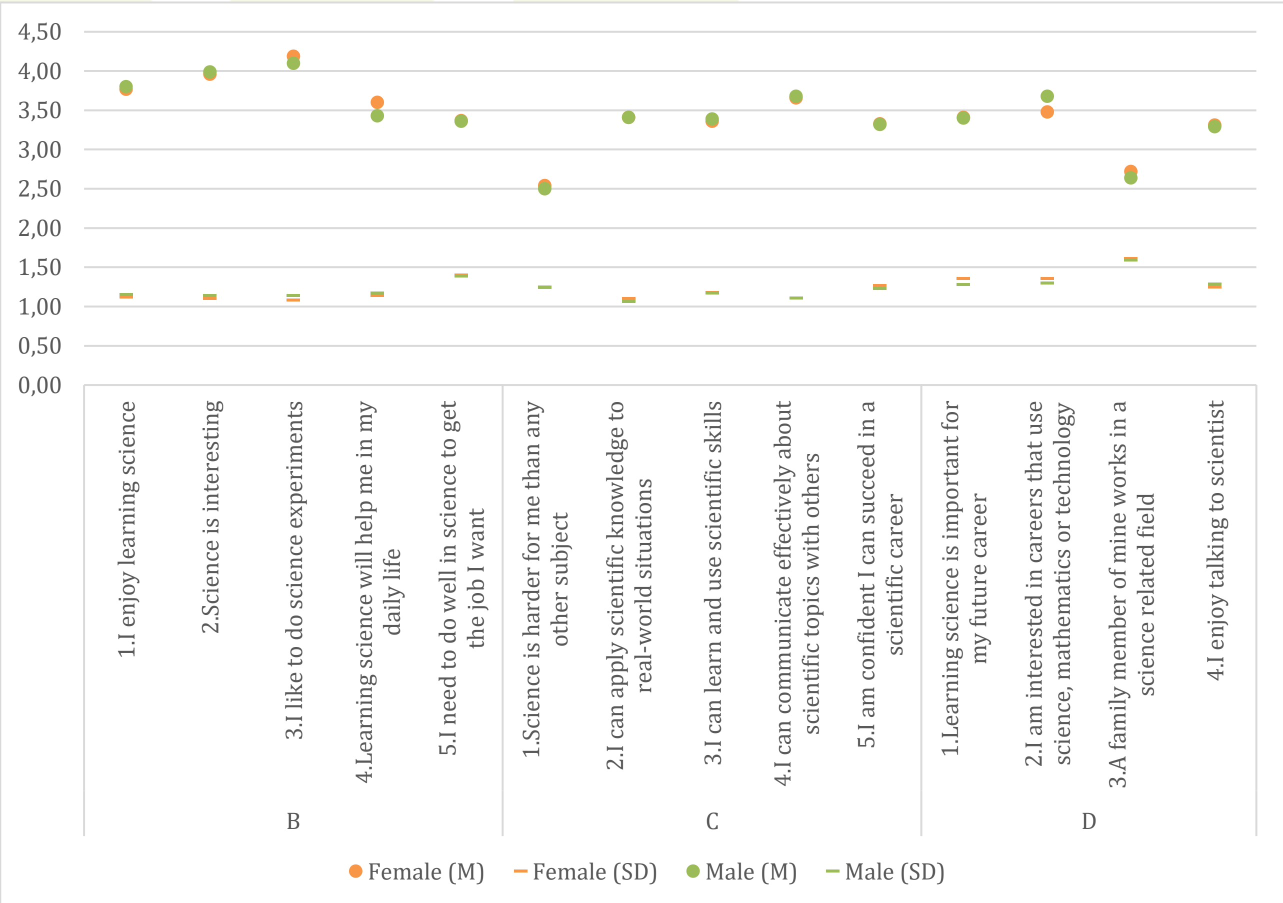

Figure 19. Mean and standard deviation of secondary pre-test by gender in OSA.

Table 26. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for secondary pre-tests in OSA.

Dimension	Item	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
					U	p
B	1.I enjoy learning science	3,77	3,80	<.001	197954	0.548
	2.Science is interesting	3,96	3,99	<.001	197150	0.460
	3.I like to do science experiments	4,19	4,10	<.001	194635	0.239
	4.Learning science will help me in my daily life	3,60	3,43	<.001	185434	0.011
	5.I need to do well in science to get the job I want	3,37	3,36	<.001	200862	0.934
C	1.Science is harder for me than any other subject	2,54	2,50	<.001	194855	0.491
	2.I can apply scientific knowledge to real-world situations	3,41	3,41	<.001	198054	0.856
	3.I can learn and use scientific skills	3,36	3,39	<.001	195269	0.533
	4.I can communicate effectively about scientific topics with others	3,66	3,68	<.001	195895	0.598
	5.I am confident I can succeed in a scientific career	3,33	3,32	<.001	197755	0.861
D	1.Learning science is important for my future career	3,41	3,40	<.001	192537	0.605
	2.I am interested in careers that use science, mathematics or technology	3,48	3,68	<.001	179899	0.009
	3.A family member of mine works in a science related field	2,72	2,64	<.001	189461	0.283
	4.I enjoy talking to scientist	3,31	3,29	<.001	195800	0.964

Note. p = p-value; U = U statistic.

- OSA post-test

The results from the secondary post-tests for OSA by gender are shown in Table 27, while Figure 20 shows the mean and standard deviation by gender. In dimension B (Attitudes and beliefs towards science), both genders showed high agreement with statements such as *enjoyment of experimentation* (Item B3; M = 4.06 for girls, 4.03 for boys) and *finding science interesting* (Item B2; M = 3.76 vs. 3.85). Boys rated slightly higher in overall interest and enjoyment, but girls reported a stronger perception that *learning science will help me in my daily life* (Item B4; M = 3.52 vs. 3.25). Dimension C (Self-efficacy towards science) shows that boys generally feel more confident and perceive science as slightly less difficult. For instance, boys rated *science is harder for me than any other subject* (Item C4) significantly lower (M = 2.34 vs. 2.61), and rated higher or equal in self-efficacy items such as *I can communicate effectively about scientific topics* (Item C3) and *I am confident I can succeed in a scientific career* (Item C5). However, both groups rated their ability to *learn and use scientific skills* (Item C2) identically (M = 3.26). In dimension D (Interest in science studies and science career), boys expressed greater interest in *pursuing STEM careers* (Item D2; M = 3.69 vs. 3.31) and slightly higher agreement with *the importance of science for their future* (Item D1). Girls, however, were more likely to report *having a family member in a science-related field* (Item D3; M = 2.82 vs. 2.67). Dimension E (Evaluation of the activity) showed that girls rated the activity more positively in almost all aspects. They found it *more fascinating* (Item E1; M = 3.89 vs. 3.69), believed it *helped them learn new concepts* (Item E2; M = 3.63 vs. 3.50), and *better understand the connection of science to daily life* (Item E3; M = 3.62 vs. 3.46). Ratings related to *collaboration with students, scientists, or industry* (Items E4–E6) were generally similar, though all items had moderate variability (SD ≈ 1.3–1.5). The Mann-Whitney U test (Table 28) showed significant differences for the gender variable in items B4, C1, and D2.

Table 27. Sample size, lost values, mean and standard deviation of secondary post-tests for each item and gender in OSA by gender.

		Female				Male			
Dimension	**Item**	**N**	**Lost**	**Mean**	**SD**	**N**	**Lost**	**Mean**	**SD**
B	**1.I enjoy learning science**	242	0	3,65	1,17	267	0	3,71	1,31
	2.Science is interesting	242	0	3,76	1,16	267	0	3,85	1,29
	3.I like to do science experiments	242	0	4,06	1,18	267	0	4,03	1,30
	4.Learning science will help me in my daily life	242	0	3,52	1,27	267	0	3,25	1,33
	5.I need to do well in science to get the job I want	242	0	3,38	1,44	267	0	3,28	1,43
C	**1.Science is harder for me than any other subject**	238	4	2,61	1,27	267	0	2,34	1,32
	2.I can apply scientific knowledge to real-world situations	238	4	3,42	1,17	267	0	3,27	1,23
	3.I can learn and use scientific skills	238	4	3,26	1,26	267	0	3,26	1,32
	4.I can communicate effectively about scientific topics with others	238	4	3,62	1,25	267	0	3,67	1,20
	5.I am confident I can succeed in a scientific career	238	4	3,40	1,28	267	0	3,41	1,34
D	**1.Learning science is important for my future career**	238	4	3,25	1,41	264	3	3,30	1,43
	2.I am interested in careers that use science, mathematics or technology	238	4	3,31	1,35	264	3	3,69	1,36
	3.A family member of mine works in a science related field	238	4	2,82	1,68	264	3	2,67	1,55
	4.I enjoy talking to scientist	238	4	3,33	1,36	264	3	3,24	1,33
E (OSA)	**1.Was fascinating**	231	11	3,89	1,20	252	15	3,69	1,34
	2.Helped me learn new concepts	231	11	3,63	1,27	252	15	3,50	1,36
	3.Helped me obtain new skills	231	11	3,41	1,30	252	15	3,40	1,26
	4.Required that I collaborate with other students	229	13	3,50	1,42	252	15	3,51	1,43
	5.Required that I collaborate with scientists	231	11	3,06	1,42	252	15	2,93	1,40
	6.Required that I collaborate with people from industry	231	11	2,68	1,55	252	15	2,69	1,54
	7.Helped me to understand the connection of science to everyday life	231	11	3,62	1,22	252	15	3,46	1,37
	8.The activity helped me solve a real problem	231	11	3,25	1,41	252	15	3,10	1,47
	9.The activity helped me participate in decision making	231	11	3,38	1,31	252	15	3,23	1,37
	10.The activity helped me understand the importance of cooperation between community and scientists	231	11	3,45	1,32	252	15	3,29	1,32
	11.I had constructive communication with mentors during the activity	230	12	3,25	1,44	252	15	3,28	1,35

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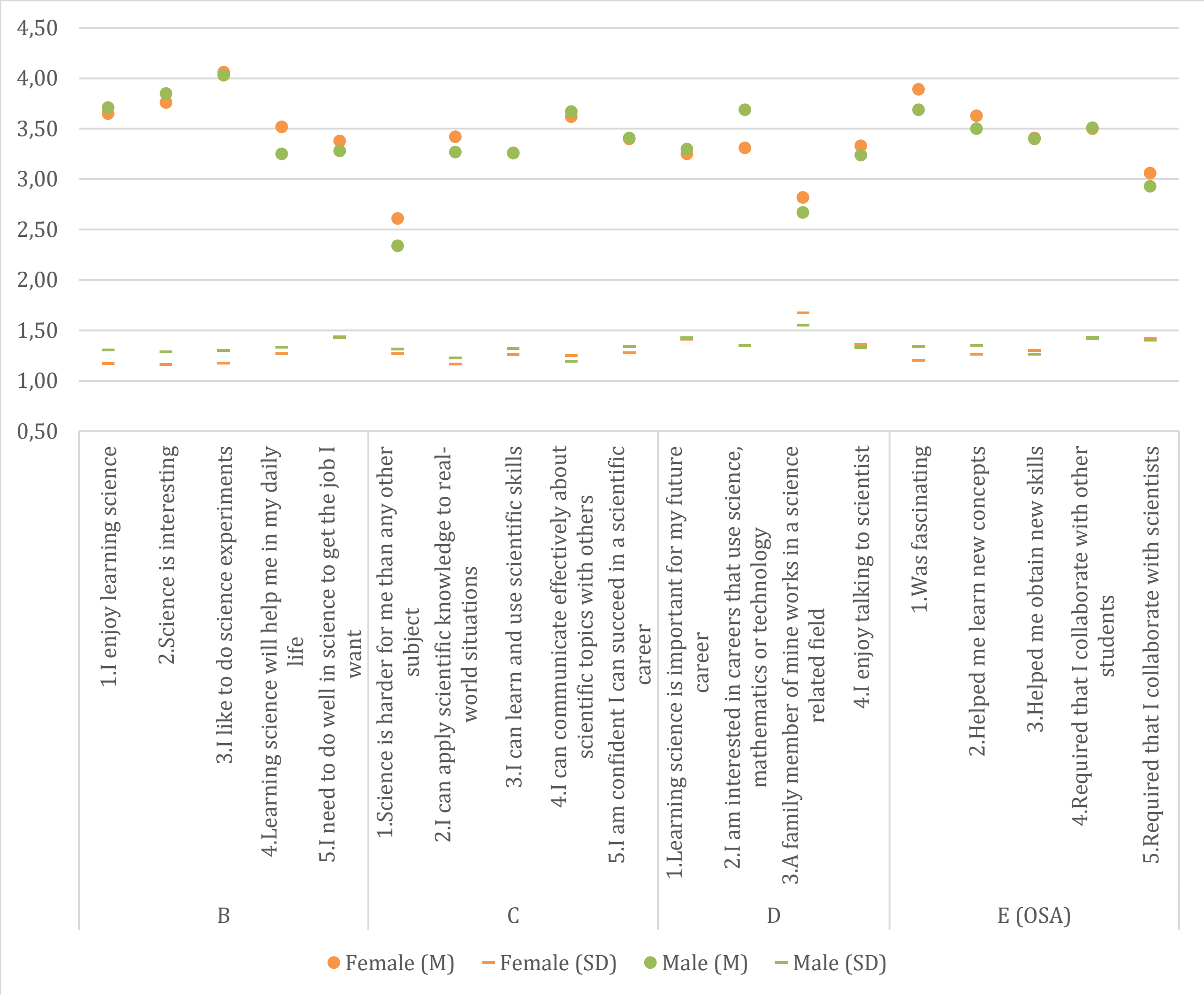

Figure 20. Mean and standard deviation of secondary post-test by gender in OSA.

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Table 28. Female and male means, p-value for Shapiro-Wilk test, and statistic and p-value for Mann-Whitney U test for secondary pre-tests in OSA.

Dimension	Item	Female mean	Male mean	Shapiro-Wilk (p)	Mann-Whitney U	
					U	p
B	1.I enjoy learning science	3,65	3,71	<.001	30588	0.282
	2.Science is interesting	3,76	3,85	<.001	29682	0.098
	3.I like to do science experiments	4,06	4,03	<.001	31920	0.800
	4.Learning science will help me in my daily life	3,52	3,25	<.001	28681	0.025
	5.I need to do well in science to get the job I want	3,38	3,28	<.001	31048	0.436
C	1.Science is harder for me than any other subject	2,61	2,34	<.001	27654	0.010
	2.I can apply scientific knowledge to real-world situations	3,42	3,27	<.001	29597	0.170
	3.I can learn and use scientific skills	3,26	3,26	<.001	31594	0.911
	4.I can communicate effectively about scientific topics with others	3,62	3,67	<.001	31271	0.751
	5.I am confident I can succeed in a scientific career	3,40	3,41	<.001	31406	0.818
D	1.Learning science is important for my future career	3,25	3,30	<.001	30734	0.667
	2.I am interested in careers that use science, mathematics or technology	3,31	3,69	<.001	26093	<.001
	3.A family member of mine works in a science related field	2,82	2,67	<.001	29810	0.306
	4.I enjoy talking to scientist	3,33	3,24	<.001	30126	0.415
E (OSA)	1.Was fascinating	3,89	3,69	<.001	26854	0.124
	2.Helped me learn new concepts	3,63	3,50	<.001	27742	0.358
	3.Helped me obtain new skills	3,41	3,40	<.001	28884	0.882
	4.Required that I collaborate with other students	3,50	3,51	<.001	28676	0.904
	5.Required that I collaborate with scientists	3,06	2,93	<.001	27639	0.328
	6.Required that I collaborate with people from industry	2,68	2,69	<.001	29065	0.978
	7.Helped me to understand the connection of science to everyday life	3,62	3,46	<.001	27527	0.288
	8.The activity helped me solve a real problem	3,25	3,10	<.001	27504	0.285
	9.The activity helped me participate in decision making	3,38	3,23	<.001	27392	0.252
	10.The activity helped me understand the importance of cooperation between community and scientists	3,45	3,29	<.001	27222	0.207
	11.I had constructive communication with mentors during the activity	3,25	3,28	<.001	28944	0.981

Note. p = p-value; U = U statistic.

3.2.4. Results pre-test/post-test for OSA

As explained above, the OSA were evaluated using both pre-tests and post-tests. No data was collected from adults in OSA. The following subsections (3.2.4.1 and 3.2.4.2) present the results at the global level (averages for pre-test and post-test considering all participants) and individually (comparing each participant's pre-test and post-test).

3.2.4.1. Primary

Table 29 and Figure 21 show the results of the comparison between pre-test and post-test for the primary questionnaires considering all the countries. There is an upward trend in motivation,

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interest, and perceived learning following the intervention. Notably, the item *I liked the topic today* (Item B1) increased substantially from a pre-test mean of 3.10 to 3.91 in the post-test. Similarly, items related to engagement and learning (such as *The workshop helped me learn new things* — Item E2; 3.29 → 3.82— and *I would like to find out more about this topic* —Item D3; 3.27 → 3.78) also showed marked improvements. A significant increase was observed in *I liked working independently* (Item E3; 3.33 → 3.72). However, one notable exception is the item *I can carry out scientific experiments independently* (Item C5), which declined from 4.10 to 3.40.

Table 29. Means and standard deviation for primary pre-test and post-test in OSA.

	Pre-test				Post-test			
Item	**N**	**Lost**	**Mean**	**SD**	**N**	**Lost**	**Mean**	**SD**
1.I like natural sciences	468	0	3.61	1.14	384	0	3.77	1.08
2.like technology and robots	468	0	3.75	1.15	384	0	3.82	1.10
3.Science helps me to solve problems	465	3	3.29	1.10	383	1	3.51	1.16
4.I like to experiment	467	1	4.14	1.24	383	1	4.17	1.34
5.What I learned today is important for my future career	464	4	3.05	1.19	382	2	3.27	1.12
6.I can carry out scientific experiments independently	465	3	4.10	1.32	381	3	3.40	1.21
7.I liked working independently	461	7	3.33	1.17	383	1	3.72	1.15
8.The workshop helped me to find a solution to problems myself	464	4	3.68	1.26	373	11	3.61	1.15
9.I liked the topic today	465	3	3.10	1.14	382	2	3.91	1.16
10.I would like to find out more about this topic	466	2	3.27	1.14	382	2	3.78	1.19
11.The workshop helped me learn new things	467	1	3.29	1.13	383	1	3.82	1.23

Note. N = sample size; Lost = Lost data; SD = Standard deviation.

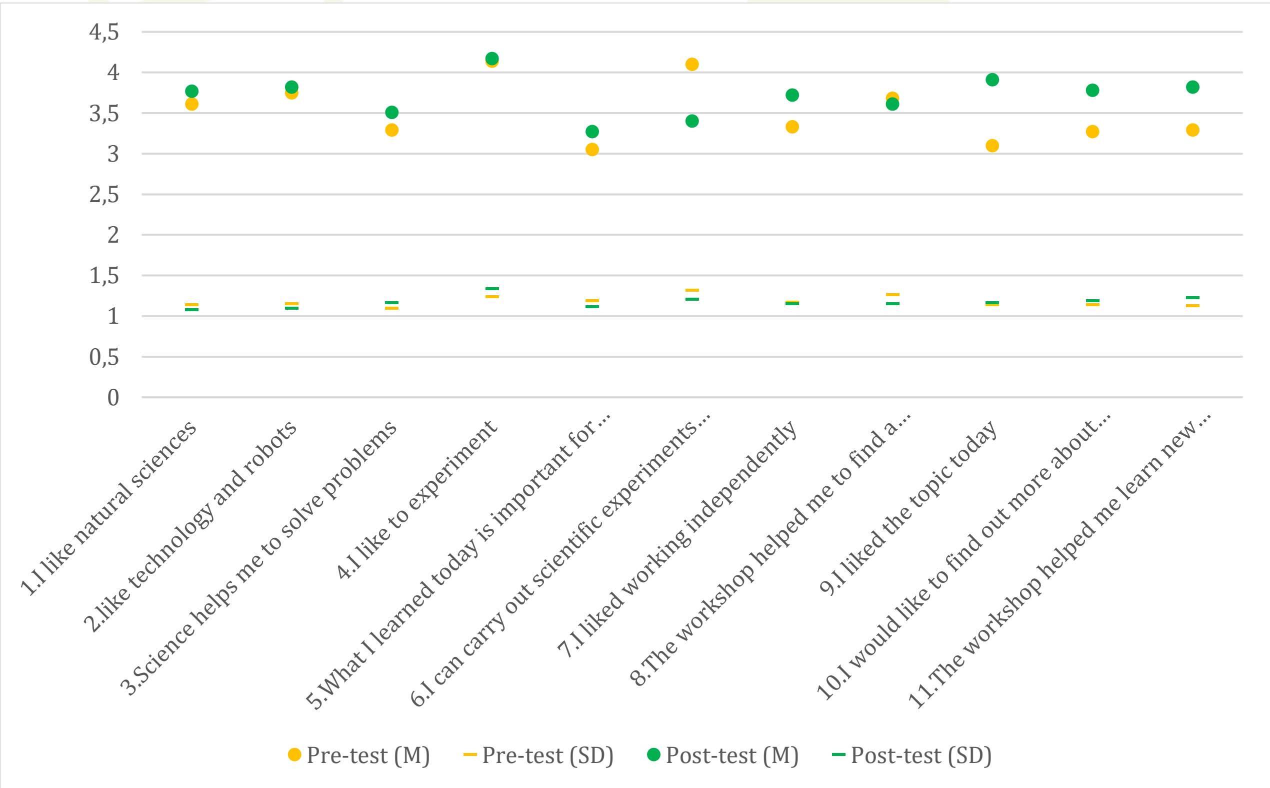

Figure 21. Mean and standard deviation of primary pre- and post-test in OSA.

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Table 30 shows the results of the pre-test and post-test comparison analyses for each participant using the Wilcoxon signed-rank test. The results show most positive ranks in all items except item 6 (I can carry out scientific experiments independently), in which there are more negative ranks. In most cases, the differences are statistically significant, and the effect size is medium to large.

Table 30. Sample size, lost values, means and standard deviation, and the Wilcoxon test results for primary's pre-tests and post-tests in OSA.

					Wilcoxon signed-rank test					
Item	**N**	**Lost**	**Mean**	**SD**	**Positive ranks**	**Negative ranks**	**Ties**	**W**	**p**	**ES**
1.I like natural sciences (Pre)	448	0	3.49	1.113	150	65	233	6837	<0,001	0.411
1.I like natural sciences (Post)	448	0	3.80	0.987						
2.I like technology and robots (Pre)	448	0	3.74	1.082	152	64	232	7358	<0.001	0.372
2.I like technology and robots (Post)	448	0	4.00	1.018						
3.Science helps me to solve problems (Pre)	445	2	3.27	0.994	184	71	193	9657	<0.001	0.394
3.Science helps me to solve problems (Post)	445	1	3.62	1.038						
4.I like to experiment (Pre)	448	0	4.26	1.191	96	63	289	5686	0.231	0.106
4.I like to experiment (Post)	448	0	4.32	1.271						
5.What I learned today is important for my future career (Pre)	444	2	3.16	1.049	159	118	171	16012	0.034	0.144
5.What I learned today is important for my future career (Post)	444	2	3.32	1.069						
6.I can carry out scientific experiments independently (Pre)	445	2	4.32	1.262	54	314	80	55253	<0.001	0.654
6.I can carry out scientific experiments independently (Post)	445	1	3.54	1.103						
7.I liked working independently (Pre)	446	2	3.30	1.036	198	67	183	9455	<0.001	0.455
7.I liked working independently (Post)	446	0	3.76	1.088						
8.The workshop helped me to find a solution to problems myself (Pre)	441	0	3.66	1.151	140	139	169	17308	0.318	0.068
8.The workshop helped me to find a solution to problems myself (Post)	441	7	3.74	1.044						
9.I liked the topic today (Pre)	447	1	3.21	1.023	272	60	116	10204	<0.001	0.629
9.I liked the topic today (Post)	447	0	3.99	1.058						
10.I would like to find out more about this topic (Pre)	446	1	3.35	0.998	245	57	146	9756	<0.001	0.568
10.I would like to find out more about this topic (Post)	446	1	3.96	1.113						
11.The workshop helped me learn new things (Pre)	447	0	3.16	1.028	289	57	102	9892	<0.001	0.669
11.The workshop helped me learn new things (Post)	447	1	4.00	1.190						

Note. Missing values, being unanswered items, were considered as level 0.

3.2.4.2. Secondary

Table 31 and Figure 21 show the results of the comparison between pre-test and post-test for the secondary questionnaires. Minor decreases were observed in items related to general interest and motivation, such as *Science is interesting* (Item B2; 3.98 → 3.80) and *I enjoy learning science* (Item B1; 3.78 → 3.67). Confidence-related items in dimension C (Self-efficacy towards science) also showed slight drops (for example, *I can learn and use scientific skills* —Item C2; 3.38 → 3.25—). Despite this, there was a small increase in the belief *I am confident I can succeed in a scientific career* (Item C5; 3.33 → 3.40).

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Table 31. Means and standard deviation for secondary pre-test and post-test in OSA.

Dimension	Item	Pre-test				Post-test			
		N	Lost	Mean	SD	N	Lost	Mean	SD
B	1.I enjoy learning science	1271	0	3.78	1.13	514	0	3.67	1.25
	2.Science is interesting	1271	0	3.98	1.12	514	0	3.80	1.24
	3.I like to do science experiments	1271	0	4.15	1.11	514	0	4.03	1.25
	4.Learning science will help me in my daily life	1270	1	3.52	1.16	514	0	3.36	1.31
	5.I need to do well in science to get the job I want	1270	1	3.37	1.39	514	0	3.32	1.43
C	1.Science is harder for me than any other subject	1263	8	2.52	1.25	510	4	2.45	1.30
	2.I can apply scientific knowledge to real-world situations	1263	8	3.41	1.08	510	4	3.33	1.21
	3.I can learn and use scientific skills	1263	8	3.38	1.18	510	4	3.25	1.29
	4.I can communicate effectively about scientific topics with others	1263	8	3.67	1.11	510	4	3.63	1.23
	5.I am confident I can succeed in a scientific career	1262	9	3.33	1.25	510	4	3.40	1.31
D	1.Learning science is important for my future career	1252	19	3.40	1.32	507	7	3.26	1.42
	2.I am interested in careers that use science, mathematics or technology	1253	18	3.57	1.34	507	7	3.50	1.37
	3.A family member of mine works in a science related field	1253	18	2.68	1.60	507	7	2.73	1.61
	4.I enjoy talking to scientist	1253	18	3.30	1.27	507	7	3.26	1.35

Note. N = sample size; Lost = Lost data; SD = Standard deviation.

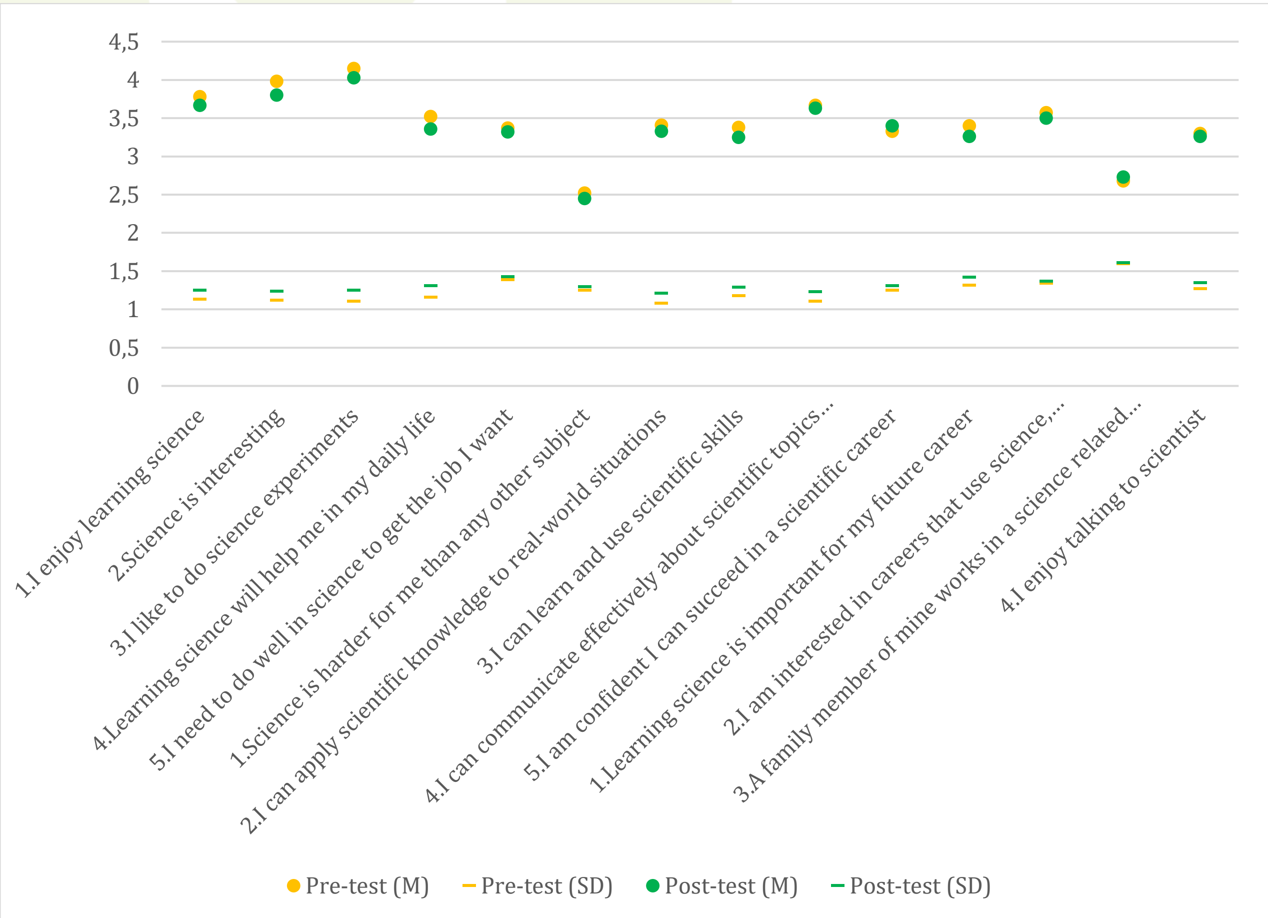

Figure 21. Mean and standard deviation of secondary pre- and post-test in OSA.

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Table 32 shows the results of the pre-test and post-test comparison analyses for each participant using the Wilcoxon signed-rank test. The results show most positive ranks in all items except B2, B3, B4 and C1, in which there are more negative ranks. However, unlike the primary results, in this case most of the differences are not statistically significant. However, unlike the primary school results, in this case most of the differences are not statistically significant. In fact, even two items with a majority of negative ranks show statistically significant differences (B3 and C1).

Table 32. Sample size, lost values, means and standard deviation, and the Wilcoxon test results for secondary's pre-tests and post-tests in OSA.

						Wilcoxon signed-rank test					
Dimension	**Item**	**N**	**Lost**	**Mean**	**SD**	**Positive ranks**	**Negative ranks**	**Ties**	**W**	**p**	**ES**
B	1.I enjoy learning science (Pre)	266	0	3,79	0,963	58	55	153	3171	0,881	0,0155
	1.I enjoy learning science (Post)	266	0	3,79	1,077						
	2.Science is interesting (Pre)	266	0	4,05	1,032	62	70	135	4826	0,298	0,0996
	2.Science is interesting (Post)	266	0	3,97	1,090						
	3.I like to do science experiments (Pre)	266	0	4,30	0,980	41	73	152	4310	0,003	0,315
	3.I like to do science experiments (Post)	266	0	4,08	1,176						
	4.Learning science will help me in my daily life (Pre)	266	0	3,45	1,049	72	77	117	5940	0,486	0,0631
	4.Learning science will help me in my daily life (Post)	266	0	3,39	1,273						
	5.I need to do well in science to get the job I want (Pre)	265	1	3,30	1,320	89	48	129	3140	<0,001	0,3259
	5.I need to do well in science to get the job I want (Post)	266	0	3,56	1,320						
C	1.Science is harder for me than any other subject (Pre)	264	2	2,65	1,183	59	90	117	6149	0,055	0,1779
	1.Science is harder for me than any other subject (Post)	263	3	2,51	1,198						
	2.I can apply scientific knowledge to real-world situations (Pre)	264	2	3,37	1,063	81	64	121	4511	0,348	0,0859
	2.I can apply scientific knowledge to real-world situations (Post)	263	3	3,43	1,143						
	3.I can learn and use scientific skills (Pre)	264	2	3,33	1,101	88	48	130	3158	0,005	0,2695
	3.I can learn and use scientific skills (Post)	263	3	3,52	1,115						
	4.I can communicate effectively about scientific topics with others (Pre)	264	2	3,73	1,029	83	63	120	4721	0,527	0,0569
	4.I can communicate effectively about scientific topics with others (Post)	263	3	3,79	1,094						
	5.I am confident I can succeed in a scientific career (Pre)	263	3	3,43	1,202	79	55	132	3143	0,014	0,2387
	5.I am confident I can succeed in a scientific career (Post)	263	3	3,58	1,254						
D	1.Learning science is important for my future career (Pre)	259	7	3,40	1,210	79	51	136	3038	0,141	0,1492

	1.Learning science is important for my future career (Post)	262	4	3,50	1,335						
	2.I am interested in careers that use science, mathematics or technology (Pre)	260	6	3,69	1,188	70	63	133	3763	0,897	0,0131
	2.I am interested in careers that use science, mathematics or technology (Post)	262	4	3,73	1,327						
	3.A family member of mine works in a science related field (Pre)	260	6	2,58	1,566	73	52	141	2707	0,073	0,1885
	3.A family member of mine works in a science related field (Post)	262	4	2,74	1,639						
	4.I enjoy talking to scientist (Pre)	260	6	3,42	1,251	74	63	129	3966	0,81	0,0241
	4.I enjoy talking to scientist (Post)	262	4	3,45	1,217						

Note. Missing values, being unanswered items, were considered as level 0.

3.2.5. Participation in several activities

The number of participants who took part in various activities in each country was very small. Regarding primary students, only 24 participants were found to have participated in two different activities, specifically: 20 students from Cyprus, three students from Germany, and one student from Portugal. Regarding the secondary students, only 50 participants were found to have participated in two different activities, specifically: 14 students from Croatia, 17 students from Cyprus, 12 students from Turkey, six students from Portugal, and one student from Germany.

3.3. Results of the case studies

The case studies are organized around the evaluation of the OSA, with data collection taking place before and after the activities. Three qualitative instruments were used: initial individual interviews (with three teachers, before the activity), retrospective individual interviews (with the same three teachers, after the activity), and a retrospective focus group (with a group of students, after the activity). The structure of the instruments is divided into several sections. All of them have a section about Background information (Part A): Code name, gender, age, educational level, speciality and years of service. The initial interview consists of three questions about previous participation in OSA, their current teaching practises, and their expectations about the project. The retrospective interview and the focus group have complementary sections organized by key themes: Part B. Value of open schooling, Part C. Impact on students and community, Part D. Willingness to continue with open schooling, Part E. Support needed for open schooling, Part F. Gender Issues, and Part G. Influence of previous activities on the open schooling activity. The structure and the themes are the same, so it is possible to compare teachers' and students' perceptions. The analysis of the data was initially carried out at the country level by local teams for linguistic reasons, based on a content/thematic analysis methodology that uses an open coding system while considering pre-established main themes/categories to ensure the homogeneity and comparability of the results, culminating in an international cross-country case study.

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3.3.1. Teachers' initial interview

3.3.1.1. Question 1

Question 1 was "Have you ever participated in an open schooling or similar activity?". Table 33 show the main findings for each country.

Table 33. Main findings found in the analysis of question 1 in teachers' initial interviews.

Country	Findings
Germany	Two teachers had previous experience through ICSE in this project or the MOST project (topics: molecular cuisine, sustainability, waste reduction).
Portugal	All teachers had substantial and sustained prior experience. Projects ranged from renewable-energy studies and environmental restoration to intergenerational cultural activities.
Cyprus	Limited experience; some teachers joined short research-based or STEAM collaborations with universities.
Turkey	Minimal direct experience; teachers participated in science fairs or eTwinning projects rather than structured co-creation initiatives.
Croatia	No teacher reported prior open-schooling experience.

Portugal stands as the only country where open schooling is institutionally normalized. Germany demonstrates limited, project-specific exposure, mainly through ICSE initiatives, rather than systemic implementation. Cyprus and Turkey exhibit teacher-driven but structurally constrained engagement, where innovation relies on individual enthusiasm. Finally, Croatia remains at an introductory awareness stage, yet shows attitudinal readiness for future integration.

3.3.1.2. Question 2

Question 2 was "How would you define your classes in terms of approaches, methodologies, contents, resources, contextualization, etc.". Table 34 show the main findings for each country.

Table 34. Main findings found in the analysis of question 2 in teachers' initial interviews.

Country	Teaching Approach	Use of Resources	Contextualization	Collaboration
Germany	Mixed, leaning participative and practice-based. Vocational focus (hands-on, reflective learning).	Combination of self-developed and digital materials.	Strong: connects science to everyday life (nutrition, sustainability).	Present in specific projects (universities, companies).
Portugal	Uniformly participative, student-centered (project-based, inquiry, STEM).	Mainly other resources: labs, simulators, databases, expert input.	Very high; projects explicitly link to environmental and social realities.	Extensive, sustained collaboration with NGOs, museums, associations, and municipalities.

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Cyprus	Predominantly expository; innovation depends on teacher initiative.	Primarily textbook-based; limited technology.	Low: teachers note missing real-life links.	Rare; hindered by bureaucracy and lack of collaborative culture.
Turkey	Mixed; from expository to participative (depending on subject and teacher).	Textbook + digital tools (GeoGebra, MEB portal).	Moderate: includes local environmental issues and current events.	Limited; occasional internal cooperation, rare external links.
Croatia	Mainly participative; inquiry-based and "Building Thinking Classrooms."	Textbook + self-developed materials.	Yes; strong emphasis on everyday applications.	Yes; active cross-subject collaboration within schools.

Portugal and Germany operationalize open schooling pedagogy through inquiry, interdisciplinarity, and authentic contexts. Croatia shows promising methodological readiness even without structural partnerships. Cyprus and Turkey reveal systemic constraints—innovation depends on personal initiative amid rigid curricula.

3.3.1.3. Question 3

Question 3 was "What do you expect from your participation in the open schooling activity?". Table 35 show the main findings for each country.

Table 35. Main findings found in the analysis of question 3 in teachers' initial interviews.

Dimension	Germany	Portugal	Cyprus	Turkey	Croatia
Student Engagement	High – expects increased motivation via practical, intergenerational work.	Very high – hands-on and authentic contexts strongly engage learners.	High – "students become little researchers."	High – expects curiosity and real-world motivation.	High – anticipates enthusiasm and creativity.
Benefits for Teacher	Yes – professional enrichment, practical inspiration.	Yes – pedagogical renewal, collaboration, reflection.	Yes – new methods, revitalized practice.	Yes – skill development, creativity.	Yes – satisfaction and innovation.
Parents' Engagement	Moderate; indirect via publicity.	Strong – active interest and public exhibitions.	Not mentioned.	Mixed – expected curiosity.	Low – mainly observation of children's work.
Community Involvement	Active – retirement homes, experts, companies.	Extensive – NGOs, local associations, municipalities.	Expected – networking with scientists.	Anticipated – energy, environment themes.	Variable – some partial engagement.

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Time Demand	More time but manageable.	More time, accepted as worthwhile.	More time, major obstacle.	More time, worthwhile.	More time, seen as demanding but motivating.
School Reception	Positive, managerial support.	Positive, institutional encouragement.	Neutral → Negative – bureaucracy, resistance.	Positive.	Mostly positive, occasional skepticism.

Across all five contexts, teachers express optimism and place high value on student engagement; however, their ability to implement open schooling is deeply shaped by institutional and cultural frameworks. In Portugal, open schooling appears as an embedded practice supported by systemic structures. In Germany, it manifests through vocational adaptation and institutional openness. In Croatia, strong pedagogical enthusiasm contrasts with the lack of infrastructure. Meanwhile, in Turkey and Cyprus, individual motivation drives the effort forward despite operating within restrictive systems.

3.3.2. Teachers' retrospective interview

3.3.2.1. Part B. Value of open schooling

The questions in this section were:

- Question 1: What do you consider as the most valuable aspect of open schooling activities for you as a teacher, for the students, for the parents and for the rest of the community?
- Question 2: How do you consider the relationship between the school, the parents and the rest of the community during the participation in the open schooling activity?
- Question 3: Do you think that the open schooling activity carried out is susceptible to be used in other contexts?

Table 36 show the main findings for each country in this section.

Table 36. Main findings found in the analysis of section B in teachers' retrospective interviews.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Teachers' Perceived Value	Enhanced motivation, collaboration, and real-world learning; still project-based	Seen as an educational philosophy promoting creativity, reflection, and	Valued for engagement and creativity but limited by rigid curricula.	Viewed as empowering and innovative, strengthening collaboration.	Recognized as enriching, promoting independence and problem-solving.

	rather than systemic.	civic responsibility.			
Value for Students	Increased engagement and self-confidence through authentic activities.	High autonomy and civic awareness; students showed pride and ownership.	Improved teamwork, creativity, and enthusiasm for science.	Greater confidence, communication, and responsibility; active learners.	Growth in curiosity and critical thinking; strong participation.
Value for Teachers / Professional Practice	Improved teamwork, reflection, and innovation; desire for institutional support.	Professional renewal and collective identity through collaboration.	Felt energized and creative but constrained by lack of time/support.	Strengthened interdisciplinary teaching and peer collaboration.	Empowered as facilitators; enjoyed freedom to design authentic projects.
Value for Parents & Community	Partnerships with local groups raised school visibility.	Strong parental and community collaboration; sustained partnerships.	Limited parental involvement; some outreach through exhibitions.	Emerging engagement; positive parental feedback.	Early-stage collaborations with local organizations; growing support.

Teachers across all countries recognized open schooling as a high-value, transformative framework enhancing student motivation, teacher creativity, and school–community connections. Portugal demonstrates systemic maturity, where open schooling is embedded in school culture. Germany benefits from strong pedagogical outcomes but remains project dependent. Cyprus and Turkey show enthusiastic but constrained implementation due to structural rigidity. Croatia reveals rapid adoption and strong alignment with open schooling principles. Overall, open schooling is valued not merely as a teaching method but as a philosophy of openness and collaboration that redefines learning as socially relevant and inclusive.

3.3.2.2. Part C. Impact on students and community

The questions in this section were:

Questions on impact on students

- Question 4: From your point of view, did participation in the open schooling activity affect students' scientific skills/competences?
- Question 5: From your point of view, did participation in the open schooling activity affect students' motivation/active participation and self-confidence?

Question on impact on community

- Question 6: From your point of view, has the open schooling activity had an impact on the community?

Table 37 show the main findings for each country in this section.

Table 37. Main findings found in the analysis of section C in teachers' retrospective interviews.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Impact on Students' Scientific Skills / Competences	Students applied science in real contexts, gaining procedural understanding and relevance.	Strong progress in inquiry, data handling, and methodological rigor.	Linked theory to real issues; improved experimental thinking and teamwork.	Learned applied STEM concepts and inquiry skills through hands-on work.	Enhanced analytical skills and environmental awareness.
Impact on Motivation, Participation & Self-Confidence	Authentic projects boosted motivation and pride in presenting results.	High autonomy and recognition strengthened curiosity and persistence.	Real-world focus increased enthusiasm and self-expression.	Very high motivation and responsibility; notable growth among low-achievers.	Active, confident learners who viewed science as meaningful.
Impact on Community	Partnerships with local groups raised science visibility.	Families and partners engaged; schools gained civic trust.	Public exhibitions improved school image and outreach.	Local fairs drew attention and recognition from community.	Awareness-raising activities built modest but positive community links.

Across contexts, teachers saw consistent educational gains: students developed real scientific competences, confidence, and motivation through authentic inquiry. Portugal and Germany show the most mature ecosystems, combining rigorous learning with community partnership. Cyprus and Turkey demonstrate strong student enthusiasm despite structural constraints. Croatia displays rapid pedagogical uptake, linking science with local relevance. Open schooling thus functions as a bridge between classroom and society, cultivating scientifically literate, confident, and socially engaged learners across Europe.

3.3.2.3. Part D. Willingness to continue with open schooling

The question in this section was:

- Question 7: After your participation in the project, do you plan to continue developing open schooling activities in the future? Explain why.

Table 38 show the main findings for each country in this section.

Table 38. Main findings found in the analysis of section D in teachers' retrospective interviews.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Future Plans	All teachers plan to continue; one integrated it into the timetable as a recurring activity.	Strong, detailed plans for continuation and expansion; annual projects and interdisciplinary collaborations planned.	All teachers intend to continue, citing student enthusiasm and professional satisfaction.	All plan smaller-scale annual projects to maintain momentum; aim to integrate open schooling within existing curricula.	All teachers intend to repeat or expand open-schooling activities in the future.
Hesitations / Barriers	Limited mainly to resource and organization challenges.	Time pressure, workload, and bureaucracy are main obstacles; lack of formal recognition discourages some.	Structural rigidity, unsupportive school environments, and heavy workload limit continuation.	Time constraints and exam pressures pose major obstacles.	Teachers recognize need for external experts and support; problems too big for schools alone.
Support Needed	Clearer organization, funding, and practical guidance; stronger institutional recognition.	Administrative flexibility, funding, training, and recognition of extra workload; support for technology and international collaboration.	Institutional and administrative support, reduced bureaucracy, continued access to university expertise.	Mentorship, access to experts, training, and administrative incentives.	External support from experts and wider networks; access to interdisciplinary collaborations.
Collaborative Networks	Strong interest in maintaining partnerships with retirement homes and other schools; request for an Open Schooling project database.	High advocacy for national and international teacher networks; value in peer exchange and shared resources.	Desire to sustain collaboration with universities and share practices through project networks.	Strong support for forming teacher clusters for sharing experiences and mentoring others.	Teachers value networks but call for inclusion of diverse professions beyond education.

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Across all countries, teachers expressed a clear and sustained commitment to continue implementing open schooling, motivated by the educational, social, and professional value they experienced. Portugal stands out with concrete, long-term planning and structured interdisciplinary collaboration. Germany and Turkey show institutional enthusiasm but depend on external or project-based support. Cyprus demonstrates strong personal motivation but faces systemic resistance and bureaucratic barriers. Croatia highlights genuine commitment coupled with recognition that external expert support is essential. Common needs include time, recognition, resources, and professional networks. Teachers across Europe view open schooling not as a one-off project but as a future-oriented model for sustainable, collaborative science education.

3.3.2.4. Part E. Support needed for open schooling

The questions in this section were:

- Question 8: How was the support received from the project to carry out the open schooling activity?
- Question 9: Apart from the project, have you received support, or encountered obstacles, from your work environment?

Table 39 show the main findings for each country in this section.

Table 39. Main findings found in the analysis of section E in teachers' retrospective interviews.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Overall Perception of Support	Very positive; valued external expertise and smooth coordination with project mentors.	Excellent; university partnerships and colleague collaboration were central to success.	Highly positive; appreciated university cooperation and mentoring support.	Strongly positive; valued expert mentoring, technical guidance, and material support.	Good; teachers satisfied with expert input and school-level assistance.
Challenges Encountered	Minor technical or organizational issues; need for clearer structure.	Time constraints, scheduling issues, and heavy workload.	Bureaucracy and lack of time; systemic rigidity.	Technical difficulties, report writing, and time management.	Workload and timetable inflexibility; lack of institutional recognition.
Usefulness of Support	External scientific expertise and materials essential; good communication.	Highly valuable scientific, pedagogical, and logistical support;	Essential for resources, confidence, and authentic	Crucial for technical success and pedagogical improvement.	Very useful; expert and university support strengthened implementation.

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		boosted professionalism.	scientific learning.		
School and Colleague Support	Generally positive school support; colleagues mostly observers.	Strong peer collaboration, growing interdisciplinary engagement.	Limited school support; minimal cooperation among teachers.	Supportive school leadership; mixed reactions from colleagues.	Mixed; some principal support but limited peer involvement.
Changes Needed for Practice	Clearer coordination and institutional frameworks.	Dedicated collaboration time, PD integration, and formalized partnerships.	Reduced bureaucracy and curriculum flexibility.	Simplified documentation and ongoing mentoring.	More in-school support, flexible scheduling, and expert involvement.
Curriculum Compatibility	Mostly compatible; activities aligned with learning goals.	Generally supportive, though exam pressures limit flexibility.	Compatible in principle but restricted by syllabus priorities.	Partially compatible; requires integration into project-based modules.	Not fully compatible; teachers value autonomy beyond standard curriculum.

Teachers across all contexts described strong appreciation for project and expert support, which they viewed as essential to the success of open schooling. Portugal and Germany reported the most structured and reliable support networks, emphasizing the power of university–school partnerships. Cyprus and Turkey valued mentoring and access to equipment but identified bureaucracy, time pressure, and rigid curricula as barriers to sustainability. Croatia highlighted satisfaction with expert help yet noted limited institutional and colleague engagement. Common needs include systematic support structures, professional development, and curricular flexibility. Teachers widely agreed that open schooling requires institutional recognition, stable partnerships, and dedicated time to become a permanent part of school culture.

3.3.2.5. Part F. Gender issues

The question in this section was:

- Question 10: Have you encountered gender differences during the implementation of the open schooling activity?

Table 40 show the main findings for each country in this section.

Table 40. Main findings found in the analysis of section F in teachers' retrospective interviews.

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Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Differences Between Girls and Boys	Minimal or none; some activities all-female. When mixed, boys built faster; girls preferred digital tools.	No major differences observed; both genders equally engaged.	No major differences; girls slightly more emotionally invested and enthusiastic.	Boys gravitated to technical work; girls excelled in organization and design.	Distinct patterns: girls diligent and detailed, boys more relaxed and less thorough.
Impact on Girls' Performance	Not significant; performance differences not gender-based.	Greater confidence and leadership than in regular classes.	High motivation and responsibility; girls often took initiative.	Girls more disciplined and expressive; leadership emerged in communication and reporting.	Girls conscientious and prepared but sometimes less confident.
Impact on Boys' Performance	No clear difference; varied by group.	Improved collaboration and engagement; disruptive students became more focused.	Collaborative and effective but less emotionally expressive.	Boys engaged technically but needed support for documentation and focus.	Boys confident but less detailed; sometimes avoided responsibility.
Group Dynamics and Collaboration	Gender not an issue; groups cooperative with complementary strengths.	Mixed groups functioned well; collaboration over competition.	Gender balance maintained; roles distributed by skill.	Mixed groups worked well when roles were balanced; stereotypes reduced.	Varied: some gender-based grouping; girls and boys worked on different problems.

Across all five countries, teachers largely reported gender equity in participation and performance, though subtle patterns persist. Portugal and Germany observed minimal gender differences, crediting balanced group formation and authentic inquiry for neutralizing bias. Cyprus and Turkey noted differences in expression and task preference—girls often more organized and communicative, boys more hands-on—but both genders performed equally well. Croatia revealed clearer contrasts in confidence and approach: girls thorough but hesitant; boys confident but less careful. Overall, open schooling provided inclusive, stereotype-challenging environments where girls displayed leadership and boys improved collaboration. Teachers concluded that authentic, mixed, inquiry-based learning helps reduce traditional gender divides and supports more equitable participation in science.

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3.3.2.6. Part G. Influence of the previous activities in the open schooling activity

The question in this section was:

- Question 11: What, if any, do you consider the interactive career talks and/or lighthouse activity have contributed to the development of the open schooling activity (contributing topics, knowledge, possible problems and/or solutions, etc.)?

Table 41 show the main findings for each country in this section.

Table 41. Main findings found in the analysis of section G in teachers' retrospective interviews.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Contribution to Open Schooling Activity	Prior workshops (molecular cuisine, escape games) provided methodological groundwork and technical know-how.	Career talks inspired topic selection, methodological innovation, and workplace visits.	Not discussed.	Previous workshops strengthened teamwork and brainstorming; improved problem-solving readiness.	Minimal influence; some ideas drawn from earlier sessions.
Influence on Students	Students recognized continuity between playful and applied science; gained agency and confidence.	Career talks connected school science to real professions and community challenges.	Not discussed.	Earlier experiences improved collaboration and initiative.	Limited awareness; modest impact on student ideas.
Influence on Teachers	Boosted confidence to design projects and integrate external expertise.	Increased self-efficacy, innovation, and understanding of professional science; enhanced teaching materials.	Not discussed.	Enhanced group management and facilitation of student ideation.	Slight influence; teachers drew some inspiration for planning.
Role of External Expertise	University collaboration enriched content and authenticity.	Partnerships with scientists and companies strengthened authenticity and engagement.	Not discussed.	Mentoring and previous cooperation improved teacher readiness.	Little or no external involvement reported.
Overall Reflection	Prior projects provided structure, reduced uncertainty, and	Previous activities served as strong catalysts for professional	No data.	Prior exposure helped teachers and students enter open	Limited effect; activities

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	encouraged continuity.	networking and student motivation.		schooling more confidently.	viewed as peripheral.

Across countries, previous ICSE experiences—especially interactive career talks and lighthouse activities—played an important preparatory role where implemented. Portugal and Germany stand out: teachers there used earlier experiences as conceptual and methodological springboards, strengthening authenticity and confidence. Turkey benefited from prior teamwork practice, which improved readiness for open schooling. Cyprus lacked explicit links to previous activities, suggesting a disconnection between project phases. Croatia reported minimal continuity, with earlier activities having limited direct impact. Overall, the findings show that iterative participation in ICSE initiatives builds teacher capacity and student familiarity, creating smoother transitions into open-schooling practice. Where such continuity is absent, activities risk being perceived as isolated rather than cumulative experiences.

3.3.3. Students' retrospective focus group

3.3.3.1. Part B. Value of open schooling

The questions in this section were:

- Question 1: What is your overall assessment of your participation in the open schooling activity (positive, negative)?
- Question 2: How do you consider the relationship between the school, the parents and the rest of the community during the participation in the open schooling activity?
- Question 3: Do you think that the open schooling activity carried out is susceptible to be used in other contexts?

Table 42 show the main findings for each country in this section.

Table 42. Main findings found in the analysis of section B in students' retrospective focus group.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Overall Perception	Positive; meaningful, socially relevant, and collaborative experience.	Very positive; engaging, active learning contrasting traditional lessons.	Very positive; meaningful, student-centered, and community-relevant.	Very positive; fun, hands-on, and different from normal lessons.	Very positive; independent, interesting, and team-oriented.
Learning	Learned about applied chemistry, additives, and	Acquired scientific knowledge, inquiry, and	Learned environmental science concepts,	Understood biological processes and ecosystems;	Learned independent research, microscopy,

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	real-world applications; practical skills valued.	problem-solving; connected theory with daily life.	inquiry methods, and civic relevance.	learned observation and problem-solving.	data analysis, and experimental care.
Teacher Role	Supportive and collaborative; appreciated teamwork between teachers and external experts.	Teachers acted as facilitators and mentors, fostering autonomy and trust.	Teachers seen as mentors; guided without dominating.	Teachers supportive and encouraging; allowed freedom to explore.	Teachers provided strong scientific and mathematical guidance; collaboration with university noted.
Parents' Participation	Minimal but positive; families discussed and showed interest.	Highly involved; parents helped with data collection and applied findings at home.	Observers; interested but not active participants.	Parents attended meetings and expressed pride.	Absent; no parental involvement reported.
Community Connection	Strong link with retirement home; students saw societal value.	Community reached indirectly through family networks and school improvements.	Awareness raised during conference; public showed interest.	Positive collaboration with experts; community interest in sustainability.	Indirect outreach through results presentation; raised local awareness.
Adaptability & Scalability	Believed activity could be repeated on new topics; enthusiasm topic-dependent.	Recognized potential to expand to new environmental or social issues; inspired peers.	Viewed the model as reusable for other problems; suggested broader civic initiatives.	Confident that similar projects could be done with simple materials; accessible to other schools.	Strong belief in replication; proposed large-scale citywide version for better data.

Across all contexts, students described open schooling as a highly positive, engaging, and empowering learning experience. Portugal, Cyprus, and Turkey emphasized agency, inquiry, and real-world relevance, showing strong understanding of the scientific process and its social impact. Germany and Croatia highlighted authentic application and teamwork, seeing science as meaningful beyond textbooks. Portugal stood out for its deep parental and community engagement, while Croatia and Cyprus reported weaker parental participation but strong peer collaboration. Overall, students across countries perceived open schooling as a transformative shift from passive to active learning, allowing them to "feel like scientists," connect science to daily life, and envision broader community and environmental contributions.

3.3.3.2. Part C. Impact on students and community

The questions in this section were:

Questions on impact on students

- Question 4: From your point of view, what have you learnt about science during the open schooling activity (concepts, practices, etc.)?
- Question 5: How did you feel during your participation in the open schooling activity?

Question on impact on community

- Question 6: From your point of view, do you think your project has had an impact on your community?

Table 43 show the main findings for each country in this section.

Table 43. Main findings found in the analysis of section C in students' retrospective focus group.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Scientific Knowledge & Understanding	Applied chemistry to food and nutrition; connected theory to daily life.	Learned environmental and physical science concepts, measurement, and variable control.	Understood urban heat island effect and climate change; linked theory to real-life context.	Learned biology concepts like metamorphosis and animal nutrition; understood ecological cycles.	Gained knowledge of microplastics and environmental contamination; learned statistical tools (Chi-square).
Scientific Practices & Skills	Practical experimentation, trial and error, and reflection on outcomes.	Developed inquiry, data collection, calibration, error analysis, and hypothesis testing.	Practiced data collection, analysis, and conclusion-drawing with teamwork.	Applied observation, comparison, and documentation; improved responsibility.	Designed and executed experiments independently; handled data and analysis autonomously.
Relevance & Confidence in Science	Recognized chemistry as useful but already trusted science.	Saw science as problem-solving and applicable to everyday life; strengthened belief in relevance.	Linked science to social good and civic responsibility; gained motivation to pursue science.	Understood science as useful for sustainable solutions; identified personal contribution.	Viewed science as practical and empowering; understood its role in community health.
Motivation & Emotional Engagement	Positive feedback from seniors	Felt like scientists solving real problems;	Felt proud to contribute to community; valued	Overcame fear and found joy in responsibility;	Initially hesitant but became engaged;

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	increased motivation.	motivated by visible impact and discovery.	meaningful, hands-on work.	emotional connection to living organisms.	excitement and pride in results.
Active Participation	Strong engagement in cooking and presenting to seniors.	Student-led investigation and peer collaboration; initiative beyond sessions.	Group discussions and collective decisions; persistent effort beyond school hours.	Team-based care for organisms; everyone contributed equally.	Intense collaboration and communication; worked autonomously with teachers' support.
Self-Confidence & Agency	Confidence through successful completion and community recognition.	High confidence and initiative; proposed new research ideas and community actions.	Felt capable of conducting "real" scientific research; improved communication skills.	Developed self-confidence and ownership; identified as "scientists."	Pride in independent work; recognized own competence in science.
Impact on Community	Seniors learned about science in daily life; strengthened school–community ties.	Parents, teachers, and community became more aware of air quality and environmental issues.	Raised public awareness through exhibitions and interactions.	Shared results at school fairs; inspired curiosity and sustainable practices.	Shocking results about microplastics raised awareness; teachers and peers reacted strongly.

Across all countries, students reported deepened understanding of science, stronger confidence, and emotional investment in learning through open schooling. Portugal and Cyprus demonstrated the strongest links between science learning and civic purpose, emphasizing environmental relevance and societal contribution. Germany and Croatia highlighted practical application and authentic inquiry, where success and public feedback reinforced confidence. Turkey stood out for emotional connection and empathy developed through hands-on, biological work. Community impact was most visible in Portugal (school and family behavior changes) and Croatia (public reaction to data). Overall, students across all contexts viewed science as collaborative, empowering, and socially meaningful, reflecting a major shift from passive learning to active participation in real-world scientific inquiry.

3.3.3.3. Part D. Willingness to continue with open schooling

The question in this section was:

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- Question 7: Following your participation in the activity, would you like to participate in open schooling or similar activities again in the future?

Table 44 show the main findings for each country in this section.

Table 44. Main findings found in the analysis of section D in students' retrospective focus group.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Willingness to Continue	Positive; students would participate again depending on topic.	Very strong; all would repeat and suggested new projects on community or global issues.	Unanimous willingness; described activity as valuable and enjoyable.	Enthusiastic; all want to join future projects and invite peers.	All confirmed willingness; described projects as "rest from routine learning."
Motivations	Enjoyed trying something new and practical.	Inspired by relevance to real problems, teamwork, and autonomy.	Valued creativity, collaboration, and sense of contribution.	Loved hands-on science and caring for living organisms.	Appreciated teamwork, autonomy, and freedom to choose projects.
Hesitations / Barriers	Limited personal interest for some students.	Time pressure, lack of teacher collaboration, and social pressure ("nerd" stigma).	High workload during exam season; time outside class was demanding.	None reported.	Time constraints; overburdened curriculum; desire for better balance with regular classes.
Support Needed	None specified.	More time, expert sessions, institutional backing, and partnerships with local organizations.	More time in curriculum, continued teacher mentorship, and funding.	Additional lab space, materials, and expert mentoring.	Institutional support, project recognition, and opportunities for class-based implementation.
Other Observations	Found experience "cool" and different from normal classes.	Students proposed peer mentoring and media involvement to expand reach.	Praised teacher support and teamwork; no regrets despite workload.	Wanted larger participation and schoolwide expansion.	Suggested non-graded project days and inclusion of digital tools like AI for analysis.

Across countries, students expressed overwhelming willingness to participate again, describing open schooling as one of their most meaningful and enjoyable learning experiences. Portugal, Cyprus, and Turkey showed the highest enthusiasm, linking participation to autonomy, relevance, and social purpose. Germany and Croatia also expressed positive attitudes, though with contextual reservations about time and workload. Common challenges include time pressure, curricular rigidity, and limited institutional coordination. Students widely emphasized that with more time, expert

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input, and school recognition, such projects could become integral parts of learning, not just extracurricular activities. Open schooling thus emerges as a model students see as both personally rewarding and socially meaningful, fostering agency, curiosity, and collaboration.

3.3.3.4. Part E. Support needed for open schooling

The questions in this section were:

- Question 8: How was the support received from the project to carry out the open schooling activity?
- Question 9: Did you receive support other than from your teacher, parents and scientists/professionals?

Table 45 show the main findings for each country in this section.

Table 45. Main findings found in the analysis of section E in students' retrospective focus group.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Overall Perception of Support	Positive; found experience well-supported and enjoyable, but no extra support mentioned.	Highly positive; praised teachers, experts, and university collaboration. Some noted lack of coordination among teachers.	Excellent teacher support; project help viewed as essential for success.	Very positive; appreciated guidance from teachers, parents, and experts.	Strong support from biology and mathematics teachers; overall experience rated highly.
Challenges Encountered	None major; some lacked personal interest.	Time management, coordination, and workload challenges.	Time constraints and extra workload outside school hours; loss of equipment.	Managing experiment conditions (worm care, materials).	Not being excused from other school activities.
Usefulness of Support	Not discussed.	Support from mentors and access to materials enhanced learning; expert sessions especially valuable.	Teachers' mentoring crucial; valued hands-on learning opportunities.	Laboratory access and materials essential; teacher collaboration effective.	Very useful; learned a lot through expert and teacher support.
School's Role	None beyond classroom.	Provided access and space; began implementing students' findings	Limited by schedule; after-hours meetings required.	Provided space and materials for experiments.	Allowed free use of school facilities;

		(e.g., ventilation improvements).			supportive environment.
Other Teachers' Role	Not mentioned.	Mixed—some helped, others resisted project interruptions.	Not mentioned.	Additional teacher assisted with supervision.	Supportive collaboration among teachers.
Suggested School Changes	None specified.	More time, teacher collaboration, expert sessions, and municipal partnerships.	Modernize teaching methods; more experimentation, digital tools, and awareness.	Create a dedicated "science project corner" for continuity.	Greater institutional flexibility and dedicated time for open-schooling projects.

Across all countries, students expressed strong satisfaction with the support they received from teachers and experts but also identified systemic barriers to sustaining open-schooling practices. Portugal and Cyprus emphasized the need for modernization and integration—more time, resources, and teacher cooperation within schools. Turkey and Croatia focused on practical enhancements, such as lab facilities, designated project spaces, and schedule flexibility. Germany reported fewer structural concerns, as students viewed the project as well-organized and enjoyable but limited to specific contexts. Overall, students across Europe perceive open schooling as well-supported yet structurally fragile—dependent on motivated teachers rather than institutional frameworks. They call for greater coordination, updated pedagogical methods, and more time and recognition to ensure such initiatives become a sustained part of school life.

3.3.3.5. Part F. Gender issues

The question in this section was:

- Question 10: Do you think there has been any difference in the participation of girls and boys during the open schooling activity?

Table 46 show the main findings for each country in this section.

Table 46. Main findings found in the analysis of section F in students' retrospective focus group.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Differences Between Girls and Boys	Not applicable – all-female group.	No significant differences; tasks and participation equally shared.	None; task division based on skills and personality, not gender.	Minimal differences; both genders equally active in mixed groups.	None; both genders worked together without role separation.

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Impact on Girls' Performance	Not discussed due to all-girl group.	Strong engagement and leadership; topic inclusivity fostered equal motivation.	Girls more organized and proactive; took initiative in planning.	Girls' active in data and presentation; equal visibility.	Girls diligent and cooperative; no tension reported.
Impact on Boys' Performance	Not discussed.	Increased motivation and confidence; enjoyed responsibility and problem-solving.	Boys more action-oriented; focused on visual and design work.	Boys' cooperative and engaged in manual or care-related tasks.	Boys equally participative and respectful.
Group Dynamics and Collaboration	Not applicable.	Highly collaborative; mixed groups improved equality and cooperation.	Strong collective decision-making; collaboration strengthened relationships.	Cooperative; minor disagreements resolved through dialogue.	Harmonious teamwork; gender balance felt natural.
Other Observations	Students appreciated trying something new.	Mixed groups prevented stereotypes; authentic inquiry promoted mutual respect.	Individual traits outweighed gender; fairness and equality emphasized.	Valued fairness and inclusion; positive teacher mediation.	Perceived equality as standard; no gender-based distinctions.

Across all five countries, students described equal participation and cooperation between girls and boys, with no major gender conflicts or stereotypes observed. Portugal, Cyprus, and Turkey explicitly reported gender balance and complementarity, noting that individual skills mattered more than gender. Germany and Croatia (where groups were all-female or highly mixed) reflected neutral or equitable dynamics without observable bias. Girls were frequently described as organized and communicative, while boys tended toward hands-on or technical contributions—yet these roles were experienced as equal and valued. Overall, students viewed open schooling as an inclusive, gender-equitable environment that emphasized collaboration, fairness, and respect. Authentic, problem-based learning blurred traditional gender lines, fostering mutual recognition and teamwork rather than competition or stereotyping.

3.3.3.6. Part G. Influence of the previous activities in the open schooling activity

The question in this section was:

- Question 11: Do you consider that the interactive career talks and/or the lighthouse activity have helped you in the development of the open schooling activity (input of issues, knowledge, possible problems and/or solutions, etc.)?

Table 47 show the main findings for each country in this section.

Table 47. Main findings found in the analysis of section G in students' retrospective focus group.

Theme	Germany	Portugal	Cyprus	Turkey	Croatia
Usefulness of Previous Activities	Not directly related to the open-schooling topic; students found the earlier Molecular Kitchen activity "fun" but more isolated.	Strongly useful; students cited career talks and lighthouse activities as foundations for understanding scientific research, teamwork, and communication.	Not applicable – no prior activities mentioned.	Highly useful; previous career talks helped students understand sustainability and community-oriented research.	Not applicable – students did not participate in prior activities.
Influence on Topic Selection and Solutions	Minimal; open-schooling topic chosen independently.	High influence; students linked prior talks on scientific careers and methods to selecting environmental and social issues.	Not applicable.	Moderate; ideas about ecology and responsibility came from earlier sessions on sustainability.	Not applicable.
Influence on Student Motivation or Skills	Students said prior activity encouraged curiosity but was more about novelty than preparation.	Built critical thinking, communication, and self-confidence; strengthened scientific method understanding and public speaking.	No influence reported.	Reinforced the belief that "science can be done by everyone"; boosted confidence and sense of agency.	No influence reported.
Other Observations	Students described it as "cool to try something new," not directly related to open schooling.	Students credited earlier experiences with shaping their perception of science as relevant, practical, and socially meaningful.	No data.	Students noted clear thematic continuity between previous and current projects.	No data.

Only a few countries demonstrated clear continuity between earlier ICSE activities and open-schooling implementation. Portugal showed the strongest integration, with students explicitly

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connecting previous career talks to scientific inquiry, communication, and confidence-building. Turkey also reflected conceptual continuity, linking sustainability and the idea of “science for everyone” across activities. Germany viewed prior experiences as isolated but enjoyable, providing engagement rather than methodological preparation. Cyprus and Croatia reported no previous involvement, suggesting fragmented project participation. Overall, where continuity existed, it strengthened student readiness, autonomy, and motivation, supporting smoother transitions into open schooling. This highlights the importance of longitudinal engagement in such initiatives—where repeated exposure builds cumulative scientific literacy and confidence rather than one-off experiences.

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4. SUMMARY OF RESULTS AND DISCUSSION

4.1. Questionnaires

The overall results of the questionnaires reveal a consistently positive attitude toward science, experimentation, and inquiry across all participant groups. Students and adults generally reported enjoyment in learning science and recognized the relevance of scientific knowledge to everyday life. These findings align with the project's aim of fostering engagement through Open Schooling Activities (OSA) that connect scientific content with real-world contexts. The data also suggest that experiential, collaborative, and hands-on components play a decisive role in shaping participants' perceptions, as seen in the high ratings of items related to experimentation, collaboration, and learning from others. Nevertheless, some differences emerged across educational levels and activities.

Among primary students, the results point to a very positive reception of the activities and the learning experience. The highest mean values corresponded to items such as I like to experiment and I like technology and robots, highlighting a motivational impact of hands-on, technology-driven learning. Students expressed not only enjoyment but also confidence in conducting scientific experiments and perceiving science as relevant to their future lives. Cross-country comparisons revealed that students in Germany and Portugal tended to rate their experiences more positively, whereas those in Croatia and Cyprus showed lower means and slightly higher variability.

For secondary students, the results also demonstrated favorable attitudes toward science, though with greater differentiation across items. The items on attitudes and beliefs toward science showed the highest means. The items on self-efficacy toward science revealed moderate confidence levels, with students feeling capable of applying and communicating scientific knowledge yet still perceiving science as a demanding subject. The items on interest in science studies and science career obtained lower means overall, suggesting that while students enjoy science, this does not always translate into a clear intention to pursue STEM-related careers. Cross-country analyses showed that Portugal and Cyprus presented the most positive results, while Croatia exhibited lower scores. LHA activities obtained the highest means across items, whereas OSA showed slightly greater variability, possibly reflecting the diversity of contexts and the higher complexity of these open and collaborative formats.

Adult participants reported highly positive evaluations of the activities, with exceptionally high ratings in items such as This activity was pleasant and This activity helped me learn new concepts. However, the small and uneven sample sizes across countries limit the generalizability of these outcomes.

Gender-related analyses revealed that both boys and girls expressed overall positive attitudes toward science and the learning experiences. Boys tended to score slightly higher in items related to self-efficacy and interest in scientific careers, whereas girls reported stronger agreement with statements connecting science to daily life. These differences, though modest, align with prior research indicating that girls often value the social and applied dimensions of science more strongly, while boys report higher confidence in performing scientific tasks. Both genders evaluated the experiences highly (Dimension E), though girls consistently provided slightly higher scores in aspects related to fascination, learning, and perceived relevance. Importantly, there are no large gender gaps in most dimensions.

Comparisons between pre- and post-test results in global terms (all participants together) provide insight into the evolution of participants' perceptions after engaging in OSA. In primary students, slight increases were observed in motivation, interest, and perceived learning, in items such as "*I liked the topic today*" and "*The workshop helped me learn new things*", suggesting that the activities enhanced students' curiosity and active participation in science. However, in secondary students, changes were subtler and occasionally negative. Minor decreases in general interest and self-efficacy were observed. Overall, the pre/post comparisons suggest that the impact of the activities is more pronounced in younger learners.

The comparison between the different activities revealed distinct patterns. LHA activities consistently achieved the highest means, ICaT activities showed slightly lower engagement in some attitudinal items, and OSA activities presented greater variability: while many students found them inspiring and meaningful, others rated them more moderately. This diversity likely reflects both contextual differences and the broader, more complex nature of OSA projects, which require higher levels of collaboration and autonomy.

Finally, the impact of the project was also measured using two indicators: 1) a comparison between pre-test and post-test results for OSA; and 2) tracking participants' involvement in various activities. On the other hand, when analysing the paired data (pre-test and post-test for the same participant), in primary students we find statistically significant positive changes, which provides some evidence in favour of the usefulness of OSA in improving certain aspects of students' perceptions. However, the results are not the same with the sample of secondary students, who, although they show improvement, this is not statistically significant, and they show more items with negative trends between the pre-test and post-test. On the other hand, not many questionnaires were found from the same participants who took part in different activities, which shows that the project has not had much impact in this regard.

4.2. Case studies

Regarding the teachers' initial interviews, the analysis reveals a continuum across the five contexts. In Portugal, open schooling is institutionalized and supported at a systemic level. In Germany, it takes the form of project-based initiatives often sustained by external partnerships. In Croatia, practices are pedagogically aligned with open-schooling principles, though still marked by limited experience. In Cyprus and Turkey, innovation is largely teacher-driven yet constrained by systemic rigidity. Overall, teachers' enthusiasm across contexts suggests that open schooling is not met with resistance but is instead waiting for the structural and cultural conditions that would enable it to flourish sustainably.

Regarding the teachers' retrospective interviews, teachers across Germany, Portugal, Cyprus, Turkey, and Croatia described open schooling as a transformative educational experience that reshaped their perspectives on teaching, learning, and collaboration. Open schooling was universally valued for making science relevant, participatory, and socially connected. Students became more motivated, confident, and active learners who applied scientific knowledge to real-life issues. Teachers, in turn, experienced renewed professional enthusiasm, enhancing their capacities for collaboration, creativity, and reflection. Moreover, communities—particularly in Portugal and Germany—became more involved through public events and partnerships, reinforcing the social dimension of education.

Across all contexts, teachers expressed a strong willingness to continue open-schooling activities. Portugal stood out for its structured and long-term implementation plans, while Germany, Turkey, and Croatia demonstrated considerable enthusiasm within the constraints of project-based initiatives. Cyprus, on the other hand, emphasized the need for policy flexibility to sustain such efforts over time. Despite this shared commitment, teachers identified several barriers, including time constraints, excessive workload, bureaucratic demands, and insufficient institutional recognition.

Participants highlighted the importance of support mechanisms, particularly the guidance and mentoring received from universities and experts, which were highly valued throughout the process. However, teachers also emphasized the need for stronger institutional and administrative backing, additional time and resources, and formal recognition through professional development opportunities. Open schooling proved most effective in contexts where collaborative structures and established partnerships between universities and schools were already in place.

Regarding gender issues, teachers reported minimal differences in participation and performance between girls and boys. Open-schooling environments were perceived as equitable spaces that encouraged inclusion and collaboration. Girls often took leadership roles, demonstrating strong organizational and persistence skills, while boys improved in teamwork and focus. The authenticity of inquiry-based learning helped reduce gender stereotypes and fostered equal participation in science-related activities.

Continuity with previous initiatives, such as earlier ICSE projects (including career talks and lighthouse activities), also played a significant role in shaping teachers' readiness for open schooling. In Portugal and Germany, such previous experiences created a clear foundation for continuity, while

Turkey benefited moderately. In contrast, Cyprus and Croatia exhibited weaker connections between earlier and current initiatives, suggesting that institutional memory and experience can significantly influence the sustainability of open-schooling practices.

Open schooling across these five European contexts demonstrates shared pedagogical values but unequal structural maturity. Teachers view open schooling as a bridge between school, science, and society—a model that promotes relevance, equity, and collaboration. Its long-term sustainability, however, will depend on the consolidation of institutional commitment, the strengthening of professional networks, and the establishment of enduring support structures capable of transforming temporary initiatives into lasting educational practice.

Regarding the students' focus groups, students across Germany, Portugal, Cyprus, Turkey, and Croatia described open schooling as a highly positive and transformative experience that significantly reshaped their perception of science and learning. They consistently portrayed it as engaging, enjoyable, and socially relevant, highlighting the sense of autonomy, teamwork, and real-world connection it fostered. For most students, open schooling represented a shift from traditional, teacher-centered lessons to active and participatory learning. Through these activities, they felt empowered to act as young scientists, applying their knowledge to meaningful social and environmental issues while strengthening both their confidence and their scientific skills.

Across all contexts, students valued the opportunity to work collaboratively and to explore science through authentic, problem-based inquiry. Portugal, Cyprus, and Turkey emphasized the development of agency, critical thinking, and civic awareness, showing strong connections between scientific learning and social responsibility. Germany and Croatia, in turn, highlighted the value of teamwork and hands-on experimentation, appreciating the tangible relevance of science beyond textbooks. The degree of parental and community involvement varied: in Portugal, families played an active role and often contributed to data collection and dissemination of results, while in other contexts, such as Croatia and Cyprus, participation was more limited, though students benefited from strong peer collaboration and support.

In terms of scientific understanding, students across countries reported significant gains not only in motivation and engagement but also in conceptual knowledge and practical inquiry skills. They learned to design experiments, collect and analyse data, test hypotheses, and interpret results, often linking scientific principles to everyday life. Portugal and Cyprus demonstrated particularly strong connections between scientific inquiry and civic engagement, especially around environmental challenges such as air quality and climate change. Germany and Croatia underlined the importance of authentic inquiry and the motivation derived from presenting tangible outcomes to others. Turkey stood out for the emotional connection students developed through hands-on biological work, which encouraged empathy, responsibility, and care. Community impact was most visible in Portugal and Croatia, where the dissemination of findings raised awareness and inspired behavioural change among families, peers, and local actors.

Students expressed overwhelming willingness to continue participating in open-schooling initiatives. They perceived these activities as some of their most meaningful and enjoyable educational experiences, combining creativity, relevance, and teamwork. Portugal, Cyprus, and Turkey showed the strongest enthusiasm, associating open schooling with autonomy, real-world engagement, and social purpose. Germany and Croatia were also positive, though students mentioned time constraints and workload as barriers. Common challenges across countries included curricular rigidity, limited coordination among teachers, and insufficient institutional support. Nonetheless, students widely agreed that with greater flexibility, expert involvement, and school recognition, open schooling could become a regular and integral part of their learning rather than an occasional project.

Regarding the support received, students expressed high levels of satisfaction, particularly with the role of teachers and external experts. They praised the mentorship and resources provided but also acknowledged that such experiences often depend on individual motivation rather than on systemic structures. Portugal and Cyprus highlighted the need for modernization, better coordination among teachers, and more time within the curriculum, while Turkey and Croatia focused on improving infrastructure and scheduling flexibility. Germany stood out for describing the experience as well-organized and enjoyable, though confined to specific project settings. Overall, students viewed open schooling as well-supported but structurally fragile, emphasizing the need for institutional commitment to ensure its sustainability and long-term integration.

Across all five countries, students reported equitable participation between girls and boys, noting that gender did not influence involvement or performance. Mixed-group collaboration was described as natural, respectful, and productive. Individual strengths and interests shaped roles more than gender, and students often perceived this balance as a sign of fairness and inclusion. Girls were frequently described as organized and communicative, while boys tended to engage more in hands-on or technical tasks, but these distinctions were valued equally and did not generate hierarchy or competition. The open and inquiry-based nature of these activities appeared to foster mutual respect and dissolve traditional gender stereotypes, promoting equality and cooperation as central educational values.

The influence of previous educational initiatives, such as career talks and lighthouse activities, was evident in some countries but absent in others. Portugal displayed the strongest continuity, with students explicitly linking earlier experiences to the development of scientific inquiry skills, teamwork, and confidence. Turkey also showed conceptual alignment, as prior exposure to sustainability-oriented activities helped students connect science with community engagement. Germany reported that previous projects were enjoyable but largely independent from the open-

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schooling topic, while Cyprus and Croatia did not report prior participation. Where continuity existed, it clearly strengthened readiness, autonomy, and motivation, suggesting that sustained engagement across projects helps build cumulative scientific literacy and long-term confidence.

Taken together, these findings reveal a shared perception of open schooling as a meaningful, empowering, and socially connected approach to science education. Across diverse national contexts, students appreciated the opportunity to learn by doing, to collaborate with peers and experts, and to see their work have tangible impact on their surroundings. They viewed open schooling not as an extracurricular novelty but as an essential model for modern education—one that links scientific understanding with civic responsibility, nurtures curiosity and equality, and transforms learning into an active and collaborative exploration of the world. These outcomes should, however, be interpreted considering contextual differences across countries and the qualitative nature of the case study approach, which privileges depth of insight over representativeness.

4.3. Integrated analysis (quantitative and qualitative) of OSA

In the evaluation of the OSA, the combination of quantitative and qualitative data made it possible to obtain structured information on attitudes, beliefs, and perceptions of scientific learning, as well as a more contextualized understanding of the processes, dynamics, and conditions for the implementation of open schooling. These two types of information (quantitative and qualitative) provide convergent results but also reveal certain inconsistencies that require further interpretation.

Overall, the results obtained through the questionnaires and the case studies show coherence and appear to reinforce each other, offering a convergent view of the effects of the OSA on participants' motivation, attitudes, and perceptions of learning. First, both instruments reflect positive attitudes toward science and scientific learning. The questionnaires showed high scores on items such as "I like to experiment", "Learning science is fun", and "Science is important in everyday life", indicating a favorable perception and general enjoyment of scientific learning. Similarly, in the retrospective focus groups, students described the activities as fun, interesting, and relevant to real life, while teachers emphasized students' active engagement and enthusiasm.

Likewise, there is clear alignment regarding motivation and enjoyment of learning. The questionnaires show very positive evaluations of the activities, on items such as "The activity was pleasant" and "I learned new things today". These results are consistent with the narratives gathered in the case studies, where both teachers and students described the OSA as engaging, enjoyable, and transformative experiences.

The relevance of learning and its connection to real life constitutes another point of convergence between questionnaires and case studies. In the questionnaires, some items indicates that participants perceive science as useful and meaningful (Science helps me understand the world around me). Complementarily, in the case studies, both teachers and students emphasized that the OSA allowed them to connect science with everyday and social contexts, for instance, environmental or sustainability issues, reinforcing the idea that scientific learning has practical value.

Both instruments also highlight the importance of practical, collaborative, and inquiry-based learning. In the questionnaires, items such as I like to work with others and I enjoy experimenting obtained high scores, reflecting positive attitudes toward cooperative and experimental work. In the case studies, this same aspect was frequently mentioned: teachers emphasized the effectiveness of hands-on learning and inquiry-based activities, while students valued teamwork and the opportunity to learn by doing.

Regarding the perception of learning scientific concepts, the questionnaires show high mean values on items such as I learned new things today, or This activity helped me understand new concepts, which reflect a positive perception of learning. In the case studies, participants specified this learning by referring to scientific inquiry skills such as designing experiments, collecting and analyzing data, or interpreting results. While the questionnaires capture a global perception of learning, the case studies provide detailed insight into its content and processes.

The perception of gender equity also appears as a point of convergence. In the questionnaires, comparative analyses of mean scores by gender across different items indicate minimal differences: boys tend to score slightly higher in self-efficacy, while girls score slightly higher in aspects related to social connection and perceived relevance. In the focus groups, both teachers and students agreed that participation was equitable, collaborative, and free from stereotypes, highlighting gender cooperation as a key value of the OSA.

The difference in impact across educational levels is also consistent between instruments. In the questionnaires, primary students show higher means than secondary students, reflecting greater enthusiasm and motivation. In the case studies, younger students are described as more curious and engaged, while secondary students more often mention time constraints, curricular demands, and lower flexibility.

Finally, there is variability across countries in both the questionnaires and the case studies, although reflected in different aspects. In the questionnaires, Portugal and Germany achieved the highest mean scores, while Croatia and Cyprus showed the lowest. In the case studies, teachers pointed to differing structural factors affecting OSA implementation: varying degrees of open schooling institutionalization, previous experience with similar projects, and differing levels of institutional support.

Despite this overall coherence, some aspects present differences in focus or minor interpretative divergences, stemming from the type of data collected and the nature of each instrument. One of the most notable differences concerns items on self-confidence and perceived scientific

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competence. In these items, post-test scores show a slight decrease, particularly among secondary students. In contrast, in the retrospective focus groups, students expressed feeling more confident, competent, and autonomous after participating in the OSA. This difference may be explained by the distinct nature of the instruments: while the questionnaire quantifies self-perception in relation to task difficulty, the case studies capture a narrative sense of empowerment and confidence that may not translate into higher numerical scores.

Another difference appears in the interest in science studies and careers. Results show moderate values, especially in secondary education, where students express an interest in science but not a clear intention to pursue scientific studies or careers. In the case studies, this theme appears more tangentially: some participants mention curiosity or inspiration but do not frame it as a vocational choice. There is no contradiction, but rather a difference in scope: the questionnaire measures a general trend, while the qualitative evidence provides context and nuance.

In summary, the questionnaires and the case studies show a robust convergence in the core dimensions (motivation, enjoyment, relevance, and attitudes toward science), along with some minor divergences arising from the different types of evidence collected. Together, both instruments offer a coherent and complementary picture of the impact of the OSA on participants and of the contextual factors influencing their implementation.

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5. LIMITATIONS

While the results across groups and activities are generally positive, the results should be interpreted considering several methodological limitations.

Firstly, although the internal consistency of the questionnaires was acceptable, the CFA showed insufficient factorial validity, indicating that the empirical data did not fully fit the proposed theoretical structure and that the relationships between items and latent dimensions were not entirely stable. This weakness limits comparability between dimensions and between countries, as participants may have interpreted some items differently depending on their educational or cultural context. Given that the questionnaire had been developed top-down based on predefined theoretical dimensions, CFA was the appropriate analytical option for this phase of the evaluation, and therefore exploratory factor analysis (EFA) was not carried out at this stage. The CFA results indicate that some relationships between items and dimensions do not fit the predefined theoretical model. For future purposes, and as part of the iterative refinement of the assessment tools, the questionnaire could be strengthened by applying an EFA to study which items and which configuration of these in different dimensions would be appropriate to ensure the empirical emergence of the predefined theoretical structure. This process would guide the optimization of item formulation and instrument structuring, which could then be confirmed with a new CFA applied to other data. Only after this psychometric development process would the validity of the instrument be improved.

Another limitation is the non-normal distributions and unequal sample sizes between countries, that reduce statistical precision and hinder the robustness of inferential analyses, especially in contexts with small samples. Likewise, in OSA activities, the low response rate in the post-test limits the possibility of establishing solid comparisons between pre- and post-measurements.

In the items of *Part B. Attitudes and beliefs towards science*, the presence of a possible ceiling effect (Staus *et al.*, 2021) suggests that high initial levels of enjoyment and interest limited the detection of improvements after the intervention, which would reflect a low sensitivity of the instrument at the upper end of the scale. Taken together, these limitations suggest that the results should be interpreted as descriptive trends rather than precise measurements of latent constructs and underscore the need to continue refining the instruments and data collection procedures after the completion of the project.

The case study methodology employed for the evaluation of the OSA enabled a deep qualitative understanding of teachers' and students' experiences. However, as a qualitative and context-dependent approach, it limits the generalizability of the findings. Each participating school and community has unique characteristics; therefore, the conclusions drawn from individual cases do not necessarily represent the diversity of practices and conditions across all participating countries.

Another limitation arises from the data collection process (initial interview with teachers, retrospective interview with the same teachers, and retrospective focus group with students), which relied on participants' subjective interpretation of past experiences. This retrospective perspective may have introduced recall bias or a selective emphasis on the aspects considered most relevant. Moreover, teachers may have tended to present their practices or results in ways aligned with project expectations. In the case of the student focus groups, the group format might have limited the expression of divergent opinions. A further limitation concerns the limited number of interviews and focus groups conducted, which restricts the breadth of perspectives captured. Differences in local implementation, interviewer style, or linguistic and cultural nuances may also have affected the comparability of results across contexts. Additionally, the qualitative analysis was first conducted at the national level and later synthesized at the international level, which, despite the use of common templates and guidelines, may have led to minor interpretative variations.

Despite these limitations, various measures were taken to mitigate their impact, and the overall results remain robust and broadly generalizable. The use of common assessment instruments across all countries, together with non-parametric statistical analyses, which are more robust in the face of non-normal distributions and unequal sample sizes, strengthened the reliability of cross-country comparisons. Furthermore, the total sample size for the implementation phase, 1939 pre-tests and 5774 post-tests collected in different activities, provides an empirical basis that supports the stability of the observed trends. Regarding the ceiling effect and possible differences in the interpretation of items, the convergence between quantitative results and qualitative evidence from case studies reinforces the consistency of the conclusions. Similarly, although qualitative data are sensitive to context, the use of shared templates, common coding procedures, and cross-country synthesis processes increased comparability and reduced potential interpretative biases. For these reasons, the limitations noted do not compromise the validity of the main results, which can be considered indicative of broader patterns that may be relevant for future implementations of ICaT, LHA, and OSA activities.

Furthermore, it is important to note that quantitative results, while providing valuable information, do not always represent the most appropriate way to evaluate the success of open schooling initiatives, as some authors have already pointed out (Cruz-Lorite *et al.*, 2025). These types of projects are characterised by open, collaborative and highly contextualised processes, whose most relevant effects, such as the strengthening of partnerships, community engagement or changes in teaching practice, are not easily captured by standardised questionnaires. Furthermore, obtaining reliable quantitative data can be particularly demanding in terms of time and effort for educational centres, which can affect the response rate. For this reason, other evaluation measures were planned and implemented from the outset of the project, such as case studies with interviews and focus groups, which allow for a deeper and more nuanced understanding of the impact of the project's activities.

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Finally, it is important to place the results obtained in the current context of research on open schooling. The available evidence shows that the impact of this type of initiative is not yet fully understood, partly due to the wide variability between implementations, the diversity of educational contexts, and the limited availability of studies with rigorous impact analysis designs. In this regard, if the European Union wishes to advance the scientific understanding of the impact of open schooling projects, it would be advisable to promote more controlled research, with less variability between implementations and methodological approaches capable of providing comparable and robust data. Likewise, if the aim is to continue exploring the transformative potential of the approach and its applicability to different contexts, future initiatives should focus on transfer projects supported by predominantly qualitative evaluations, which allow for the capture of processes, community dynamics, and cultural changes that are difficult to identify through exclusively quantitative methods.

6. CONCLUSIONS AND RECOMMENDATIONS

The evaluation of the three types of activities (Interactive Career Talks -ICaT-, Lighthouse Activities -LHA-, and Open Schooling Activities -OSA-) provides a comprehensive and rigorous overview of the project's educational impact across different national contexts and educational levels. The combination of quantitative instruments (questionnaires) and qualitative instruments (case studies) produced complementary results that capture both the measurement of attitudes and perceptions and the contextual analysis of participants' experiences. The main conclusions of the evaluation of the activities are:

- Overall, the results show a **positive and consistent impact on students' motivation, attitudes toward science, and perceived learning**, with nuances specific to each type of activity.
- All three activity formats share an **orientation toward active, inquiry-based, and meaningful learning**, though they differ in nature and degree of complexity:
- **ICaT successfully stimulated interest in scientific careers**, particularly through direct interaction with professional role models and opportunities for personal exchange.
- **LHA were characterized by interdisciplinarity and strong connections to real-life problems**, providing a collaborative framework among schools, enterprises, and the wider community that strengthened the practical application of scientific knowledge.
- **OSA**, in turn, **achieved the broadest impact** by combining scientific learning, collaborative work, and community participation, generating experiences with a strong social and civic dimension.

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- The results also reveal an **overall consistency across countries, with some variations attributable to contextual factors**. Portugal and Germany show the highest mean scores in most indicators, associated with a greater degree of institutionalization and prior experience with open schooling approaches. Croatia, Cyprus, and Turkey report similar levels of motivation and commitment but face greater structural constraints and weaker institutional support.
- Likewise, the data show a **greater impact at the primary level than at the secondary level**, where curricular demands and limited time reduce flexibility for participatory activities. Regarding gender, both quantitative analyses and focus groups indicate equitable and collaborative participation, with no significant differences in motivation or enjoyment.
- Some **interpretative differences were observed in the perception of scientific competence** (self-efficacy) **between the questionnaires and the case studies**. Post-test scores in secondary education show a slight decrease, whereas the qualitative data reveal an increased sense of confidence and autonomy.
- Taken together, the evidence demonstrates that **ICaT, LHA, and OSA have the potential to strengthen motivation and scientific learning**, promote collaboration and equity, and improve the connection between school science and real life.
- Finally, **the assessment instruments used provided comparable and useful information** across all countries and educational levels. Since the questionnaire was initially structured around predefined dimensions, the use of CFA was appropriate for this stage. Looking ahead, the consortium could consider updating the items and structure of the questionnaire and initiating a psychometric development process based on an AFE to further refine the instrument for future phases of the project.

Based on these findings, the following recommendations are proposed to improve the implementation, monitoring, and sustainability of Interactive Career Talks (ICaT), Lighthouse Activities (LHA), and Open Schooling Activities (OSA) in European educational contexts:

- **Integration of the three activity types within schools.** ICaT, LHA, and OSA appear to function effectively as complementary activities within a shared open schooling framework. Their joint implementation seems to address different dimensions of science education, offering well-rounded learning experiences.
- **Provide differentiated professional development for teachers.** Each activity type requires specific competencies: managing interaction with external professionals and supporting students' career orientation (ICaT); interdisciplinary design and collaboration with external partners (LHA); and pedagogical leadership in community-based environments (OSA).

Tailored training and mentoring programs should be developed to address these specific needs.

- **Strengthen collaboration with external stakeholders.** The involvement of role models, professionals, enterprises, and local organizations is essential for the quality and impact of the activities. The results show that such collaboration increases motivation and the perceived social relevance of science learning. Sustaining partnerships with universities, municipalities, and NGOs is key to ensuring long-term impact and community engagement.
- **Promote equity and inclusion.** The participatory and cooperative approach should remain a central principle. Inclusive strategies are recommended to address socioeconomic and cultural diversity among students, as well as potential gender-related differences that may arise in different contexts.
- **Ensure sustainability through institutional support and recognition.** The success of OSA — and, to a lesser extent, LHA and ICaT— depends on institutional backing. It would be desirable for educational authorities to formally acknowledge teachers' time, planning, and effort through stable resources and formal incentives (e.g., certification or workload recognition). School leaders should integrate Open Schooling principles into school development plans and allocate dedicated time for project implementation. Recognizing Open Schooling in teacher and student evaluations would reinforce its educational value.
- **Create stable networks.** Teachers and schools should strengthen collaboration through Open Schooling networks and co-design projects with students and external partners. They are encouraged to promote interdisciplinary learning and use digital tools to document and share progress. Reflection and peer mentoring should be integrated as ongoing practices to enhance professional growth and sustain collaborative cultures.
- **Strengthen continuous evaluation and cross-context comparability.** The methodological approach used has proven effective. It is recommended to maintain common instruments (questionnaires and case studies) in future project phases to ensure evidence continuity and enable longitudinal analysis.
- **Policy priorities.** Policymakers should embed Open Schooling in national curricula and institutionalize partnerships to guarantee continuity and scalability. Supporting professional development and peer-learning networks will strengthen teachers' capacity for innovation. Long-term investment, inclusive co-design, and ethical use of digital and AI tools are essential to sustain schools as open, collaborative ecosystems.

In terms of the **educational implications** of the project, **the open schooling approach enabled** teachers, together with external partners, **to implement projects that would otherwise not have been possible, and** which appeared to **have a significant impact on students' attitudes towards**

science. The project also succeeded in changing teachers' opinions about what can be achieved with science-based projects, which may influence their teaching towards more scientific or research-based methods.

7. REFERENCES

Blades, D. W. (2011). Time and teacher control in curriculum adoption: lessons from the lighthouse schools project. In L. Yore, E. Flier-Keller, D. Blades, T. Pelton & D. Zandvliet (Eds.), *Pacific CRYSTAL Centre for Science, Mathematics, and Technology Literacy: Lessons Learned* (pp. 203-216). Sense Publishers.

Bogner, F. X., & Sotiriou, S. (2023). Open Schooling Matters: Student Effects in Science Motivation, Intrinsic Motivation and State Emotions. *Journal of Higher Education Theory and Practice, 23*(2). 137-153.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Creswell, J. (2014). *Qualitative, quantitative, and mixed methods approaches*. Sage.

Cruz-Lorite, I. M., Nikolaou, M., Nisiforou, E., & Evagorou, M. (2025). Open schooling in science education: A systematic literature review. *European Journal of Educational Research, 14*(4), 1063-1085. https://doi.org/10.12973/eu-jer.14.4.1063

European Union. (2015). *Science Education for Responsible Citizenship, Directorate-General for Research and Innovation Science with and for Society*. European Union: Brussels.

European Union. (2016). Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

Federal Ministry of Justice. (2017). Federal Data Protection Act of 30 June 2017 (Federal Law Gazette I p. 2097), as last amended by Article 10 of the Act of 23 June 2021 (Federal Law Gazette I, p. 1858; 2022 I p. 1045).

Sotiriou, S., Cherouvis, S., Zygouritsas, N., Giannakopoulou, A., Milopoulos, G., Bogner, F.X., Verboon, F., & de Kroon, S. (2017). *Open Schooling Roadmap. A Guide for School Leaders and Innovative Teachers*. EPINOIA S.A.

Sotiriou, M., Sotiriou, S., & Bogner, F.X. (2021) Developing a Self-Reflection Tool to Assess Schools' Openness. *Frontiers of Education, 6*, 714227.

UNFCCC. (2017). *Momentum for Change*. Available at: https://cop23.unfccc.int/news/winners-of-2017-un-climate-solutions-awards-announced

Watts, F.M., & Finkenstaedt-Quinn, S.A. (2021). The current state of methods for establishing reliability in qualitative chemistry education research articles. *Chemical Education Research and Practice, 22*, 565-578. https://doi.org/10.1039/D1RP00007A

Woods-Townsend, K., Christodoulou, A., Rietdijk, W., Byrne, J., Griffiths, J. B. and Grace, M. M. (2016). Meet the scientist: the value of short interactions between scientists and students. *International Journal of Science Education, Part B 6*(1), pp. 89–113. https://doi.org/10.1080/21548455.2015.1016134.

Staus, N., O'Connell, K., & Storksdieck, M. (2021). Addressing the Ceiling Effect when Assessing STEM Out-Of-School Time Experiences. *Frontiers in Education, 6*, 690431. https://doi.org/10.3389/feduc.2021.690431.

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Appendix I. Tables of results

Appendix I.1 Table of results of primary pre-tests by country

Item	Country	N	Lost	Mean	SD
1.I like natural sciences	Cyprus	118	0	3.01	1.499
	Germany	162	0	3.85	1.065
	Portugal	188	0	3.78	0.762
2.I like technology and robots	Cyprus	118	0	2.99	1.405
	Germany	162	0	3.90	1.209
	Portugal	188	0	4.10	0.549
3.Science helps me to solve problems	Cyprus	118	0	3.03	1.435
	Germany	160	2	3.21	1.140
	Portugal	187	1	3.52	0.713
4.I like to experiment	Cyprus	118	0	3.19	1.309
	Germany	161	1	4.04	1.341
	Portugal	188	0	4.83	0.430
5.What I learned today is important for my future career	Cyprus	118	0	3.14	1.434
	Germany	159	3	2.76	1.270
	Portugal	187	1	3.24	0.856
6.I can carry out scientific experiments independently	Cyprus	118	0	3.22	1.445
	Germany	159	3	3.78	1.376
	Portugal	188	0	4.92	0.371
7.I like working independently	Cyprus	118	0	2.97	1.459
	Germany	155	7	3.40	1.287
	Portugal	188	0	3.49	0.749
8.The workshop helped me to find a solution to problems myself	Cyprus	118	0	2.82	1.363
	Germany	158	4	3.82	1.404
	Portugal	188	0	4.11	0.685
9.I am interested in today's topic	Cyprus	118	0	3.03	1.420
	Germany	159	3	2.84	1.163
	Portugal	188	0	3.36	0.832
10.I would like to find out more about this topic	Cyprus	118	0	3.25	1.421
	Germany	160	2	3.15	1.294
	Portugal	188	0	3.38	0.717
11.The workshop helped me learn new things	Cyprus	118	0	2.83	1.434
	Germany	161	1	3.48	1.194
	Portugal	188	0	3.42	0.708

Note. N = sample size; Lost = Lost data; SD = Standard deviation.

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Appendix I.2 Table of results of secondary pre-tests by country

Dimension	Item	Country	N	Lost	Mean	SD
B	1.I enjoy learning science	Croatia	129	0	4.00	0.884
		Cyprus	63	0	3.94	1.014
		Germany	313	0	3.18	1.189
		Portugal	341	0	3.78	0.945
		Turkey	425	0	4.15	1.136
	2.Science is interesting	Croatia	129	0	4.45	0.750
		Cyprus	63	0	3.89	1.138
		Germany	313	0	3.40	1.236
		Portugal	341	0	4.04	0.898
		Turkey	425	0	4.22	1.114
	3.I like to do science experiments	Croatia	129	0	4.46	0.829
		Cyprus	63	0	4.24	1.011
		Germany	313	0	3.57	1.257
		Portugal	341	0	4.38	0.815
		Turkey	425	0	4.28	1.148
	4.Learning science will help me in my daily life	Croatia	129	0	3.82	0.939
		Cyprus	63	0	3.68	1.090
		Germany	313	0	2.83	1.034
		Portugal	341	0	3.52	1.005
		Turkey	424	1	3.92	1.200
	5.I need to do well in science to get the job I want	Croatia	129	0	3.51	1.153
		Cyprus	63	0	3.78	1.250
		Germany	313	0	2.59	1.315
		Portugal	340	1	3.61	1.343
		Turkey	425	0	3.64	1.363
C	1.Science is harder for me than any other subject	Croatia	128	1	3.23	1.096
		Cyprus	63	0	2.83	1.212
		Germany	312	1	2.51	1.162
		Portugal	341	0	2.60	1.137
		Turkey	419	6	2.20	1.330
	2.I can apply scientific knowledge to real-world situations	Croatia	128	1	3.91	0.882
		Cyprus	63	0	3.68	0.858
		Germany	312	1	2.77	1.008
		Portugal	341	0	3.30	0.923
		Turkey	419	6	3.79	1.087
	3.I can learn and use scientific skills	Croatia	128	1	3.55	1.033
		Cyprus	63	0	3.60	1.086
		Germany	312	1	2.69	1.140
		Portugal	341	0	3.38	0.970
		Turkey	419	6	3.79	1.193
	4.I can communicate effectively about scientific topics with others	Croatia	128	1	4.20	0.836
		Cyprus	63	0	3.92	0.747
		Germany	312	1	2.93	1.038
		Portugal	341	0	3.48	0.876
		Turkey	419	6	4.17	1.096
	5.I am confident I can succeed in a scientific career	Croatia	128	1	3.69	1.033

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		Cyprus	63	0	3.44	1.104
		Germany	312	1	2.66	1.210
		Portugal	340	1	3.21	1.160
		Turkey	419	6	3.79	1.196
D	1.Learning science is important for my future career	Croatia	127	2	3.54	1.139
		Cyprus	63	0	3.84	1.110
		Germany	310	3	2.55	1.226
		Portugal	337	4	3.58	1.242
		Turkey	415	10	3.79	1.261
	2.I am interested in careers that use science, mathematics or technology	Croatia	127	2	3.91	1.165
		Cyprus	63	0	3.65	1.233
		Germany	310	3	2.82	1.331
		Portugal	338	3	3.72	1.255
		Turkey	415	10	3.91	1.252
	3.A family member of mine works in a science related field	Croatia	127	2	2.47	1.568
		Cyprus	63	0	3.49	1.447
		Germany	310	3	2.69	1.564
		Portugal	338	3	2.97	1.645
		Turkey	415	10	2.38	1.548
	4.I enjoy talking to scientist	Croatia	127	2	3.66	1.190
		Cyprus	63	0	3.65	1.138
		Germany	310	3	2.73	1.247
		Portugal	338	3	3.15	1.056
		Turkey	415	10	3.67	1.304

Note. N = sample size; Lost = Lost data; SD = Standard deviation.

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Appendix I.3 Table of results of primary post-tests by country and type of activity

Item	Country	Type of activities	N	Lost	Mean	SD
1.I like natural sciences	Croatia	ICaT	0	0	—	—
		LHA	22	0	2.32	1.249
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	288	1	3.79	1.254
		OSA	117	0	3.50	1.430
	Germany	ICaT	102	1	3.52	1.167
		LHA	2695	51	4.27	0.889
		OSA	100	0	3.74	1.203
	Portugal	ICaT	61	0	3.92	0.557
		LHA	26	0	4.15	1.434
		OSA	168	0	3.99	0.563
2.I like technology and robots	Croatia	ICaT	0	0	—	—
		LHA	22	0	2.41	1.623
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	289	0	3.80	1.200
		OSA	117	0	3.34	1.294
	Germany	ICaT	101	2	3.86	1.209
		LHA	2674	72	4.33	0.988
		OSA	100	0	3.61	1.325
	Portugal	ICaT	61	0	4.21	0.551
		LHA	26	0	4.65	0.892
		OSA	168	0	4.27	0.457
3.Science helps me to solve problems	Croatia	ICaT	0	0	—	—
		LHA	22	0	4.09	1.269
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	288	1	3.95	1.156
		OSA	117	0	3.44	1.441
	Germany	ICaT	99	4	2.70	1.224
		LHA	2672	74	3.64	1.120
		OSA	100	0	2.98	1.239
	Portugal	ICaT	61	0	3.84	0.583
		LHA	26	0	3.85	1.156
		OSA	167	1	3.87	0.642
4.I like to experiment	Croatia	ICaT	0	0	—	—
		LHA	22	0	4.45	0.912
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	288	1	3.78	1.219
		OSA	117	0	3.21	1.431
	Germany	ICaT	100	3	4.28	1.064
		LHA	2693	53	4.56	0.864
		OSA	99	1	3.93	1.500

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	Portugal	ICaT	61	0	4.97	0.180
		LHA	26	0	4.69	0.884
		OSA	168	0	4.98	0.133
5.What I learned today is important for my future career	Croatia	ICaT	0	0	—	—
		LHA	22	0	3.00	1.155
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	285	4	3.78	1.171
		OSA	117	0	3.42	1.341
	Germany	ICaT	93	10	2.56	1.255
		LHA	2632	114	3.52	1.269
		OSA	99	1	3.00	1.237
	Portugal	ICaT	61	0	3.30	0.738
		LHA	26	0	2.96	1.399
		OSA	167	1	3.34	0.811
6.I can carry out scientific experiments independently	Croatia	ICaT	0	0	—	—
		LHA	22	0	2.73	1.316
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	287	2	3.74	1.228
		OSA	117	0	3.04	1.494
	Germany	ICaT	96	7	3.09	1.385
		LHA	2645	101	3.96	1.082
		OSA	97	3	3.07	1.333
	Portugal	ICaT	61	0	3.87	0.826
		LHA	26	0	3.50	1.241
		OSA	168	0	3.83	0.644
7.I liked working independently	Croatia	ICaT	0	0	—	—
		LHA	22	0	2.73	1.316
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	286	3	3.82	1.136
		OSA	117	0	3.43	1.360
	Germany	ICaT	48	55	3.21	1.414
		LHA	2641	105	4.27	1.024
		OSA	99	1	3.74	1.461
	Portugal	ICaT	61	0	3.82	0.592
		LHA	26	0	3.81	1.096
		OSA	168	0	3.92	0.638
8.The workshop helped me to find a solution to problems myself	Croatia	ICaT	0	0	—	—
		LHA	22	0	3.36	1.590
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	285	4	3.89	1.153
		OSA	117	0	3.40	1.445
	Germany	ICaT	51	52	2.49	1.120
		LHA	2651	95	3.84	1.114
		OSA	89	11	3.16	1.269
	Portugal	ICaT	61	0	3.59	0.559
		LHA	26	0	3.08	1.354

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		OSA	168	0	4.00	0.589
9.I liked the topic today	Croatia	ICaT	0	0	—	—
		LHA	22	0	3.91	1.540
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	288	1	3.79	1.150
		OSA	117	0	3.54	1.310
	Germany	ICaT	98	5	3.69	1.040
		LHA	2666	80	4.57	0.862
		OSA	98	2	3.82	1.495
	Portugal	ICaT	61	0	4.11	0.580
		LHA	26	0	4.27	1.151
		OSA	168	0	4.23	0.599
10.I would like to find out more about this topic	Croatia	ICaT	0	0	—	—
		LHA	22	0	3.45	1.335
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	282	7	3.85	1.144
		OSA	117	0	3.52	1.430
	Germany	ICaT	101	2	3.09	1.209
		LHA	2667	79	4.19	1.030
		OSA	99	1	3.49	1.459
	Portugal	ICaT	61	0	4.00	0.516
		LHA	26	0	3.81	1.234
		OSA	167	1	4.14	0.604
11.The workshop helped me learn new things	Croatia	ICaT	0	0	—	—
		LHA	22	0	4.00	1.574
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	285	4	3.88	1.178
		OSA	117	0	3.27	1.343
	Germany	ICaT	91	12	3.13	1.293
		LHA	2673	73	4.30	0.985
		OSA	99	1	3.38	1.419
	Portugal	ICaT	61	0	4.34	0.602
		LHA	26	0	4.62	0.852
		OSA	168	0	4.46	0.546
12. Later I would like to do something in the natural sciences	Croatia	ICaT	0	0	—	—
		LHA	22	0	3.27	1.453
		OSA	0	0	—	—
	Cyprus	ICaT	0	0	—	—
		LHA	285	4	3.92	1.090
		OSA	0	117	—	—
	Germany	ICaT	100	3	2.66	1.350
		LHA	2658	88	3.31	1.372
		OSA	99	1	2.92	1.353
	Portugal	ICaT	61	0	3.61	0.665
		LHA	26	0	3.38	1.577
		OSA	167	1	3.59	0.770

Note. — = Not applicable; N = sample size; Lost = Lost data; SD = Standard deviation.

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Appendix I.4 Table of results from secondary post-tests by country and type of activity

Dimension	Item	Country	Type of activity	N	Lost	Mean	SD
B	1.I enjoy learning science	Croatia	ICaT	296	0	3.91	0.959
			LHA	115	0	3.31	1.252
			OSA	41	0	3.95	0.947
		Cyprus	ICaT	116	0	4.05	0.720
			LHA	32	0	4.25	0.842
			OSA	28	0	4.29	0.763
		Germany	ICaT	25	0	3.60	1.225
			LHA	79	0	3.03	1.143
			OSA	132	0	2.84	1.138
		Portugal	ICaT	72	0	3.82	0.635
			LHA	207	1	4.07	0.785
			OSA	76	0	3.96	0.720
		Turkey	ICaT	275	0	3.52	1.147
			LHA	295	0	4.33	0.914
			OSA	237	0	3.92	1.330
	2.Science is interesting	Croatia	ICaT	296	0	4.24	0.874
			LHA	115	0	3.93	1.205
			OSA	41	0	4.29	0.873
		Cyprus	ICaT	116	0	4.09	0.559
			LHA	32	0	4.22	0.832
			OSA	28	0	4.25	0.799
		Germany	ICaT	25	0	3.92	1.152
			LHA	79	0	3.70	1.042
			OSA	132	0	3.14	1.177
		Portugal	ICaT	72	0	4.18	0.589
			LHA	208	0	4.17	0.779
			OSA	76	0	4.22	0.723
		Turkey	ICaT	275	0	3.65	1.218
			LHA	295	0	4.34	0.874
			OSA	237	0	3.89	1.350
	3.I like to do science experiments	Croatia	ICaT	296	0	4.47	0.798
			LHA	115	0	4.28	1.097
			OSA	41	0	4.37	1.043
		Cyprus	ICaT	116	0	4.21	0.808
			LHA	32	0	4.50	0.672
			OSA	28	0	4.54	0.637
		Germany	ICaT	25	0	3.92	1.038
			LHA	79	0	3.77	1.109
			OSA	132	0	3.27	1.273
		Portugal	ICaT	72	0	4.71	0.542
			LHA	208	0	4.41	0.762
			OSA	76	0	4.43	0.914
		Turkey	ICaT	275	0	3.63	1.321
			LHA	295	0	4.36	0.979
			OSA	237	0	4.20	1.255

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	4.Learning science will help me in my daily life	Croatia	ICaT	296	0	3.86	0.921
			LHA	114	1	3.53	1.352
			OSA	41	0	3.61	1.181
		Cyprus	ICaT	116	0	3.58	0.886
			LHA	32	0	4.41	0.615
			OSA	28	0	3.96	0.999
		Germany	ICaT	25	0	3.12	1.092
			LHA	79	0	2.89	0.906
			OSA	132	0	2.45	1.043
		Portugal	ICaT	72	0	3.83	0.581
			LHA	208	0	3.77	0.865
			OSA	76	0	3.63	0.991
		Turkey	ICaT	275	0	3.37	1.264
			LHA	295	0	3.95	1.127
			OSA	237	0	3.67	1.350
	5.I need to do well in science to get the job I want	Croatia	ICaT	296	0	3.82	1.141
			LHA	114	1	3.66	1.407
			OSA	41	0	3.51	1.207
		Cyprus	ICaT	116	0	3.59	1.238
			LHA	32	0	4.22	0.751
			OSA	28	0	4.29	0.810
		Germany	ICaT	25	0	2.52	1.418
			LHA	79	0	2.52	1.376
			OSA	132	0	2.46	1.298
		Portugal	ICaT	72	0	4.10	0.632
			LHA	208	0	3.85	1.161
			OSA	76	0	3.91	1.009
		Turkey	ICaT	275	0	3.10	1.449
			LHA	295	0	3.83	1.258
			OSA	237	0	3.46	1.488
C	**1.Science is harder for me than any other subject**	Croatia	ICaT	291	5	3.49	1.118
			LHA	112	3	3.06	1.188
			OSA	41	0	3.00	1.285
		Cyprus	ICaT	116	0	2.96	0.999
			LHA	32	0	3.47	0.879
			OSA	28	0	2.89	0.875
		Germany	ICaT	25	0	2.24	1.200
			LHA	78	1	3.13	1.273
			OSA	129	3	2.47	1.199
		Portugal	ICaT	72	0	2.13	0.580
			LHA	208	0	2.56	1.145
			OSA	76	0	2.29	0.830
		Turkey	ICaT	272	3	2.66	1.258
			LHA	295	0	2.35	1.441
			OSA	236	1	2.35	1.481
	2.I can apply scientific knowledge to real-world situations	Croatia	ICaT	291	5	3.70	0.995
			LHA	112	3	3.42	1.167
			OSA	41	0	3.98	0.908
		Cyprus	ICaT	116	0	3.60	0.756
			LHA	32	0	3.78	0.906

			OSA	28	0	3.82	1.090
		Germany	ICaT	25	0	2.88	1.201
			LHA	78	1	3.15	0.704
			OSA	129	3	2.55	1.046
		Portugal	ICaT	72	0	3.32	0.577
			LHA	208	0	3.33	0.834
			OSA	76	0	3.39	0.896
		Turkey	ICaT	272	3	3.36	1.255
			LHA	295	0	4.03	1.036
			OSA	236	1	3.56	1.238
	3.I can learn and use scientific skills	Croatia	ICaT	291	5	3.56	1.120
			LHA	112	3	3.29	1.418
			OSA	41	0	3.66	1.132
		Cyprus	ICaT	116	0	3.29	0.865
			LHA	32	0	3.38	0.833
			OSA	28	0	4.00	1.054
		Germany	ICaT	25	0	3.08	1.256
			LHA	78	1	2.69	1.073
			OSA	129	3	2.55	1.179
		Portugal	ICaT	72	0	3.76	0.593
			LHA	208	0	3.61	0.889
			OSA	76	0	3.37	0.862
		Turkey	ICaT	272	3	3.31	1.291
			LHA	295	0	3.99	1.097
			OSA	236	1	3.43	1.371
	4.I can communicate effectively about scientific topics with others	Croatia	ICaT	291	5	4.04	0.976
			LHA	112	3	4.05	1.114
			OSA	41	0	4.24	0.888
		Cyprus	ICaT	116	0	4.01	0.679
			LHA	32	0	3.94	0.669
			OSA	28	0	4.00	0.903
		Germany	ICaT	25	0	3.24	1.300
			LHA	78	1	3.15	0.774
			OSA	129	3	2.84	1.149
		Portugal	ICaT	72	0	3.40	0.744
			LHA	208	0	3.65	0.838
			OSA	76	0	3.75	0.768
		Turkey	ICaT	272	3	3.65	1.106
			LHA	295	0	4.32	0.914
			OSA	236	1	3.87	1.289
	5.I am confident I can succeed in a scientific career	Croatia	ICaT	291	5	3.56	1.254
			LHA	112	3	3.68	1.396
			OSA	41	0	3.71	1.101
		Cyprus	ICaT	116	0	3.47	1.130
			LHA	32	0	3.50	1.136
			OSA	28	0	4.14	1.008
		Germany	ICaT	25	0	3.12	1.481
			LHA	78	1	2.49	1.225
			OSA	129	3	2.60	1.259
		Portugal	ICaT	72	0	3.72	0.716

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			LHA	208	0	3.36	1.072
			OSA	76	0	3.59	0.996
		Turkey	ICaT	272	3	3.14	1.282
			LHA	295	0	3.84	1.119
			OSA	236	1	3.63	1.313
D	**1.Learning science is important for my future career**	Croatia	ICaT	289	7	3.78	1.100
			LHA	112	3	3.23	1.315
			OSA	41	0	3.46	1.247
		Cyprus	ICaT	116	0	4.09	1.055
			LHA	32	0	4.22	0.751
			OSA	28	0	4.25	0.799
		Germany	ICaT	25	0	2.76	1.393
			LHA	78	1	2.56	1.244
			OSA	126	6	2.25	1.211
		Portugal	ICaT	72	0	4.06	0.579
			LHA	208	0	3.77	1.097
			OSA	76	0	3.83	0.999
		Turkey	ICaT	272	3	3.21	1.370
			LHA	295	0	3.72	1.317
			OSA	236	1	3.47	1.445
	2.I am interested in careers that use science, mathematics or technology	Croatia	ICaT	289	7	3.80	1.206
			LHA	112	3	3.58	1.393
			OSA	41	0	3.78	1.275
		Cyprus	ICaT	116	0	3.77	0.990
			LHA	32	0	3.94	0.669
			OSA	28	0	4.11	1.100
		Germany	ICaT	25	0	3.52	1.262
			LHA	78	1	3.03	1.338
			OSA	126	6	2.70	1.273
		Portugal	ICaT	72	0	4.11	0.723
			LHA	208	0	3.82	1.092
			OSA	76	0	4.26	0.755
		Turkey	ICaT	272	3	3.47	1.372
			LHA	295	0	4.04	1.216
			OSA	236	1	3.55	1.406
	3.A family member of mine works in a science related field	Croatia	ICaT	289	7	3.29	1.502
			LHA	112	3	2.79	1.700
			OSA	41	0	3.15	1.590
		Cyprus	ICaT	116	0	3.34	1.278
			LHA	32	0	4.22	0.751
			OSA	28	0	3.64	1.283
		Germany	ICaT	25	0	3.16	1.748
			LHA	78	1	3.18	1.457
			OSA	126	6	2.63	1.446
		Portugal	ICaT	72	0	3.63	0.638
			LHA	208	0	2.78	1.480
			OSA	76	0	2.55	1.843
		Turkey	ICaT	272	3	2.52	1.565
			LHA	295	0	2.66	1.718
			OSA	236	1	2.66	1.613

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	4.I enjoy talking to scientist	Croatia	ICaT	289	7	3.90	1.124
			LHA	112	3	3.25	1.430
			OSA	41	0	3.73	1.049
		Cyprus	ICaT	116	0	3.84	1.071
			LHA	32	0	4.41	0.615
			OSA	28	0	4.07	0.900
		Germany	ICaT	25	0	3.28	1.173
			LHA	78	1	2.95	0.966
			OSA	126	6	2.56	1.311
		Portugal	ICaT	72	0	2.49	1.869
			LHA	208	0	3.36	1.067
			OSA	76	0	3.37	0.964
		Turkey	ICaT	272	3	3.25	1.389
			LHA	295	0	4.05	1.107
			OSA	236	1	3.43	1.426
E (ICaT)	**1.Before participating in this activity, I already felt that a STEM career would be a good choice for me**	Croatia	ICaT	287	9	3.52	1.240
			LHA	0	0	—	—
			OSA	0	0	—	—
		Cyprus	ICaT	116	0	3.59	0.875
			LHA	0	0	—	—
			OSA	0	0	—	—
		Germany	ICaT	24	1	3.08	1.472
			LHA	39	40	4.18	0.885
			OSA	0	0	—	—
		Portugal	ICaT	72	0	3.82	0.877
			LHA	0	0	—	—
			OSA	0	0	—	—
		Turkey	ICaT	270	5	2.72	1.328
			LHA	0	0	—	—
			OSA	0	0	—	—
	2.The guest speaker(s) clearly presented their career path and I learned something new about their profession from their presentation	Croatia	ICaT	287	9	4.42	0.823
			LHA	0	0	—	—
			OSA	0	0	—	—
		Cyprus	ICaT	116	0	3.47	0.869
			LHA	0	0	—	—
			OSA	0	0	—	—
		Germany	ICaT	24	1	4.38	0.770
			LHA	39	40	3.87	1.105
			OSA	0	0	—	—
		Portugal	ICaT	72	0	4.68	0.526
			LHA	0	0	—	—
			OSA	0	0	—	—
		Turkey	ICaT	270	5	3.43	1.226
			LHA	0	0	—	—
			OSA	0	0	—	—
	3.I believe that the activity was useful for me personally and I had the opportunity to actively participate in the discussion	Croatia	ICaT	287	9	4.14	0.971
			LHA	0	0	—	—
			OSA	0	0	—	—
		Cyprus	ICaT	116	0	3.87	0.704
			LHA	0	0	—	—

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			OSA	0	0	—	—
		Germany	ICaT	24	1	3.50	1.103
			LHA	39	40	2.44	0.940
			OSA	0	0	—	—
		Portugal	ICaT	72	0	4.10	0.754
			LHA	0	0	—	—
			OSA	0	0	—	—
		Turkey	ICaT	270	5	3.08	1.223
			LHA	0	0	—	—
			OSA	0	0	—	—
	4.This activity helped me remove existing dilemmas or stereotypes about STEM careers and encouraged me to further consider choosing a STEM profession	Croatia	ICaT	287	9	3.79	1.133
			LHA	0	0	—	—
			OSA	0	0	—	—
		Cyprus	ICaT	116	0	3.47	0.909
			LHA	0	0	—	—
			OSA	0	0	—	—
		Germany	ICaT	24	1	3.04	1.160
			LHA	39	40	3.00	1.026
			OSA	0	0	—	—
		Portugal	ICaT	72	0	4.01	0.741
			LHA	0	0	—	—
			OSA	0	0	—	—
		Turkey	ICaT	270	5	2.77	1.298
			LHA	0	0	—	—
			OSA	0	0	—	—
E (LHA)	**1.Was fascinating**	Croatia	ICaT	0	0	—	—
			LHA	111	4	3.91	1.345
			OSA	0	0	—	—
		Cyprus	ICaT	0	0	—	—
			LHA	32	0	4.50	0.672
			OSA	0	0	—	—
		Germany	ICaT	0	0	—	—
			LHA	78	1	3.64	1.139
			OSA	0	0	—	—
		Portugal	ICaT	0	0	—	—
			LHA	208	0	4.25	0.699
			OSA	0	0	—	—
		Turkey	ICaT	0	0	—	—
			LHA	294	1	4.41	0.865
			OSA	0	0	—	—
	2.Helped me learn new concepts	Croatia	ICaT	0	0	—	—
			LHA	110	5	3.43	1.474
			OSA	0	0	—	—
		Cyprus	ICaT	0	0	—	—
			LHA	32	0	3.78	0.906
			OSA	0	0	—	—
		Germany	ICaT	0	0	—	—
			LHA	39	40	3.87	1.105
			OSA	0	0	—	—
		Portugal	ICaT	0	0	—	—

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			LHA	208	0	4.22	0.784
			OSA	0	0	—	—
		Turkey	ICaT	0	0	—	—
			LHA	294	1	4.25	0.983
			OSA	0	0	—	—
	3.Helped me to understand the connection of science to everyday life	Croatia	ICaT	0	0	—	—
			LHA	110	5	3.20	1.483
			OSA	0	0	—	—
		Cyprus	ICaT	0	0	—	—
			LHA	32	0	3.38	0.833
			OSA	0	0	—	—
		Germany	ICaT	0	0	—	—
			LHA	39	40	2.44	0.940
			OSA	0	0	—	—
		Portugal	ICaT	0	0	—	—
			LHA	208	0	4.04	0.886
			OSA	0	0	—	—
		Turkey	ICaT	0	0	—	—
			LHA	294	1	4.19	1.092
			OSA	0	0	—	—
	4.The activity helped me understand the importance of cooperation between community and scientists	Croatia	ICaT	0	0	—	—
			LHA	111	4	3.61	1.343
			OSA	0	0	—	—
		Cyprus	ICaT	0	0	—	—
			LHA	32	0	3.38	0.942
			OSA	0	0	—	—
		Germany	ICaT	0	0	—	—
			LHA	39	40	3.00	1.026
			OSA	0	0	—	—
		Portugal	ICaT	0	0	—	—
			LHA	208	0	3.71	1.042
			OSA	0	0	—	—
		Turkey	ICaT	0	0	—	—
			LHA	294	1	4.03	1.126
			OSA	0	0	—	—
	5.Required to interact with other participants (students, scientists, people from the industry)	Croatia	ICaT	0	0	—	—
			LHA	111	4	3.89	1.330
			OSA	0	0	—	—
		Cyprus	ICaT	0	0	—	—
			LHA	32	0	4.38	0.554
			OSA	0	0	—	—
		Germany	ICaT	0	0	—	—
			LHA	39	40	3.10	1.119
			OSA	0	0	—	—
		Portugal	ICaT	0	0	—	—
			LHA	208	0	3.94	1.115
			OSA	0	0	—	—
		Turkey	ICaT	0	0	—	—
			LHA	294	1	4.08	1.171
			OSA	0	0	—	—

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E (OSA)	1.Was fascinating	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	4.55	0.891
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.46	0.693
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	3.45	1.260
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	3.71	0.889
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	3.73	1.443
	2.Helped me learn new concepts	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	4.13	0.935
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.36	0.826
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	3.14	1.237
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	3.86	0.839
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	3.45	1.494
	3.Helped me obtain new skills	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	3.97	0.944
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.14	1.113
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	2.91	1.142
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	3.63	0.842
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	3.37	1.445
	4.Required that I collaborate with other students	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	3.50	1.409
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—

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			OSA	28	0	4.25	0.799
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	3.36	1.345
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	4.42	0.956
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	228	9	3.16	1.505
	5.Required that I collaborate with scientists	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	3.47	1.156
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.32	0.723
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	2.69	1.313
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	2.89	1.253
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	2.91	1.506
	6.Required that I collaborate with people from industry	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	3.55	1.267
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.00	1.277
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	2.42	1.331
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	1.30	0.828
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	2.94	1.564
	7.Helped me to understand the connection of science to everyday life	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	4.39	0.755
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.04	0.962
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	2.71	1.092
		Portugal	ICaT	0	0	—	—

			LHA	0	0	—	—
			OSA	73	3	4.04	1.033
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	3.57	1.390
	8.The activity helped me solve a real problem	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	3.71	1.412
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.14	0.756
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	2.32	1.221
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	3.79	1.301
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	3.18	1.451
	9.The activity helped me participate in decision making	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	3.87	1.070
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.07	1.086
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	2.53	1.220
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	3.47	1.179
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	3.43	1.371
	10.The activity helped me understand the importance of cooperation between community and scientists	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	4.11	1.110
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.39	0.737
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	2.71	1.090
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	3.29	1.007
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	230	7	3.45	1.449

	11.I had constructive communication with mentors during the activity	Croatia	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	38	3	4.05	1.161
		Cyprus	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	28	0	4.43	0.634
		Germany	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	119	13	3.00	1.282
		Portugal	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	73	3	3.30	1.187
		Turkey	ICaT	0	0	—	—
			LHA	0	0	—	—
			OSA	229	8	3.13	1.506

Note. — = Not applicable.

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Appendix I.5 Table of results from adults post-tests by country

Item	Country	N	Lost	Mean	SD
1.This activity was pleasant	Croatia	4	0	5.00	0.000
	Germany	7	0	4.00	1.155
	Portugal	105	0	4.50	0.786
2.This activity helped me learn new concepts	Croatia	4	0	5.00	0.000
	Germany	7	0	3.71	1.380
	Portugal	105	0	4.47	0.760
3.This activity helped me understand the connection between science and everyday life	Croatia	4	0	5.00	0.000
	Germany	7	0	4.14	0.690
	Portugal	105	0	4.26	0.920
4.This activity Helped me understand the importance of collaboration between the community and scientists	Croatia	4	0	5.00	0.000
	Germany	7	0	3.86	1.069
	Portugal	105	0	4.30	0.940
5.This activity it was necessary to communicate with other participants peers scientists people from the company	Croatia	4	0	5.00	0.000
	Germany	7	0	4.57	1.134
	Portugal	105	0	4.29	0.958

Note. N = sample size; Lost = Lost data; SD = Standard deviation.

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Appendix II. Evaluation instruments

This section includes all the instruments used for data collection.

Appendix II.1 Primary students' questionnaires

Primary students' questionnaire

[Please provide the evaluation moment: pre-test ☐ post-test ☐]

[Please provide the name of the activity]:

Partner(s) involved in designing the activity

[Please provide the name of the partner(s) involved in the activity]:

[Please add the date]:

Part A. Background information

Code Name: … … … … … … … [the initial of your name/the number of the day you were born (i.e. if it was July 15 write 15)/the initial of your mother's name]

Age:

Gender:

Type of activity you are attending (you can check only one):

Lighthouse activity ☐ Open schooling activity ☐ Interactive career talks ☐ Local science fairs ☐

Mention the name of the activity: … … … …

Part B. Attitudes and beliefs towards science

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)

Statements	1	2	3	4	5
1. I like natural sciences					
2. I like technology and robots					
3. Science helps me to solve problems					
4. I like to experiment					
5. What I learned today is important for my future career					
6. I can carry out scientific experiments independently					
7. I like working independently					
8. The workshop helped me to find a solution to problems myself					

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9. I am interested in today's topic					
10. I would like to find out more about this topic					
11. The workshop helped me learn new things					

The post-test includes the same questions as the pre-test, plus the following:

Part B. Attitudes and beliefs towards science

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
Statements	**1**	**2**	**3**	**4**	**5**
12. Later, I would like to do something in the natural sciences					

1. What did you like most?

2. If you could have a second morning session, Which topic would you like?

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Appendix II.2 Secondary students' questionnaire

Secondary students' questionnaire

[Please provide the evaluation moment: pre-test ☐ post-test ☐]

[Please provide the name of the activity]:

Partner(s) involved in designing the activity

[Please provide the name of the partner(s) involved in the activity]:

- *[Please add the date]:*

Part A. Background information

Code Name: … … … … … … … [the initial of your name/the number of the day you were born (i.e. if it was July 15 write 15)/the initial of your mother's name]
Age:
Gender:

I participate in science-related activities, such as: (you can check more than one)

- science museums ☐
- science festivals ☐
- science-related education programs ☐
- field trips ☐
- astronomy observations ☐
- none of the above ☐
- other (please indicate) ☐

Where do you gain scientific knowledge from? (you can check more than one)

- media/online ☐
- school ☐
- parents ☐
- friend ☐
- activities happening out of school ☐
- other (please indicate) ☐

Type of activity you are attending (you can check only one):
Lighthouse activity ☐ Open schooling activity ☐ Interactive career talks ☐ Local science fairs ☐

Mention the name of the activity: … … … …

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All questions that follow in part B are about science. Which subject comes to mind when you listen to the word science? Answer the questions in Part B having this subject in mind (you can check more than one)

Biology ☐ Chemistry ☐ Physics ☐ Mathematics ☐ Other/s: … … … …

Part B. Attitudes and beliefs towards science

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
Statements	**1**	**2**	**3**	**4**	**5**
1. I enjoy learning science					
2. Science is interesting					
3. I like to do science experiments					
4. Learning science will help me in my daily life					
5. I need to do well in science to get the job I want					

Part C. Self-efficacy towards science

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
Statements	**1**	**2**	**3**	**4**	**5**
1. Science is harder for me than any other subject					
2. I can apply scientific knowledge to real-world situations					
3. I can learn and use scientific skills					
4. I can communicate effectively about scientific topics with others					
5. I am confident I can succeed in a scientific career					

Part D. Interest in science studies and science career

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
Statements	**1**	**2**	**3**	**4**	**5**
1. Learning science is important for my future career					
2. I am interested in careers that use science, mathematics or technology					
3. A family member of mine works in a science related field					
4. I enjoy talking to scientist					

The post-test includes the same questions as the pre-test, plus the following depending on the type of activity (ICaT, LHA or OSA):

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Part E. 1.Evaluation of Open Schooling Activities

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
This activity:	1	2	3	4	5
1. Was fascinating					
2. Helped me learn new concepts					
3. Helped me obtain new skills					
4. Required that I collaborate with other students					
5. Required that I collaborate with scientists					
6. Required that I collaborate with people from industry					
7. Helped me to understand the connection of science to everyday life					
8. The activity helped me solve a real problem					
9. The activity helped me participate in decision making					
10. The activity helped me understand the importance of cooperation between community and scientists					
11. I had constructive communication with mentors during the activity.					

Open-ended questions

1. What did you like the most in this activity?
2. What would you like to do differently in this activity?
3. How well did you interact with scientists in the activity? In which way did you interact with them?

Part E. 2.Evaluation of Lighthouse Activities

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
This activity:	1	2	3	4	5
1. Was fascinating					
2. Helped me learn new concepts					
3. Helped me to understand the connection of science to everyday life					
4. The activity helped me understand the importance of cooperation between community and scientists					
5. Required to interact with other participants (students, scientists, people from the industry)					

Open-ended questions

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1. What did you like the most in this activity?
2. What would you like to do differently in this activity?

Part E. 3.Evaluation of Interactive Career Talks

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
This activity:	**1**	**2**	**3**	**4**	**5**
1. Before participating in this activity, I already felt that a STEM career would be a good choice for me.					
2. The guest speaker(s) clearly presented their career path and I learned something new about their profession from their presentation.					
3. I believe that the activity was useful for me personally and I had the opportunity to actively participate in the discussion.					
4. This activity helped me remove existing dilemmas or stereotypes about STEM careers and encouraged me to further consider choosing a STEM profession.					

Open-ended questions

1. What did you like the most in this activity?
2. What would you like to do differently in this activity?

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Appendix II.3 Adults' questionnaire

Adults' questionnaire

[Please provide the evaluation moment: pre-test ☐ post-test ☐]

[Please provide the name of the activity]:

Partner(s) involved in designing the activity

[Please provide the name of the partner(s) involved in the activity]:

[Please add the date]:

Part A. Background information

I participated in the project as a … … … … [parent/teacher/scientist]
Code Name: …….. [the initial of the name of your child participating in this activity/the number of the day your child were born (i.e. if it was July 15 write 15)/the initial of the mother of this child/the number of the day your child participating in this activity]
Gender:
Age:
Educational level
Profession:
Type of activity you are attending: (you can check only one):

Lighthouse activity ☐ Open schooling activity ☐ Interactive career talks ☐ Local science fairs ☐

Part B. Evaluation of activity for parents

Please indicate your level of agreement or disagreement on the following statements using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)					
This activity…	1	2	3	4	5
1. … was pleasant					
2. … helped me to learn new concepts					
3. … helped me understand the connection between science and everyday life					
4. … helped me understand the importance of collaboration between the community and scientists					
5. It was necessary to communicate with other participants peers scientists people from the company					

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Appendix II.4 Template for the teachers' initial interview

Teachers' initial interview

[Please provide the name of the activity]:

Partner(s) involved in designing the activity

[Please provide the name of the partner(s) involved in the activity]:

[Please add the date]:

Part A. Background information

Code Name: … … … … [the initial of your name/the number of the day you were born (i.e. if it was July 15 write 15)/the initial of your mother's name]
Gender:
Age:
Educational level:
Speciality (e. g. Biology, Physics, etc):

Years of service:

Part B. Questions

1. Have you ever participated in an open schooling or similar activity?

IF YES, can you describe (briefly) the activity (topic, place, duration, educational goals, and difficulties found)?

2. How would you define your classes in terms of approaches, methodologies, contents, resources, contextualization, etc.

(You can comment on questions such as whether your classes are usually expository or participative, whether you stick to textbook content or use other sources, whether you focus on teaching content or also procedures and/or attitudes, whether you usually deal with current/media/conflictive issues in the classroom, whether you collaborate with other people - such as other teachers, professionals, disseminators, associations, administrations, etc. - for one or more of your classes, etc.).

3. What do you expect from your participation in the open schooling activity?

(You can comment on questions such as whether you expect students to be more engaged than they usually are in class or not, whether you think they will be more focused/motivated/interested or less than usual, whether you think it can help you as a teacher and, if so, which ones, whether you think this kind of activity can help you to handle some problems you usually encounter in the classroom and, if so, which ones - if you have had to deal with problems related to gender issues, please comment on them -, whether you expect to have

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to spend more time on this activity than on other activities you usually do in class, how you think your school, workmates and parents will receive the activity, etc.).

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Appendix II.5 Template for the teachers' retrospective interview

Teachers' retrospective interview

[Please provide the name of the activity]:

Partner(s) involved in designing the activity

[Please provide the name of the partner(s) involved in the activity]:

[Please add the date]:

Part A. Background information

Code Name: … … … … [the initial of your name/the number of the day you were born (i.e. if it was July 15 write 15)/the initial of your mother's name]
Gender:
Age:
Educational level:
Specialization:
Years of service:

Part B. Value of open schooling

1. What do you consider as the most valuable aspect of open schooling activities for you as a teacher, for the students, for the parents and for the rest of the community?

Supporting questions (SQ) for interviewers:

a. What was the most valuable insight you gained via your participation in the open schooling activity?
b. Has the whole experience affected your personal/professional development? In which ways?
c. Have you noticed any changes in your teaching approach, after your participation in the program?
d. Were you able to make connections between the community problems and the curriculum?
e. In your opinion, what was the most valuable insight the students gained via their participation in the open schooling activity?
f. Were the students able to see connections between the community problems and the curriculum?
g. In your opinion, what was the most valuable insight the parents gained via their participation in the open schooling activity?
h. In your opinion, what was the most valuable insight the community gained via their participation in the open schooling activity?

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i. Has the open schooling activity helped to identify and address the local problems of the community? Or was it already known?

2. How do you consider the relationship between the school, the parents and the rest of the community during the participation in the open schooling activity?

SQ for interviewers:

a. What do you consider as the most valuable effects on the relationships between the school, the parents and the rest of the community during the participation in the open schooling activity? Would you highlight any negative aspects?
b. In which group did you perceive the greatest participation during the activity (parents, scientists/professionals/other members of the community)?
c. What kind of synergies or relationships have been established (e.g. collaboration between parents and other members of the community)? Did you expect such synergies to occur?

3. Do you think that the open schooling activity carried out is susceptible to be used in other contexts?

SQ for interviewers:

a. Do you think that the open schooling activity carried out is susceptible to be used in other schools of the country? And in other countries?
b. Do you think that the open schooling activity carried out is an educational resource that can be used by other teachers?
c. Do you think that the open schooling activity carried out is susceptible to be adapted for other educational levels?

Part C. Impact on students and community

Impact on students

4. From your point of view, did participation in the open schooling activity affect students' scientific skills/competences?

SQ for interviewers:

a. Has participation influenced students' learning of scientific content knowledge?
b. Has participation influenced students' learning of scientific practices/procedures? E. g., ask questions, hypothesise, collect and analyse data, use scientific concepts in real life problems, etc.)
c. Do you feel that the open schooling activity has helped students learn about the relevance of science to real-life challenges?
d. Do you think the activity has been able to strengthen the students' understanding of and confidence in science as a means of solving problems in modern society?

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e. Is open schooling a way of giving prominence to scientific literacy/life-long learning? Why/why not.

5. From your point of view, did participation in the open schooling activity affect students' motivation/active participation and self-confidence?

SQ for interviewers:

a. Do you think that parental involvement has been a motivating factor for students?
b. Do you think that dealing with local community problems has been a motivating factor for students?
c. Do you think that the challenge of facing and having to propose solutions to local community problems has been a motivating factor for students?
d. Did the students receive feedback from the local population on your proposed solution (shown in the local fair?)? How did they feel about it?

Impact on community

6. From your point of view, has the open schooling activity had an impact on the community?

SQ for interviewers:

a. Do you think the activity has contributed to the scientific literacy (learning of scientific concepts/practices) of the local adult population?
b. Do you feel that the open schooling activity has helped local people learn about the relevance of science to real-life challenges?
c. Do you think the activity has been able to strengthen the local population's understanding of and confidence in science as a means of solving problems in modern society?
d. How did you perceive the interest of the local population in the solution proposed by the students (shown in the local fair?)?
e. Have you perceived interest from other teachers and/or stakeholders to participate in open schooling activities? IF YES, in which ways are they interested? Have you known about other teachers interested or thinking about participating in/carrying out open schooling activities in the future?

Part D. Willingness of continuing with open schooling

7. After your participation in the project, do you plan to continue developing open schooling activities in the future? Explain why.

SQ for interviewers:

a. What kind of support would you ask for in the future to carry out an open schooling activity?

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b. Would you consider the formation of a collaborative network of teachers to be useful for the further implementation of open schooling activities? Would you feel more confident in continuing to do so?

Part E. Support needed for open schooling

8. How was the support received from the project to carry out the open schooling activity?

SQ for interviewers:

a. What difficulties have you encountered when designing and implementing the open schooling activity?
b. What was the usefulness of the support packages, the different stakeholders (mentors, Science Education Institutes/local coordinators/Science Research Institutes/Community Institutions/Community institutions/enterprises) and/or the lab equipment resources for designing and developing the open schooling activity?
c. If you had participated in other open schooling or similar activities before participating in this project, what difference do you find between previous experiences and this one?

9. Apart from the project, have you received support, or encountered obstacles, from your work environment?

SQ for interviewers:

a. How did you perceive the role of your school in your participation in the program (support or obstacle)?
b. How did you perceive the role of your colleagues in your participation in the program (support or obstacle)?
c. Do you think there is something to be changed in the common teachers' practices to support integration of open schooling approaches?
d. Can curriculum be considered as compatible to support the changes required for developing open schooling activities?

Part F. Gender Issues

10. Have you encountered gender differences during the implementation of the open schooling activity?

SQ for interviewers:

a. Did you find differences between boys and girls during the open schooling activity (interest, motivation, active participation, topics proposed, decision-making processes)?
b. Have you found differences in girls' performance in the open schooling activity compared to more traditional activities (interest, motivation, active participation, topics proposed, decision-making processes)? If so, do you think that open schooling activity has helped you to manage these differences?

c. Did you highlight any issues in relation to the way boys work during the activity? Did you find any differences with respect to their usual way of working in class?
d. Did you find any differences in the relationships girls and boys establish when working? E.g. do they usually mix to work together in class, or do they tend to be grouped by gender? Did you notice any differences in this respect in the open schooling activity?

Part G. Influence of the previous activities in the open schooling activity

11. What, if any, do you consider the interactive career talks and/or lighthouse activity have contributed to the development of the open schooling activity (contributing topics, knowledge, possible problems and/or solutions, etc.)?

<u>SQ for interviewers:</u>

a. Do you think that the interactive career talks and/or the lighthouse activity have influenced the students during the open schooling activity (contributing topics, knowledge, procedures, possible problems and/or solutions, etc.?
b. Did the interactive career talks and the lighthouse activity as a teacher help you to lead the open schooling activity?

Appendix II.6 Template for the students' retrospective focus group

Students' focus group

[Please provide the name of the activity]:

Partner(s) involved in designing the activity

[Please provide the name of the partner(s) involved in the activity]:

[Please add the date]:

Part A. Background information

Participants:

Participant 1.
Code Name: …….. [the initial of their name/the number of the day they were born (i.e. if it was July 15 write 15)/the initial of their mother's name]
Gender:
Age:

Participant 2.
Code Name: …….. [the initial of their name/the number of the day they were born (i.e. if it was July 15 write 15)/the initial of their mother's name]
Gender:
Age:

Participant 3.
Code Name: …….. [the initial of their name/the number of the day they were born (i.e. if it was July 15 write 15)/the initial of their mother's name]
Gender:
Age:

Participant 4.
Code Name: …….. [the initial of their name/the number of the day they were born (i.e. if it was July 15 write 15)/the initial of their mother's name]
Gender:
Age:

Participant 5.
Code Name: …….. [the initial of their name/the number of the day they were born (i.e. if it was July 15 write 15)/the initial of their mother's name]
Gender:
Age:

Participant 6.

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Code Name: …….. [the initial of their name/the number of the day they were born (i.e. if it was July 15 write 15)/the initial of their mother's name]
Gender:
Age:

Participant X.

Code Name: …….. [the initial of their name/the number of the day they were born (i.e. if it was July 15 write 15)/the initial of their mother's name]
Gender:
Age:

Part B. Value of open schooling

1. What is your overall assessment of your participation in the open schooling activity (positive, negative)?

Supporting questions (S.Q.) for interviewers:

a. What would you highlight that you have learned during the activity? What have you done differently from what you usually do in other classroom activities? Have you been able to see connections between the problems in your community and the content you see in class?
b. How did you perceive your parents' participation in the activity? Do you feel that your parents have learned something from participating in the activity?
c. How did you perceive your teacher's work in the activity? Did you notice anything different in the way he/she worked compared to other activities you normally do in class?
d. Do you think that the members of your community have learned something from the work you have done? Do you think that you have contributed something to solving a problem in your community?

2. How do you consider the relationship between the school, the parents and the rest of the community during the participation in the open schooling activity?

SQ for interviewers:

a. What has been the best thing about the collaboration between your school, parents and the rest of the community during the participation in the open schooling activity? Would you highlight any negative aspects?

3. Do you think that the open schooling activity carried out is susceptible to be used in other contexts?

SQ for interviewers:

a. Do you think that this type of activity could be applied to other problems in your community? Do you think that the open schooling activity carried out could/should be used in other schools in your city/town?

Part C. Impact on students and community

Impact on students

4. From your point of view, what have you learnt about science during the open schooling activity (concepts, practices, etc.)?

SQ for interviewers:

a. Have you learnt new scientific concepts? (e. g., a word you did not know, a natural phenomenon, things related to environmental problems, etc.)
b. Have you learnt something new about how scientist/science work/s? (E. g., ask questions, hypothesise, collect and analyse data, use scientific concepts/models in real life problems, etc.)
c. After participating in the activity, do you think that science is relevant to the problems we face in our daily lives? Did you think so before?
d. Do you feel that you now have a better understanding of science, and do you trust it as a means of solving the problems of modern society? Did you think so before?

5. How did you feel during your participation in the open schooling activity?

SQ for interviewers:

a. Has it been a motivating activity for you?
b. Did you enjoy participating in the open schooling activity more than other activities you normally do in class? What kind of activities?
c. Did you try to be actively involved in the activity? Did you offer to participate in as many tasks as you could? Were there any tasks in which you were not very motivated?
d. Did you like your parents' participation in the activity?
e. What was it like to have to deal with a real problem in your community? What positive aspects would you highlight from working with a real problem in your community? Any negative aspects?
f. Have you received feedback from your community about your project? IF SO, what did they think of it?

Impact on community

6. From your point of view, do you think your project has had an impact on your community?

SQ for interviewers:

a. Do you think the activity has contributed to members of your community learning about science (science concepts/practices)?
b. Do you think the activity has helped your community to learn about the relevance of science to real problems in our daily lives?

c. Do you think your activity has helped your community to understand and trust science more as a means to solve real problems in our daily lives?
d. How did you perceive the interest of the local population in the solution you proposed in the project?

Part D. Willingness of continuing with open schooling

7. Following your participation in the activity, would you like to participate in open schooling or similar activities again in the future?

SQ for interviewers:

a. What would you change if you were to participate in an open schooling activity or similar in the future?
b. Have you missed any kind of help or resources to develop the activity?

Part E. Support needed for open schooling

8. How was the support received from the project to carry out the open schooling activity?

SQ for interviewers:

a. What difficulties have you encountered during the open schooling activity?
b. How did you perceive the help given by the other participants (teachers, parents, scientists, professionals, etc.)?
c. Were the materials and resources (e.g., laboratory equipment) helpful during the activity?

9. Did you receive support other than from your teacher, parents and scientists/professionals?

SQ for interviewers:

a. Have you received support from your school to develop the activity? Have you encountered any obstacles at school?
b. Did other teachers collaborate? What was the opinion of the other teachers about your participation in the activity? Did they help you or did you encounter any obstacles?
c. What do you think should change in the school in order to be able to develop more open schooling activities?

Part F. Gender Issues

10. Do you think there has been any difference in the participation of girls and boys during the open schooling activity?

SQ for interviewers:

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a. Did you notice any differences between your classmates, boys and girls, during the open schooling activity (interests, participation, topics proposed, way of working)?
b. Have you experienced any conflicts or situations to be resolved that you consider to be gender-related? E.g. Different tasks were assigned to boys and girls without taking into account your preferences, it was assumed that girls or boys could not do a certain task, etc. If so, have there been more of these situations or less than in other more traditional activities you usually do in class?
c. Who do you think participated more actively in the activity (more interest, more motivation, more enthusiasm, etc.), the girls or the boys? Have you noticed any differences in the participation of girls and boys compared to other more traditional activities that you do in class? E.g. girls or boys tend to participate more in class and in the open schooling activity it was the other way around.
d. During the open schooling activity, did you work in mixed groups (girls and boys)? How do you usually work on the activities you usually do in class?

Part G. Influence of the previous activities in the open schooling activity

11. Do you consider that the interactive career talks and/or the lighthouse activity have helped you in the development of the open schooling activity (input of issues, knowledge, possible problems and/or solutions, etc.)?

SQ for interviewers:

a. Have the interactive career talks and/or the lighthouse activity been useful in developing the open schooling activity?
b. Did they help you to propose/choose topics/problems/solutions?
c. Did you use concepts/procedures/approaches you have seen in those activities during the open schooling activities?

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Appendix II.7 Observation template for Lighthouse Activities

Observation Template

[Please provide the name of the Lighthouse activity]:

[Please provide the name of the observer]:

Date:
Local:
Partners involved:
Target group:
Number of participants:

A. Conceptual knowledge

The activity promotes the development of conceptual knowledge

Theme	**Field notes**
Environmental issues - Green Deal	
Digitalization	
Health	

B. Skills

The activity promotes the development of skills.

Skills	**Field notes**
Attitudes	
Skill in mobilising knowledge	
Communication skills	
Creativity	
Formulating hypotheses	
Appropriate use of technology in solving the problem/challenge	
High order thinking skills (decomposition; abstraction; pattern recognition; error detection; ...)	
Critical thinking skills	

C. Experienced difficulties

The participants experienced difficulties.

Difficulties	**Field notes**
Overall level of difficulty	
Application of concepts	
Specific actions / processes	

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Understanding of the problem / challenge	
Create or identify a valid solution to the problem / challenge	

D. Relevance

The activity is relevant.

Relevance	**Field notes**
Relevance of the activity according to its objectives	
Applicability of mobilised knowledge to real-life contexts	
Engagement of the participants in the activity (active participation, questions asked, and discussions generated)	
The different subjects are considered and well articulated in the implementation of the activity.	
The activity in its implementation promotes collaborative work between participants.	

E. Consistency

The activity is logically designed.

Consistency	**Field notes**
Clarity of procedures	
Coherence with the objectives to be achieved	
The activity follows a logical and coherent flow with stages well connected.	
Adequacy of resources, support and instructions	
Time allocated for the activity is adequate	

F. Practicality

The activity is usable in the settings for which it has been designed.

Practicality	**Field notes**
Allows areas of knowledge to be integrated and mobilized	
Enables the application of competences / skills	
Accessibility of resources	
Time needed to carry out the activity	
Adequate Complexity	
Suitability of space	
Cost	
The activity can be adapted to different contexts or groups of participants	

G. Activity effectiveness

Using the activity results in the desired outcomes.

Effectiveness	**Field notes**
The activity is aligned with the specific objectives it aims to achieve.	
The activity is implemented consistently and according to the initial planning.	

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The activity intervention has a long-term impact on the participants. The effects last beyond the activity itself.	
Participants' satisfaction with the activity	

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Appendix III. Evaluation timeline