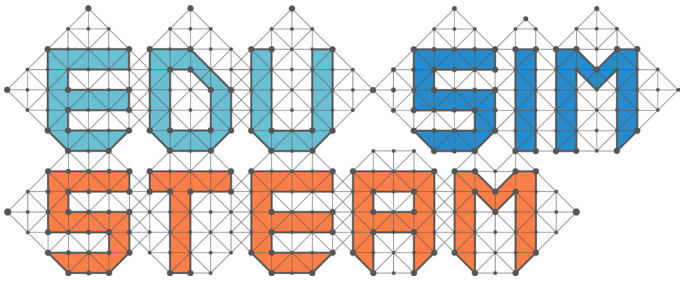
EDUSIMSTEAM Needs Analysis Report

Deliverable 1.2 EDUSIMSTEAM Needs Analysis Report

Erasmus+ KA3 Forward Looking Cooperation project



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List of Abbreviations

DGIET	:	General Directorate of Innovation and Education Technologies
EDUSIMSTEAM	:	Fostering STEAM Education in Schools Project
EU	:	European Union
ICT	:	Information and Communication Technologies
IOP	:	Innovative Online Platform
K12	:	Kindergarten through the 12th grade school levels
METU	:	Middle East Technical University
MoNE	:	Ministry of Turkish National Education
MOOC	:	Massive Open Online Course
STEAM	:	Science, Technology, Engineering, Art and Mathematics
WP	:	Work Package

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Abstract

Fostering STEAM Education in Schools (EDUSIMSTEAM) Project aims to promote an effective STEAM approach in education and to enhance the related teachers' skills and curriculum. This report introduces the needs analysis performed in order to meet the general aim of the EDUSIMSTEAM project, whilst valuing the general input given by STEAM educators on different countries adjacent to the project committee. The data were collected through surveys and interviews conducted between February 2020 and October 2020. The participants were 1108 teachers from Turkey, Spain, Portugal, Lithuania, Ireland, and the Netherlands. In the analysis of the data, SurveyMonkey's statistics interface for questionnaires and content analysis for interviews were used. The particular analysis focused on determining teachers' needs for STEAM education and the 21st century skills. Results revealed that although teachers from the participating countries have some information about STEAM education, there is still need for further training sessions on STEAM practices.

Keywords: EDUSIMSTEAM, STEAM, needs analysis, surveys, interviews, report

Introduction

"Fostering STEAM Education in Schools (EDUSIMSTEAM)" Consortium conducted needs analysis at European scale as a key deliverable for setting up the basis for understanding teachers' professional needs. The main goal of this deliverable is to provide pedagogical reference on education policies that will be applied along the EDUSIMSTEAM project, therefore representing a baseline analysis as a roadmap.

The report contains project information, scientific literature, methodology, results, conclusion and discussion sections. In the first section, project information, the EDUSIMSTEAM project will be described with its objectives, partners and work packages. In scientific literature section, the data collection has been limited to the teachers who could be reached at that very moment due to the COVID-19 epidemic. In order to assemble a meaningful diagnostic of the major needs and motivations of teachers, the data analyses will be complemented with the most up-to-date evidence from scientific literature. Next, data generation, data analysis and participants will be presented in methodology section. Then, characteristics of participants, survey and interview results will be explained in the results section. Finally, the findings will be reviewed and discussed in conclusion and discussion section.

1. Project Information

Fostering STEAM education in Schools (EDUSIMSTEAM) is an Erasmus+ KA3 Forward Looking Cooperation project. The duration of the project is 36 months, from January 2020 to December 2022. The objective of this project is to employ an innovative and up-to-date framework and solutions with the participation of 10 partners from the EU countries for employing an effective STEAM approach in education in an interdisciplinary way and developing the related teachers' skills and curriculum. EDUSIMSTEAM targets teachers and students in K-12 schools to define their needs for STEAM education and gain STEAM methodology through teacher training, online platform, curriculum, learning scenario studies and policy making documents. Along with all the studies and project outputs to be carried out for this purpose, it is desired to form the transnational dimension of STEAM as an innovative policy in education throughout the partner countries in the European Union (EU).

Ministry of National Education – General Directorate of Innovation and Education Technologies (MoNE-DGIET) from Turkey is the coordinator in the project and partners of the projects are BothSocial from Netherlands, Blackrock Education Center (BEC) from Ireland, Kaunas University of Technology from Lithuania, CTEM Academy from Portugal, H2 Learning from Ireland, Education Department of Galicia from Spain, Middle East Technical University (METU) from Turkey, Vilnius University from Lithuania, and ROBOTSAN from Turkey.

To achieve the aims and objectives in the project, our project designs and develops new methods, means and experiences for teachers and students in the scholastic systems of partner countries. Our project divided into the following 7 work packages (WPs) for 36 months:

1.WP1 - Design of the Project (Needs Analysis, Strategy Development)

The partners highlighted the importance of the needs analysis as they need the baseline and pedagogical needs on what their teachers and students do expect to be enrolled in a comprehensive study. The design of teaching in STEAM fields that will make difference and also develop strategy among partners to determine the best ways to achieve the project's goals.

2.WP2 - Teacher Training & Training Curriculum

The aim is to provide online training to all teachers in K12 schools by using the data results of WP1 in order to be able to incorporate STEAM skills into their curriculum. The project team plans to focus on robotics and algorithmic thinking for teacher trainings; meaning they will use STEAM approach through robots and robotic programs. Then, a curriculum will be prepared for teacher education in order to gain the skills of robotics literacy and algorithmic thinking at the international level. The prepared curriculum will be used during the teacher training process and will be open to access for teachers after the project.

3.WP3 - Scenario Development

Learning scenarios will be prepared in cooperation with a faculty of education in order to ensure that all studies on robotics literacy and algorithmic thinking skills will be developed in parallel with the K12 schools' curricula. These learning scenarios will help the students to make sense of all the work they will do in order to develop their robotic literacy and algorithmic thinking skills in a certain context. Rather than being limited to acquiring a few terms and information on robotic coding, the studies will enable students to associate robotic coding with real-life skills through scenarios and use 21st century skills such as problem-solving and creative thinking.

4.WP4 - Innovative Online Platform (IOP)

The project team will develop an online module where students and teachers can practice their Math, Science, Art and ICT skills together based on the robotics design. The online training activity, which will be supported by using robotic algorithm preparation and simulation software ready for use in different languages, can be widely applied to both national and European stakeholders and participatory teachers. It will also provide quick feedback and effective training results.

5.WP5 - A Practical Guide for Policy Makers

A strategy guide will be prepared in order to present the main points and technical contents of all STEAM works. This guide will be prepared for policy makers to use the project outputs to develop robotics literacy and algorithmic thinking skills for teachers and students in the curricula of the countries in K12 schools.

6.WP6 - Project Monitoring

Every study, progress and result made within the scope of the project will be recorded through a report. Then, in order to measure and evaluate all the piloting studies, a framework questionnaire will be prepared which defines certain skills on robotic literacy and algorithmic thinking and measure the development of teachers and students. Then, a reporting will be carried out. Finally, the prepared report will be shared as an output on the platform so every participant or interested individual on EDUSIMSTEAM will have access to all the data.

7.WP7 - Project Evaluation and Dissemination

The project will serve as a pilot study for other STEAM based projects and the outputs will be sampled for other colleges and universities throughout the EU. The results of the project evaluation will be disseminated on the web sites, report and media, which will contain a special info-booklet devoted to this project. Additional dissemination will occur through presentations at conferences, such as teacher education and science education conferences, regionally and nationally, and through articles published in peer-reviewed journals. EU Strategy Document will be spread to all ministries.

In the process, the coordinator and the partners will communicate and collaborate effectively to carry out the project tasks and work packages, to spread this STEAM-based project outputs and results in all networks, and to maximize impact and increase the quality. At the end of the project, a strategy guide for policy makers will be shared and the policy will highlight partner countries to become the best education and training service in Europe by 2050. Further information can be found on the project website: http://edusimsteam.eba.gov.tr/

2. Literature Review

The specific goal of the EDUSIMSTEAM project is to provide a strategy guide for policy makers so as to offer the best STEAM education and training service in Europe by 2050. That's why it will be useful to review other STEAM projects. The roles of teachers and students in STEAM projects will also be addressed.

2.1. Prior STEAM Projects as Catalysts for the EDUSIMSTEAM Project

An important function of the STEAM education is to stimulate the teacher to start from a human-centered approach towards solving the needs of students, using a design thinking method. In the process, the following techniques are used: 1. Empathy and perspective taking. 2. Idea generation. 3. Sketching a blueprint. 4. Test and refine a prototype. 5. Obtaining user feedback and reflection and 6. Disseminating the design rationale to a larger audience. Both at the side of the student and the teacher, the inquiry method is prevalent: Asking questions; the willingness to give up earlier intuitions or even earlier apprehensions is the main attitude that helps reconsider fixed interpretations. Postman and Weingartner (1969) suggest that inquiring teachers have the following characteristics (pp. 34–37): They avoid telling students what they "ought to know". They talk to students mostly by questioning, and especially by asking divergent questions. They do not accept short, simple answers to questions. They encourage students to interact directly with one another, and avoid judging what is said in student interactions. They do not summarize students' discussion. They do not plan the exact direction of their lessons in advance, and allow it to develop in response to students' interests. Their lessons pose problems to students. They gauge their success by change in students' inquiry behaviors (with the above characteristics of "good learners" as a goal). It is a natural tendency to start encouraging teachers to show these 'inquiry-based' teaching styles. However, that will only work if the teacher feels the genuine inclination to explore and restructure his/her understanding of a certain STEAM topic. Critical thinking is one of the ingredients that help teachers to anticipate inquiry-based teaching. Jon and Susan Awbrey (1995) have formulated: "the teacher acts as a catalyst of student inquiry, serving as a mediator or sign to quicken the actualization of something already present in the potential of the student. The student's impulse is the 'moving spring' of inquiry, but impulse does not direct intelligent inquiry". In order to nurture this process, teachers need to find creative ways so that students feel that it is much better to 'play' with alternative approaches, rather than 'jump to conclusions'. For this sake, it shows to be effective that teachers from time to time stay confronted with problems that have no ready-fixed solution for them at that moment; it allows them to re-experience the sensation of conceptual conflicts that their students have at a regular basis. In short: "teaching by learning". The underlying STEAM projects illustrate the creativeness teachers displayed in making the simple ingredients into inquiry contexts:

1. Easy Steam Activities for Kids
2. 100 STEAM Projects for Teachers
3. 25 STEAM Projects for Kids
4. 50+ Totally Awesome STEAM Projects to Boost Creativity
5. DIY STEAM Projects
6. STEAM Projects by Scholar's Choice
7. 300+ Best Science & STEAM Projects images in 2020
8. 28 Days of STEM Activities and STEAM Activities for Kids
9. 21 STEAM Projects for Learning All Summer Long
10. 23 Fun STEAM and STEM Activities for Kids
11. 10 simple STEAM projects
12. Steam Projects for Kids

2.2. Integrating Inquiry into the EDUSIMSTEAM Project

It may be clear from the prior list of ongoing STEAM projects worldwide, that the affinity to unify curricular domains for the sake of larger pedagogical goals has been recognized at large. In the context of the EDUSIMSTEAM Project, curricular domains were identified as STEAM domains: Science, Technology, Engineering, Arts and Mathematics. It is the power of allowing teachers from various disciplines to work together and design a new didactic format that recognizes the learners' social/cognitive developmental stage and is keen on phenomena in daily life that would be ignored in formal- silo based curricula. Thematic instruction assumes students learn best when they can associate new information holistically with across the entire curriculum and with their own lives, experiences, and communities (Kommers, 2004). Exactly the tendency to make learners aware of prior adjacent knowledge stimulates to recognize analogies, reflection and metacognition (techniques to elicit learners to make schematic representations and provoke naïve questions on how to explain counter-intuitive phenomena and even psychological occurrences like optical illusions and kinematic immersion). For instance, the works by Daan Roosegaarde has gained pertinent interest by educators who see a new genre of catching young learners' attention. Another good example of how media, art and youth culture may trigger involvement and curiosity is the yearly festival GOGBOT; it is the yearly free open-air field lab exhibition includes mind-boggling audiovisual art, gigantic robots and an interactive hamster wheel. Recently, it presented the Dutch premiere of Cluster, an immersive installation by Play modes. TETEM is a permanent expository and creative lab that bridges artists' media constructions with youngsters' drive to search for the boundaries of imagination. It exemplifies the most successful creations in Makerlabs and Fablabs. A good example on how new technologies

may affect future didactics already nowadays is the recent Make-It-Real Project. It delivered a highway from the state-of-the-art 3D printing to the needed teachers' new competences so that learners with a weaker talent for science abstractions could really make curves and spaces that would be difficult to imagine from a paper page.

2.3. Conclusion

The efforts to invigorate and disseminate STEAM lesson templates in regular (primary- and secondary) education can be streamed by articulating a recognized didactic genre like "Inquiry-Based Learning" as it builds upon three decades of research and development. The new element in the EDUSIMSTEAM project is the speed of current new technologies like the easy-handled Arduino, Raspberry Pi, and the BBC Micro:bit. The later one can be programmed with JavaScript and Python, but recently also with Scratch-like commands and dragging with the mouse. All of these new technologies have a low-level entry; however, for teachers, it is not a self-evident tool for STEAM projects. This is the reason that EDUSIMSTEAM needs to invest in didactic templates in order to work as demonstrator for teachers who have the interest, but might hesitate to start.

3. Methodology

In this part, there are 5 subsections: the design of the study, participants, instruments, data generation and data analysis. Firstly, the design of the study will be remarked. Next, participants of the study will be specified. Later, instruments will be explained. After that, data generation will be clarified. Finally, information on the data analysis will be provided.

3.1. Design of the Study

The Needs Analysis is targeted at designing the educational online platform, content of teacher training and the required STEAM activities in the project. The aim is also to analyse the problematic areas teachers experience in teaching in a transdisciplinary way. For that reason, each partner is expected to do field analysis and distribute at least 400 surveys to the teachers in their region and so semi-structured interviews in order to better serve the communities of teachers in the partner countries. The surveys include their need for STEAM approach, how much they are prepared for the 21st century skills, the STEAM areas they lack in adequate knowledge. The stakeholders in the partner countries -large educational organizations- are also planned to be visited in order to get their opinions about an effective STEAM application and policy making in the countries. However, the COVID-19 crisis has shut down schools, so it is important to confess that it was hard to generate the data for the analysis.

This study followed a multiple exploratory case study approach with mixed methods (Yin, 2014). According to Yin (2014), case studies are appropriate when asking "how," "why," "what," and "who" questions. This multiple case study approach is suitable for this research as the research does not only focus on one country as Turkey but it also focuses on cases in five other countries, being Ireland, Lithuania, Netherlands, Portugal and Spain. This study is also an exploratory case study as there is no pre-determined outcome, and there is the exploration, searched through with surveys and interviews.

3.2. Participants

The participants of the study were teachers from six countries: Ireland (n=114), Lithuania (n=223), Netherlands (n=38), Portugal (n=123), Spain (n=310) and Turkey (n= 1121) with the greatest sample. The first numbers in the parentheses (n) shows the number of participants who attempted to complete the survey by answering at least one question. In the following sections, this document will report the data after eliminating the missing values.

The following table shows the percentages of teachers, participating from each country. To note, having a smaller number from other countries than Turkey is not a disadvantage considering the number of teachers in each country; it is expected prior to the data generation to have a greater number of teachers from Turkey, which has more than a million teachers recruited as of 2020.

Table 1. The participating countries and the percentages of participants

Countries	Percentages (%)
Ireland	5,83
Lithuania	11,39
Netherlands	1,94
Portugal	6,29
Spain	15,84
Turkey	57,18

3.2.1. Gender

All of the participants identified themselves as either female or male. The following table shows the percentages of females and males in each of the participating countries.

Table 2. Gender percentages by participating countries

Percentages / Countries	Female percentage	Male Percentage
Ireland	92,86	7,14
Lithuania	89,47	10,53
Netherlands	77,78	22,22
Portugal	51,72	48,28
Spain	38,19	61,81
Turkey	81.66	18.34

3.2.2. Age

Age ranges were defined as 20-25, 26-30, 31-35, 36-40, 41-45, 46-50, 51-55, 56-60, and more than 61. Although teachers from each age level responded to the Questionnaire, the most frequent responses were different in each country: The most frequent age ranges were 31-35 in Ireland, 46-50 in Spain and 51-55 in Lithuania. The age of the teachers ranged from 36-40 in both Portugal and Turkey. The age range of the participants were normally distributed for most of the countries. The following chart shows the percentage of participants in each of the age groups.

Table 3. Age percentages by participating countries

Country / Age	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
20-25	2,86	1,75	33,33	NA*	NA	1,02
26-30	10,00	0,88	22,22	6,90	5,53	8,30
31-35	24.29	3,51	22,22	6,90	5,03	19,21
36-40	17,14	7,89	11,11	24,14	14,07	32.17
41-45	8.57	19,30	NA	17,24	16,08	20,52
46-50	11.43	22,81	NA	6,90	23,12	11,79
51-55	17,14	23,68	NA	17,24	21,61	4,80
56-60	5,71	14,91	11,11	20,69	10,55	1,75
61+	2,86	5,26	NA	NA	4,02	0,44

*NA: Not Applicable

3.2.3. School Type

School types are clarified as kindergarten, primary school, secondary school and high school. Although participants were from all school types, most of the participants were generally from primary school in Ireland (80%) and in Turkey (44.40%), from secondary school in Spain (53.77%), from high school in Lithuania (65.79%) and from university in Portugal (51.72%).

Table 4. School type percentages by participating countries

Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Kindergarten 2.86%	Darželis 0.88%	Kindergarten 33.33%	Kindergarten 3.45%	Kindergarten 24.12%	Kindergarten 12.08%
Primary school 80%	Pradinė mokykla 12.28%	Primary school 11.11%	Primary school 6.90%	Primary school 40.20%	Primary school 44.40%
Middle school 20%	Pagrindinė mokykla 47.37%	Voortgezet Onderwijs 33.34%	Middle school 13.79%	Secondary school 53.77%	Middle school 26.35%
Secondary school and vocational school 4.29%	Vidurinė mokykla 65.79%	MBO 11.11%	Secondary school 31.03%	University 37.69%	Secondary school 14.99%
	Profesinė mokykla 8.77%	HBO 11.11%	University 51.72%		Vocational school 6.11%
			Polytechnic Institute (similar to University) 6.90%		

3.3. Instruments

Both survey (see Appendix 1) and interview (see Appendix 2) as instruments were adopted for the study. The instruments were produced by the Scientific Board of the project, and they are found to be reliable and valid.

In the survey, first, age, gender and school type as demographic information were demanded. Then, there were 14 items: questions 1, 2, 3, 4, 5, 7 and 8 embodied multiple choice items; questions 6 and 9 included four-point Likert scale (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree); questions 10, 12 and 14 composed of five-point Likert scale (1: Not Important, 2: Hardly important, 3: Not Sure, 4: Rather important, 5: Very important); questions 11 and 13 contained three-point Likert scale (1: I don't need, 2: I need a little, 3: I need a lot)

In the interviews, 13 questions were asked to teachers after their age, gender and school type were requested as demographic information. The aim was to triangulate the data from questionnaires and interviews.

3.4. Data Generation

For this report, the data is generated through surveys and interviews. It is important to note that the instruments are piloted before the main data generation process. The survey was carried out between February 2020 and October 2020. The survey data is collected via SurveyMonkey, which is an online survey platform. The interviews were follow-up interviews to support quantitative survey results; they were one-to-one online interviews in a written text format. They were only conducted with Turkish teachers and hence reported fully in the Appendix 3.

3.5. Data Analysis

The survey data was analyzed with the help of SurveyMonkey's statistics interface, which provided descriptive statistics to present. This report included percentages and means as descriptive statistics to report the survey results. The interviews were analyzed thematically. The transcripts were meticulously read. The interview transcripts were copied to a sheet and sentences which are directly related to the research questions were put into separate columns to see the general approach.

4. Results

In this section, the survey results will be reported with the support from the interview results. Moreover, the case in the interviewed country will be described.

This section includes the reports of the STEAM professional training hours, teachers' preferences on the type of courses, teachers' opinions on in-service trainings, timing for teachers' training, timing for additional training per day, teachers' preferences on learning environment for in-service training, important 21st century skills for STEAM education, training needs of teachers for the 21st century skills, the importance of interdisciplinary STEAM education in schools, teachers' training needs in respect to cross-curricular STEAM education, and finally, expected technical features of the software for online STEAM training.

4.1. Teachers' Experience

In the survey, the years of experience ranges were defined as 0-5, 6-10, 11-15, 16-20 and more than 20 years. According to high rates, while teachers have been teaching for more than 20 years in Ireland (32.86%), Lithuania (69.57%), Portugal (41.38%) and Spain (43.22%); they have been teaching for 11-15 years in Turkey (28.68%), and for 16-20 years in Netherlands.

Table 5. Teachers' years of experience in percentages by participating countries

Country / Experience	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
0-5 years	12.86%	5.22%	22.22%	6.90%	11.56%	7.86%
6-10 years	20.00%	4.75%	33.33%	10.34%	4.52%	16.89%
11-15 years	24.29%	9.57%	NA	20.69%	23.12%	28.68%
16-20 years	10.00%	11.30%	44.44%	20.69%	17.59%	21.83%
20+ years	32.86%	69.57%	NA	41.38%	43.22%	24.75%

4.2. Grade Levels of Teachers' Teaching

Grade levels were defined according to the school levels in separate countries. Although participants were from all grade levels, most of the teachers taught in primary schools in Ireland (82.86%) and also in Turkey (40.76%), others being mostly secondary.

Table 6. Grade levels of teachers' teaching in percentages by participating countries

Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Kindergarten **2.86%**	Darželis **0.87%**	Kindergarten **11.11%**	Kindergarten **NA**	Kindergarten **16.58%**	Kindergarten **15.28%**
Primary school **82.86%**	Pradinė mokykla **13.91%**	Primary school **11.11%**	Primary school **3.45%**	Primary school **34.17%**	Primary school **40.76%**
Secondary school **18.57%**	Pagrindinė mokykla **66.09%**	Secondary school **44.44%**	Secondary school **41.38%**	Secondary school **50.75%**	Middle school **29.55%**
High school and vocational school **5.71%**	Vidurinė mokykla **73.04%**	MBO/HAVO **44.44%**	University **62.07%**	University **35.68%**	Secondary school **22.56%**
				Formación Profesional **10.55%**	

4.3. Subject Areas of Teachers

In the survey, the subject areas are defined as Mathematics, Science, Technology, Engineering, Art and Other. In Ireland, the rates of the participants teaching technology (42.86%) and engineering (22.86%) are below 50%. As for Mathematics (78.57%), Science (70%), Art (65.71%) and Other (51.43%) subjects, their rate is above 50%. This is probably explained by the fact that the majority of teachers participating in Ireland are primary school teachers. In Lithuania, most participants teach engineering (60%). The rates of the other subjects are below 50%. In the Netherlands, Portugal and Spain, participants teach all subjects, but their rates are below 50%. In Turkey, participants generally teach mathematics (50.51%) and science (55.75), the rates of the other subjects are below 50%. To note, what the interviewed teachers viewed as STEAM professional training was mostly webinars or MOOCs rather than something more engaging. (see Table 7)

Table 7. Teachers' subject areas in percentages (%) by participating countries

Country / Subject Area	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Mathematics	78.57	26.09	22.23	17.24	30.65	50.51
Science	70.00	21.74	11.11	31.03	29.65	55.75
Technology	42.86	9.57	33.33	17.24	32.16	33.62
Engineering	22.86	60.00	NA	27.59	3.52	19.21
Art	65.71	12.17	22.22	17.25	14.07	37.41
Other	51.43	6.09	11.11	24.14	48.74	44.69

4.4. STEAM Professional Training Hours

The training hours in the survey were identified as 0, 1-10, 11-20 and more than 20 hours. The participants were asked to state their training experiences in the previous year (in 2019). Considering the highest percentages, 50% of the participants in Ireland, 39.13% of the participants in Lithuania and 44.45% of the participants in the Netherlands attended training sessions for 1-10 hours in 2019. In Spain, the highest percentage was 49.25 with 20+ training hours; which means 49.25% of the teachers in Spain had more than 20 hours of training. However, % 41.38 of the participants from Portugal and 42.07% of the participants from Turkey did not attend any training. As a conclusion, most of the teachers - particularly from Portugal and Turkey - did not receive enough STEAM training in the countries revealing a demanding necessity of implementing such courses.

Table 8. Hours of STEAM professional training (including Communities of Practice, online courses/MOOCs, conferences, accredited courses, etc.) by percentage of participants

Country / Subject Area	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Not attended	34.29%	26.96%	11.11%	41.38%	15.08%	42.07%
1-10 hours	50.00%	39.13%	44.45%	34.48%	20.10%	28.53%
11-20 hours	5.71%	14.78%	33.33%	10.34%	15.58%	8.59%
20+ hours	10.00%	19.13%	11.11%	13.79%	49.25%	20.82%

Interview results of Turkey regarding the training experiences were noted in detail in Table A3. For example, Teacher 1 said that "I have been following STEAM courses very closely for 3 years. I received STEAM theoretical and practical training sessions from a University (2 months and 2 days). I completed 4-week courses of "STEM is everywhere" from European Schoolnet. Finally, I am attending the webinar of Yıldız Technical University, which started on 13.10. I am continuing the training course now. I have also participated in the presentations containing course contents/methods that can be added to STEAM."

4.5. Teachers' Preferences on the Type of Courses

In the survey, course types were defined as MOOC, Webinar, Face-to-face training, traditional lecture and other types. When it was gone over data from the countries, most of the teachers would like to participate in webinars. As a reminder, what the teacher participants viewed as STEAM professional training was mostly webinars or MOOCs rather than something more engaging. Interestingly, in Turkey, the numbers were so close and the teachers were open to MOOC, webinar and face-to-face training, and the participants were so eager for STEAM courses that they were open to more types. Again, the traditional lecture was the least wanted type of course by the participants. Table 9 shows the percentages for each type of training for all countries.

Table 9. Type of courses on STEAM Education teachers would like to participate in by the percentage of teachers who chose them (%)

Country / Type	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
MOOC	12.86	26.96	55.56	55.17	32.66	67.98
Webinar	70.00	70.43	44.44	72.41	50.25	68.12
Face-to-face training	61.43	53.91	11.12	31.03	50.26	66.23
Traditional lecture	17.14	12.17	11.11	20.69	24.12	16.45
Other	5.71	8.70	NA	10.34	31.16	6.11

Interview results of Turkey regarding Teachers' preferences on the type of courses were noted in detail in Table A5. This shows that half of the teachers interviewed were open to both face-to-face and online training sessions.

4.6. Teachers' Opinions on In-Service Trainings

Table 10 shows descriptive statistics (mean and percentages) for the teachers' opinions on in-service teacher training sessions. For this item, a 4 Likert scale (1: Strongly Disagree, 2: Disagree, 3: Agree, 4: Strongly Agree) is used. For percentages to report the opinions, the total percentages were calculated by adding percentage values of Agree (the first value) and Strongly agree (the second value). Although the best way to determine the central tendency on a set of ordinal data is to use the mode or median; a purist will tell you that the mean cannot be defined from an ordinal set. It is known that the means mostly are not reported in an ordinal scale statistically, they are only reported to show the trend to the reader in this section.

Table 10. Teachers' opinions on in-service trainings by percentages

Country / Item	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
I would like to participate in such professional development activities relevant to STEAM education.	31.43 + 62.86 = 94.29% (M=3.53)	52.17 + 46.96 = 99,13% (M=3.46)	11.12 + 22.22 = 33,34% (M=1.89)	55.17 + 34.48 = 89,65% (M=3,24)	36.36 + 60.10 = 96,70% (M=3.56)	19.83 + 78.28 = 98,11% (M=3.75)
I can attend quality professional development programs relevant to STEAM education at any time.	34.78 + 21.74 = 56,52% (M=2.67)	44.74 + 16.67 = 61,41% (M=2.70)	33.34 + 33.33 = 66,67% (M=2.00)	51.72 + 17.24 = 68,96% (M=2.86)	48.24 + 15.58 = 63,82% (M=2.72)	38.10 + 56.50 = 94,60% (M=3.51)
I believe that the training in STEAM education will improve my teaching processes.	57.14 + 34.29 = 91,43% (M=3.21)	50.88 + 33.33 = 84,81% (M=3.14)	22.23 + 44.44 = 66,67% (M=2.11)	51.72 + 20.69 = 72,41 (M=2,90)	46.39 + 38.14 = 84,53% (M=3.19)	34.84 + 60.20 = 95,04% (M=3.53)
I believe that STEAM professional development training that I will attend will be very beneficial for the students in school.	32.86 + 62.86 = 95,72% (M=3.56)	62.28 + 36.84 = 99,12% (M=3.36)	33.34 + 22.22 = 55,56% (M=2.11)	44.83 + 44.83 = 89,66% (M=3.34)	32.66 + 64.32 = 96,98% (M=3.60)	21.43 + 77.26 = 98,69% (M=3.75)
My participation in STEAM professional in-service training is supported by all staff at our school.	52.86 + 28.57 = 81,43% (M=3.07)	60.53 + 14.91 = 75,44% (M=2.87)	33.34 + 22.22 = 55,56% (M=2.11)	62.07 + 13.79 = 75,86% (M=2.86)	56.61 + 22.75 = 79,36% (M=2.99)	42.13 + 46.21 = 88,34% (M=3.33)
My school administrators support me in attending STEAM in-service.	35.71 + 60.00 = 95,71% (M=3.54)	52.68 + 45.54 = 98,22% (M=3.44)	33.34 + 22.22 = 55,56% (M=2.11)	58.62 + 34.48 = 93,10 (M=3.24)	29.29 + 67.68 = 96,97% (M=3.63)	21,75 + 76,93 = 98,68 (M=3.75)

Overall, it has been found that the teachers would like to participate in such professional development activities relevant to STEAM education. Professional development activities in this context are in-service teacher training sessions on particular STEAM topics. However, the number of the teachers who can attend quality professional development programs decreased because of timing. The teachers reported that they cannot attend at any time as they have a schedule to follow so it is an important issue to plan in-service training in terms of timing. Moreover, teachers believed that STEAM professional development training would improve their teaching processes and be very beneficial for the students in their school. In addition, they stated that their school administrators and all staff at their school supported the teachers in attending STEAM professional in-service training.

4.7. Timing for Teachers' Training

It is important to plan teachers' training in terms of timing to get a high level of participation. According to the data, most of the teachers want to attend STEAM training on weekday evenings for all countries. On weekday mornings or afternoons and at the weekends, they mostly chose not to have training sessions. This might be because of the fact that they probably have lessons at their school on weekdays and at the weekends, they may need rest. Hence, they prefer it on weekday evenings. Table 11 shows the trend for teachers' choices of timing for the training sessions on STEAM education.

Table 11. Teachers' choices of timing for teachers' STEAM training by percentage

Country / Timing	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Weekday mornings	30%	10,43%	33,34%	20,69%	15,08%	10,48%
Weekday afternoons	37,14%	45,22%	NA	13,79%	51,26%	24,16%
Weekday evenings	65,71%	63,68%	33,33%	65,52%	31,66%	59,39%
Weekend mornings	18,57%	16,52%	11,11%	27,59%	28,64%	16,74%
Weekend afternoons	15,71%	16,53%	22,22%	13,79%	7,54%	27,80%
Weekend evenings	12,86%	16,52%	22,22%	10,34%	4,02%	39,59%

The interview results of Turkey regarding the required training contents and time for such in-service training were noted in detail in Table A4. Planning, distance education and teaching methods were the three main codes reported. For example, about planning, Teacher 4 noted that "As I am a teacher, I believe that I do not have any knowledge gap on how to implement and plan STEAM lessons." Secondly, about distance education, Teacher 1 stated that "I also think there are parts I need to learn about how to conduct distance education." Finally, an example from the teaching methods is that "I need to improve my teaching skills in using technology in the field of robotics, coding, 3d printing, cloud computing, and the Arduino."

4.8. Timing for Additional Training per day

It is found in the analysis that participants can afford an hour (38,57%) and 2 hours (37,14%) in Ireland – the rates for the hours are close-, 2 hours (43,10%) in Lithuania, less than an hour (33,33%) to an hour (33,34%) in the Netherlands, an hour in Portugal (65,52%) and Spain (45,23%), 2 hours (43,38%) in Turkey. Some teachers are more enthusiastic and hence for the next cycle of this analysis, it is needed to define their additional training hours per day in this item.

Table 12. Timing for additional training per day by percentage (%)

Country / Timing	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Less than 1 hour	11,43	13,79	33,33	20,69	15,08	1,89
1 hour	38,57	34,48	33,34	65,52	45,23	28,24
2 hours	37,14	43,10	22,22	13,79	35,68	43,38
3 hours	4,29	4,31	NA	NA	2,01	14,26
3 hours +	8,57	4,31	11,11	NA	2,01	12,23

Interview results of Turkey regarding the required training contents and time for such in-service training were noted in detail in Table A4. Teachers' expectations for timing were varied in the interviews, from 2 hours a day (teacher 4) to 5-6 hours a week (teacher 5).

4.9. Teachers' Preferences on Learning Environment for In-Service Training Sessions

In the table, descriptive statistics were used to show percentages of the items related to teachers' preferences on the learning environment for in-service training sessions. For the items regarding this theme, there is a 4-point Likert scale (1: Strongly Disagree, 2: Disagree, 3: Agree, 4: Strongly Agree). For percentages in the tables, total percentages were calculated by adding percentage values of Agree (the first value) and Strongly agree (the second value); see Table 13.

In the follow-up interviews of Turkey regarding teachers' preferences on the type of courses were noted in detail in Table A5. This shows that half of the interviewed teachers were open to both face-to-face and online training sessions.

Considering the survey results supported with the interview results, participants were open to all these options. However, they were not so eager for in-service training centers in another province. When it comes to the online training, webinars or MOOCs can be used to train the teachers especially during the COVID-19 pandemic.

Table 13. Teachers' preferences on learning environment for in-service trainings (%)

Country / Item	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Attending face-to-face in-service training at my school.	43.48 + 36.23 = 79,71%	65.22 + 19.13 = 85,35%	44.00 + 0.00 = 44,44%	48,28 + 24,14 = 72,42%	43.81 + 37.11 = 80,92%	35.77 + 48.86 = 84,63%
Participating in a training held in-service training center in my province.	53.62 + 28.99 = 82,61%	62.61 + 19.13 = 81,74%	50.00 + 0.00 = 50,00%	37,93 + 13,79 = 51,72%	48.17 + 31.94 = 80,11%	37.99 + 45.74 = 83,73%
Creating a learning community and cooperating with other teachers in our province.	53.73 + 23.88 = 77,61%	70.43 + 17.39 = 87,82%	37.50 + 0.00 = 37,50%	64.29 + 10.71 = 75,00%	51.81 + 35.75 = 87,56%	40.33 + 51.42 = 91,75%
Participating in training held in-service training centers in another province.	23.88 + 7.46 = 31,29%	40.87 + 11.30 = 52,17%	25.00 + 0.00 = 25,00%	20.69 + 3.45 = 24,11%	37.89 + 11.05 = 48,94%	24.66 + 31.96 = 56,62%
Receiving training from a teacher teaching in my field.	64.18 + 20.90 = 85,08%	51.72 + 41.38 = 93,10%	25.00 + 0.00 = 25,00%	79.31 + 10.34 = 89,65%	54.92 + 38.86 = 86,17%	39.43 + 53.78 = 93,21%
Participating in virtual environment webinars.	51.47 + 32.35 = 83,82%	51.72 + 43.97 = 95,69%	25.00 + 12.50 = 37,50%	48.28 + 48.28 = 96,56%	55.38 + 31.79 = 87,17%	38.43 + 52.08 = 90,51%
Through online self-study materials.	42.03 + 21.74 = 63,77%	49.57 + 40.87 = 90,44%	25.00 + 12.50 = 37,50%	44.83 + 44.83 = 89,66%	50.00 + 33.84 = 83,84%	43.18 + 47.98 = 91,16%
Participating in online communities and forums through discussion rooms or blogs on the Internet.	39.39 + 21.21 = 60,60%	59.65 + 25.44 = 85,09%	12.50 + 12.00 = 25,00%	51.72 + 27.59 = 79,31%	46.67 + 20.00 = 66,67%	36.90 + 37.95 = 74,85%
Following a specialist teacher's lecture in his/her class.	52.17 + 23.19 = 75,36%	62.61 + 23.48 = 86,09%	37.50 + 12.50 = 50,00%	65.52 + 31.03 = 96,55%	49.23 + 43.08 = 92,31%	42.17 + 49.10 = 91,27%
Taking in-service training both face-to-face and online.	54.41 + 32.35 = 86,76%	63.79 + 29.31 = 93,10%	50.00 + 12.00 = 62,50%	62.07 + 27.59 = 89,66%	52.02 + 38.89 = 90,91%	31.60 + 61.87 = 93,47%

4.10. Important 21st Century Skills for STEAM Education

Another result to report is the important 21st century skills for STEAM education. In the items regarding this issue, a 5 Likert scale (1: Not Important, 2: Hardly Important, 3: Not sure, 4: Rather Important, 5: Very Important) was used. To report the results, total percentages were calculated by adding percentage values of Rather Important (the first value) and Very Important (the second value).

Table 14. Teachers' perceived most important 21st century skills for STEAM education (in %)

Country / Item	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Critical Thinking: The careful analysis of something to better understand it.	12.86 + 82.86 = 95,72%	38.26 + 60.00 = 98,26%	11.11 + 22.22 = 33,33%	48.28 + 48.28 = 96,56%	25.63 + 70.85 = 96,48%	27.80 + 70.89 = 98,69%
Creative Thinking: Solving open problems in an original way	14.49 + 81.16 = 95,65%	31.03 + 66.38 = 94,41%	25.00 + 12.50 = 37,50%	37.93 + 51.72 = 89,65%	23.62 + 73.87 = 97,49%	19.27 + 79.71 = 98,98%
Collaboration: Skills to build and work in teams	17.39 + 78.26 = 95,65%	46.55 + 50.86 = 97,41%	12.50 + 25.00 = 37,50%	41.38 + 55.17 = 96,55%	26.77 + 71.72 = 98,49%	23.84 + 73.55 = 97,39%
Communicating: Empathic listening and being sensitive for emotion in all modalities of communication such as writing, reading, and listening	30.00 + 64.29 = 94,29%	53.91 + 35.65 = 89,56%	50.00 + 0.00 = 50,00%	37.93 + 51.72 = 89,65%	32.66 + 59.30 = 91,96%	25.87 + 71.80 = 97,67%
Information Literacy: Researching, writing, consuming and producing information	30.00 + 62.86 = 92,82%	41.74 + 56.52 = 98,26%	25.00 + 25.00 = 50,00%	41.38 + 44.83 = 86,21%	35.35 + 58.08 = 93,43%	20.41 + 78.13 = 98,54%
Media Literacy: The skills to consider the media information critically	32.86 + 60.00 = 92,86%	40.52 + 51.72 = 92,24%	50.00 + 0.00 = 50,00%	51.72 + 27.59 = 79,31%	35.86 + 60.61 = 96,47%	27.92 + 67.84 = 95,76%
Technology Literacy: Student skills to use new educational technology and use it to create effective and tasteful communication	34.29 + 58.57 = 92,86%	41.74 + 56.52 = 98,26%	37.50 + 12.50 = 50,00%	41.38 + 48.28 = 89,66%	28.79 + 69.19 = 97,98%	20.93 + 77.62 = 98,55%
Social Skills: Students' skills to collaborate and partner in learning	28.57 + 65.71 = 94,28%	50.00 + 45.61 = 95,61%	25.00 + 25.00 = 50,00%	51.72 + 31.03 = 82,75%	31.47 + 63.96 = 95,43%	23.87 + 74.53 = 98,40%
Problem Solving/ Productivity: student skills to learn in the discovery mode, project- and problem-based	22.86 + 72.86 = 95,72%	44.35 + 54.78 = 99,13%	37.50 + 12.50 = 50,00%	48.28 + 37.93 = 86,21%	29.44 + 65.99 = 95,43%	14.85 + 83.84 = 98,69%

Table 14 continues in the next page.

Leadership: Student attitude to take initiative and show flexibility, risk-taking, conflict resolution	31.43 + 61.43 = 93,86%	55.65 + 39.13 = 94,78%	37.50 + 12.50 = 50,00%	48.28 + 31.03 = 79,31%	45.45 + 39.90 = 85,35%	30.86 + 66.23 = 97,09%
Flexibility: Student skills to analyze what is going around them and making arrangements while keeping learning priorities in mind	27.14 + 65.71 = 92,85%	59.13 + 38.26 = 71,63%	37.50 + 12.50 = 50,00%	55.17 + 24.14 = 79,31%	36.87 + 56.06 = 92,93%	27.41 + 69.97 = 97,38%
Initiative: The skills of students to step forward with an idea and enjoy the satisfaction	28.57 + 67.14 = 95,71%	48.28 + 46.55 = 94,83%	25.00 + 12.50 = 50,00%	58.62 + 27.59 = 86,21%	37.06 + 58.38 = 95,44%	24.74 + 73.06 = 97,80%

In the follow-up interviews of Turkey, most of the teachers stated that among all these skills, critical thinking, creative thinking, problem solving and productivity are more important than others. For detailed investigation, please see Table A6 in the appendix.

To sum up, nearly all participants (nearly half in the Netherlands) thought that critical thinking, creative thinking, collaborating, communicating, information literacy, media literacy, technology literacy, social skills, problem-solving, leadership, flexibility and initiative were the important 21st century skills for STEAM Education. The rates from all countries were quite high. Whether teachers were able to teach these perceived important skills were discussed in section 4.2.8.

4.11. Training Needs of Teachers for the 21st Century Skills

For measuring teachers' training needs for the 21st century skills, a 3 Likert scale (1: I Don't Need, 2: I Need A Little, 3: I Need A Lot) was used. For reporting the percentages, total percentages were calculated by adding percentage values of I Need A Little (the first value) and I Need A Lot (the second value).

Table 15. Teachers' training needs in their perceived important 21st century skills for STEAM education (%)

Country / Item	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Critical Thinking: The careful analysis of something to better understand it.	63.77 + 30.43 = 94,23%	39.47 + 57.89 = 97,36%	50.00 + 12.50 = 62,50%	62.07 + 17.24 = 80,31%	63.08 + 18.97 = 82,05%	49.34 + 44.05 = 93,39%
Creative Thinking: Solving open problems in an original way	60.87 + 33.33 = 94,20%	32.76 + 64.66 = 97,42%	22.23 + 22.22 = 44,45%	51.72 + 44.83 = 96,55%	58.08 + 36.36 = 94,44%	40.52 + 54.08 = 94,60%
Collaboration: Skills to build and work in teams	57.97 + 27.54 = 85,51%	42.48 + 54.87 = 97,35%	50.00 + 12.50 = 62,50%	37.93 + 27.59 = 65,52%	59.39 + 23.86 = 83,25%	45.91 + 41.52 = 87,43%
Communicating: Empathic listening and being sensitive for emotion in all modalities of communication such as writing, reading, and listening	57.14 + 24.29 = 81,43%	53.45 + 42.24 = 95,69%	25.00 + 12.50 = 37,50%	44.83 + 31.03 = 75,86%	59.90 + 15.74 = 75,64%	45.77 + 39.94 = 85,71%
Information Literacy: Researching, writing, consuming and producing information	54.29 + 32.86 = 87,15%	43.48 + 45.22 = 88,70%	50.00 + 12.50 = 62,50%	58.62 + 20.69 = 79,31%	64.29 + 15.31 = 79,60%	41.35 + 46.77 = 88,12%
Media Literacy: The skills to consider the media information critically	52.86 + 34.29 = 87,15%	52.17 + 41.74 = 93,91%	37.50 + 12.50 = 50,00%	65.52 + 17.24 = 82,76%	65.15 + 18.18 = 83,33%	44.87 + 45.16 = 90,03%
Technology Literacy: Student skills to use new educational technology and use it to create effective and tasteful communication	46.38 + 47.83 = 94,21%	39.13 + 56.52 = 95,65%	25.00 + 12.50 = 37,50%	41.38 + 48.28 = 89,66%	58.38 + 28.43 = 86,81%	44.33 + 49.42 = 93,75%
Social Skills: Students' skills to collaborate and partner in learning	60.00 + 22.86 = 82,86%	42.98 + 53.51 = 96,49%	37.50 + 12.50 = 50,00%	41.38 + 31.03 = 72,41%	63.27 + 17.35 = 80,62%	46.57 + 37.52 = 84,09%
Problem Solving/ Productivity: student skills to learn in the discovery mode, project- and problem-based	61.43 + 35.71 = 97,14%	34.78 + 64.35 = 99,13%	37.50 + 12.50 = 50,00%	48.28 + 27.59 = 75,87%	62.37 + 27.32 = 89,69%	42.46 + 47.88 = 90,34%

Table 15 continues in the next page.

Leadership: Student attitude to take initiative and show flexibility, risk-taking, conflict resolution	62.86 + 28.57 = 91,43%	40.87 + 54.78 = 95,65%	25.00 + 12.50 = 37,50%	55.17 + 34.48 = 89,65%	56.12 + 28.57 = 84,69%	45.47 + 40.94 = 86,41%
Flexibility: Student skills to analyze what is going around them and making arrangements while keeping learning priorities in mind	64.29 + 28.57 = 92,86%	42.11 + 56.14 = 98,25%	37.50 + 12.50 = 50,00%	65.52 + 31.03 = 96,55%	64.97 + 20.30 = 85,27%	47.81 + 40.20 = 88,01%
Initiative: The skills of students to step forward with an idea and enjoy the satisfaction	65.71 + 28.57 = 94,28%	43.36 + 53.98 = 97,34%	37.50 + 12.50 = 50,00%	53.57 + 32.14 = 85,71%	62.94 + 23.86 = 86,80%	46.27 + 44.51 = 90,78%

When training needs of teachers were examined for the 21st century skills, for the important skills reported in section 4.2.7, high percentages were reported for each country. Teachers were really eager for training, and most of the participants thought that they needed training for the 21st century skills - critical thinking, creative thinking, collaborating, communicating, information literacy, media literacy, technology literacy, social skills, problem-solving, leadership, flexibility and initiative.

4.12. The Importance of Interdisciplinary STEAM Education in Schools

For analyzing the importance of interdisciplinary STEAM education in schools, a 5 Likert scale (1: Not Important, 2: Hardly Important, 3: Not sure, 4: Rather Important, 5: Very Important) was used. For the report, total percentages were calculated by adding percentage values of Rather Important (the first value) and Very Important (the second value).

Table 16. Teachers' opinions on the importance of interdisciplinary STEAM education in schools by percentage

Country / Item	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
STEAM (Science, Technology, Engineering, Arts and Mathematics) Education	34.29 +55.71 = 90,00%	45.40 +50.92 = 96,32%	12.50 +25.00 = 37,50%	51.72 +44.83 = 96,55%	35.18 +52.76 = 87,94%	25.76 +71.62 = 97,38%
Project-Based Learning in STEAM Education	30.00 +61.43 = 91,43%	50.93 +37.89 = 88,82%	12.50 +25.00 = 37,50%	50.00 +28.57 = 78,57%	35.35 +50.00 = 85,35%	25.15 +72.81 = 97,96%
Engineering Design Processes in STEAM Education	34.29 +42.86 = 77,15%	45.68 +37.65 = 83,33%	12.50 +25.00 = 37,50%	41.38 +24.14 = 65,52%	36.73 +27.04 = 63,77%	28.63 +66.67 = 95,30%
Inquiry-based Learning Processes in STEAM Education	32.86 +62.86 = 75,72%	43.83 +51.85 = 95,68%	0.00 +33.33 = 33,33%	51.72 +17.24 = 68,96%	43.88 +35.20 = 79,08%	25.11 +72.99 = 98,10%
Usage of STEAM to solve real-life problems	28.57 +61.43 = 90,00%	39.88 +55.21 = 92,09%	12.50 +25.00 = 37,50%	53.57 +39.29 = 92,86%	44.39 +45.41 = 89,80%	22.34 +75.47 = 97,81%
Assessment and Testing in STEAM education	45.71 +25.71 = 71,42%	60.49 +25.93 = 86,42%	12.50 +25.00 = 37,50%	37.93 +27.59 = 65,52%	45.96 +32.32 = 78,28%	31.68 +59.71 = 91,42%
Cooperative Learning Environments in STEAM education	34.29 +54.29 = 88,58%	55.28 +35.40 = 90,68%	12.50 +25.00 = 37,50%	57.14 +28.57 = 85,71%	43.43 +39.90 = 83,33%	28.80 +69.74 = 98,54%
Building a school culture in which everyone in the school is involved in STEAM education processes	27.14 +62.86 = 90,00%	53.99 +35.58 = 89,57%	12.50 +25.00 = 37,50%	44.83 +27.59 = 72,42%	44.67 +37.56 = 82,23%	26.13 +69.78 = 95,91%
Cooperation and collaboration between teachers for STEAM education	24.29 +67.14 = 91,43%	49.38 +45.06 = 94,44%	12.50 +25.00 = 37,50%	59.26 +25.93 = 85,19%	39.59 +47.21 = 86,80%	25.73 +71.35 = 97,08%
Cooperation with Industry, Universities, other schools for STEAM education	32.86 +48.57 = 81,43%	48.75 +45.00 = 93,75%	0.00 +37.50 = 37,50%	41.38 +44.83 = 86,21%	43.08 +37.44 = 80,52%	28.99 +67.79 = 96,78%

In the table, the high numbers for each item can be seen. Nearly all participants gave importance to all items. Related to this issue, when teachers were asked to comment on their schools' STEAM goals in the interviews, they either had uncertain goals, or commented on the following topics: Developing the 21st century skills; Professional development; and Integrating various teaching methods. The detailed analysis on this is presented in Table A1.

4.13. Teachers' Training Needs in respect to Cross-Curricular STEAM Education in Schools

For this item, a 3 Likert scale (1: I Don't Need, 2: I Need A Little, 3: I Need A Lot) was used. For percentages, total percentages were calculated by adding percentage values of I Need A Little (the first value) and I Need A Lot (the second value).

Table 17. Teachers' training needs in respect to cross-curricular STEAM education in schools by percentage

Country / Item	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
Interdisciplinary STEAM (Science, Technology, Engineering, Arts and Mathematics) Education	52.86 +44.29 =97,15%	46.01 +53.99 =100,00%	37.50 +25.00 =62,50%	41.38 +37.93 =79,31%	64.97 +27.92 =92,89%	34.21 +63.03 =97,24%
Project-Based Learning in STEAM Education	55.07 +43.48 =98,55%	48.45 +50.31 =98,76%	12.50 +37.50 =50,00%	50.00 +35.71 =85,71%	54.27 +35.68 =89,95%	33.77 +61.70 =95,47%
Engineering Design Processes in STEAM Education	30.00 +68.57 =98,57%	40.74 +54.94 =95,68%	25.00 +37.50 =62,50%	34.48 +34.48 =68,96%	46.67 +42.05 =88,72%	31.09 +63.78 =94,87%
Inquiry-based Learning Processes in STEAM Education	51.43 +42.86 =94,29%	38.89 +60.49 =99,38%	25.00 +37.50 =62,50%	31.03 +41.38 =72,41%	59.18 +33.16 =92,34%	36.55 +58.92 =95,47%
Usage of STEAM to solve real-life problems	46.38 +49.28 =95,66%	38.04 +61.35 =99,39%	12.50 +37.50 =50,00%	44.83 +41.38 =86,21%	59.90 +31.98 =91,88%	33.92 +61.11 =95,03%
Assessment and Testing in STEAM education	42.86 +48.57 =91,43%	50.00 +46.91 =96,91%	25.00 +25.00 =50,00%	58.62 +31.03 =89,65%	57.73 +37.11 =94,84%	36.35 +60.44 =96,79%
Cooperative Learning Environments in STEAM education	54.41 +38.24 =92,65%	49.69 +47.85 =97,54%	22.22 +22.22 =44,44%	48.28 +41.38 =89,66%	60.20 +31.63 =91,83%	38.16 +56.87 =95,03%
Building a school culture in which everyone in the school is involved in STEAM education processes	34.29 +54.29 =88,58%	46.58 +49.69 =96,27%	37.50 +25.00 =62,50%	44.83 +34.48 =79,31%	59.18 +34.18 =93,36%	32.26 +64.82 =97,08%
Cooperation and collaboration between teachers for STEAM education	47.14 +45.71 =92,85%	46.91 +51.85 =98,76%	37.50 +25.00 =62,50%	48.28 +37.93 =86,21%	60.71 +31.12 =91,83%	36.07 +59.53 =95,60%
Cooperation with Industry, Universities, other schools for STEAM education	35.71 +55.71 =91,42%	42.86 +56.52 =99,38%	37.50 +25.00 =62,50%	37.93 +48.28 =86,21%	52.31 +38.46 =90,77%	31.24 +65.55 =96,79%

In respect to cross-curricular STEAM education in schools, teachers need training for the given items in the Table 17. It is clear that the rates for training needs are quite high. In addition to these, in the interviews, teachers stated that they are interested in the STEAM training sessions on the following topics: Robotics, Coding/ Computer programming, 3D printing, Cloud computing, Energy storage, Autonomous vehicles, Fossil fuel extraction technologies, Advanced materials, Climate change, Mobile internet, Internet of thing, Artificial intelligence, New generation generic studies, Renewable energy, Plant growing and agriculture, Augmented reality, Recycling, Virtual reality, Space sciences, Drone design (see Table A8 for the details). Robotics and drone design were stated by all of the interviewed teachers.

4.14. Expected Technical Features of the Software for Online STEAM Training

For the teachers' expected technical features of the software for online STEAM training, a 5 Likert scale (1: Not Important, 2: Hardly Important, 3: Not sure, 4: Rather Important, 5: Very Important) was used. In order to report the percentages, total percentages were calculated by adding values of Rather Important (the first value) and Very Important (the second value). According to the participating teachers, the software for online STEAM training should have the following technical features in the given percentages in Table 18.

Table 16. Teachers' opinions on the importance of interdisciplinary STEAM education in schools by percentage

Country / Item	Ireland	Lithuania	Netherlands	Portugal	Spain	Turkey
There should be training scenarios appropriate for STEAM education.	40.00 +50.00 =90,00%	48.77 +43.21 =91,98%	0.00 +37.50 =37,50%	48.28 +37.93 =86,21%	43.65 +45.69 =89,34%	33.62 +62.45 =96,07%
It should provide a facility of adequate amount of practice and exercise relevant to STEAM education.	35.71 +48.57 =84,28%	38.04 +60.12 =98,16%	12.50 +25.00 =37,50%	34.48 +58.62 =93,10%	43.15 +47.72 =90,87%	29.65 +68.46 =98,11%
STEAM activities and scenarios should be based on real-life problems.	31.88 +55.07 =86,92%	44.44 +52.47 =96,91%	25.00 +12.50 =37,50%	37.93 +51.72 =89,65%	30.30 +65.66 =95,96%	26.98 +70.97 =97,95%
It should provide the facility for sufficient practice and exercise to students.	22.86 +64.29 =87,15%	37.65 +61.11 =98,76%	33.33 +11.11 =44,44%	27.59 +58.62 =86,21%	39.29 +55.61 =94,90%	24.09 +73.72 =97,81%
It should allow collaboration with other learners.	27.14 +50.00 =77,14%	54.32 +40.12 =94,44%	12.50 +37.50 =50,00%	48.28 +37.93 =86,21%	37.56 +57.36 =94,92%	27.07 +70.31 =97,38%
It should activate relevant prior experiences of learners.	28.57 +54.29 =82,86%	49.69 +45.34 =95,03%	12.50 +25.00 =37,50%	50.00 +14.29 =64,29%	48.98 +37.76 =86,74%	25.91 +71.47 =97,38%
It should have a dashboard in which the instructor is given a list of common errors.	28.57 +40.00 =68,57%	45.68 +36.42 =82,10%	0.00 +25.00 =25,00%	48.15 +25.93 =74,08%	50.51 +33.67 =84,18%	31.19 +59.44 =90,63%

Moreover, participating teachers of Turkey stated in their interviews that when they received such training sessions online, they expected from a STEAM simulation software to have the following features:

- Being online (Web-based and mobile)
- Being able to draw a specific path for each student's level of development
- Using VR and AR
- Having a user-friendly interface
- Being suitable for group work
- Being available for all branches of teachers, and
- Serving as a tool for enhancing teaching and finding solutions to real-world problems (see Table A9 and A10 in the appendices for the detailed analysis).

5. Conclusion and Discussion

5.1. Conclusion

In conclusion, it is found that teachers from the participating countries were aware of the STEAM education, its necessary methods and the 21st century skills, as well as the importance of interdisciplinary STEAM education in schools such as Project-Based Learning, Inquiry-based Learning, Cooperative Learning, etc. and they need training for these STEAM education methods. It is important to note that not all teachers have the same understanding of STEAM education.

The teachers interviewed have varied opinions about STEAM and these are noted in the appendices.

The teachers believe in the importance of STEAM education and they clearly state that they need extra training on not only STEAM education but also the 21st century skills which have become almost a necessity in the current education in many countries. Teachers believe that STEAM trainings will improve their teaching processes and be very beneficial for the students in their school. Moreover, teachers from all countries generally prefer webinars for training sessions. This might be because this format became dominant during Covid-19. This finding is important to plan timing to get a high level of participation. While teachers want to be there to be trained, they do not prefer weekends for the training sessions. Most of the teachers want to attend STEAM trainings on weekday evenings for all countries. Our STEAM project could take a bit longer orientation to refine the essence of STEAM education.

5.2. Discussion

Adjacent to the survey outcomes, the literature study shows that the STEAM education affects not only the integration of contents throughout curricula, but maybe even more essential is its affordance to allow a diversity of recent new instructional methods that help the process of inquiry by the students. These instructional ingredients are: exploratory, constructivist, collaborative, authentic and new ways of 'guided discovery' learning. Subsequently, the most challenging implication of STEAM might be the encouragement of teachers to undertake this wider repertoire of guiding and mentoring the students. The COVID-19 period, which dominates the world at this very moment for about 10 months has compromised the educational sector very much. Its first-order effect has been the overwhelming need for blended learning, in the sense that teachers at primary-, secondary- and tertiary level have been forced to apply distance-learning practices quite unexpectedly. It did not just urge them to explore tools for video-conferencing; more essential was the step to address learners in all unorthodox configurations (individual, dyads, small groups, etc.).

This force majeure has taken away teachers' aptitude to gradually allow new didactic approaches in their day-to-day practice. The good side of this unfortunate catastrophe for modal and innovative practice is that our EDUSIMSTEAM project could take a bit longer orientation to redefine the essence of STEAM education. This is to say the project can take more time to define or redefine what the participants understand by STEAM education for each of the participating countries. Already in the prior two remote project meetings it has proven that each of the project partners have complementary ideas on how a proper inquiry attitude at the teacher and the student should be instigated, coached and encouraged. In the next phase of the EDUSIMSTEAM project it will be the challenge to elicit and orchestrate the optimal mix of didactic ingredients and combine them in an apprehensive guideline for teachers, school leaders, curriculum designers and policy makers. It can be seen as a 'blessing in disguise' that in this complex era, we are obliged to take a more explicit stand on how STEAM needs to be conceived for the next decades. Further-on, as bycatch, it was found in the data that in Turkey, teachers' years of experiences are smaller than all other countries, this could be considered related to the young population of Turkey. An interesting finding, which might also explain their relatively high response rate to the broadcasted survey.

References

- Awbrey, Jon, and Awbrey, Susan (1995), "Interpretation as Action: The Risk of Inquiry", Inquiry: Critical Thinking Across the Disciplines 15, 40-52.
- Gombrich. E.H.; Art and Illusion Princeton: Princeton University Press, ISBN 978-0-691-07000-1. 2000.
- Kommers, P.A.M. (2004). Cognitive Support for Learning; Imagining the Unknown. Amsterdam, Nederland: IOS Pre.
- Postman, Neil, and Weingartner, Charles (1969), Teaching as a Subversive Activity, Dell, New York, NY.
- Roosegaarde, Daan; The art monograph book of Daan Roosegaarde about his projects and ideas is published by Phaidon with contributions by Fumio Nanjo, Carol Becker, and Nico Daswani. Now available at Phaidon.
- Williams, R.C.; (2017). Exploring Vacation and Etiquette Themes in Social Studies, Primary Source Inquiry for Middle and High School. Maryland: Rowman & Littlefield Publishers. pp. 93–4. ISBN 978-1-4758-3198-6.
- Yin, R.K. (2014). Case Study Research Design and Methods (5th ed.). Thousand Oaks, CA: Sage.

Appendices

Appendix 1. Survey

STEAM EDUCATION PROFESSIONAL DEVELOPMENT NEEDS ANALYSIS SURVEY

If you teach your students science, technology, engineering, art or mathematics (STEAM), you are a STEAM teacher. In order to improve your STEAM professional development qualification, we need to get information from you through this needs analysis questionnaire. Your responses to this survey will help us plan STEAM in-service training for you. The results will be shared with you, so you should write your current email in this survey. Please read the questions and then write the appropriate answers in the blanks or answer them drawing a cross sign in the boxes.

Name:
Age: Gender: M ☐ F ☐
Email:
Province:
SubProvince:
Country:
School type*: Date: / /
(DD / MM/ YYYY)

*School type: Kindergarten, Primary School, Secondary School, High School or Vocational High School

1. How many years have you been teaching?

0-5 years ☐ *6-10 years* ☐ *11-15 years* ☐ *16-20 years* ☐ *More than 20 years* ☐

2. At what grade levels do you teach?

Kindergarten ☐ *Primary* ☐ *Secondary* ☐ *High School* ☐

3. What subject areas do you teach?

Mathematics ☐ *Science* ☐ *Technology* ☐ *Engineering* ☐ *Art* ☐ *Other* ☐

4. How many hours of STEAM professional training (including Communities of Practice, online courses/MOOCs, conferences, accredited courses, etc.) did you attend in the last year?

Never attended ☐ *1-10 hours* ☐ *11-20 hours* ☐ *> 20 hours* ☐

5. Do you have explicit ideas on the type of courses on STEAM Education you would like to participate shortly?

MOOC Webinar ☐ *Face-to-face training* ☐ *Traditional lecture* ☐ *Other* ☐

6. What are your opinions on getting an in-service training about STEAM Education?

I would like to participate in such professional development activities relevant to STEAM education.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

I can attend quality professional development programs relevant to STEAM education at any time.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

My school administrators support me in attending STEAM in-service.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

I believe that STEAM professional development training that I will attend will be very beneficial for the students in our school.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

My participation in STEAM professional in-service training is supported by all staff at our school.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

I believe that the training in STEAM education will improve my teaching processes.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

7. At what time do you want to participate in STEAM Professional Development online training (such as MOOC, webinars, etc.)?

Weekday Mornings ☐ *Weekday Afternoons* ☐ *Weekday Evenings* ☐
Weekend Mornings ☐ *Weekend Afternoons* ☐ *Weekend Evenings* ☐

8. How long can you afford for additional training per day?

< 1 hour ☐ *1 hour* ☐ *2 hours* ☐ *3 hours* ☐ *More than 3 hours* ☐

9. In what kind of learning environment would you prefer to take STEAM in-service training?

Attending face-to-face in-service trainings at my school.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Participating in a training held in-service training center in my province.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Creating a learning community and cooperating with other teachers in our province.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Participating in trainings held in-service training centers in another province.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Receiving training from a teacher teaching in my field.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Participating in virtual environment webinars.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Through online self-study materials.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Participating in online communities and forums through discussion rooms or blogs on the Internet.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Following a specialist teacher's lecture in his/her class.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

Taking in-service training both face-to-face and online.

Strongly disagree ☐ *Disagree* ☐ *Agree* ☐ *Strongly agree* ☐

10. Which 21st Century Skills are important for STEAM Education?
(Please refer to 1. Not Important, 2. Hardly important, 3. Not Sure, 4. Rather important, 5. Very important)

Critical Thinking: The careful analysis of something to better understand it.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Creative Thinking: Solving open problems in an original way

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Collaborating: Skills to build and work in teams

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Communicating: Empathic listening and being sensitive for emotion in all modalities of communication: Writing, reading, and listening

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Information Literacy: Researching, writing, consuming and producing information.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Media Literacy: The skills to consider the media information critically

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Technology Literacy: Student skills to use new educational technology and use it to create effective and tasteful communication.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Social Skills: Students' skills to collaborate and partner in learning.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Problem Solving/Productivity: Students' skills to learn in the discovery mode, project- and problem-based.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Leadership: Student attitude to take initiative and show flexibility, risk-taking, conflict resolution

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Flexibility: Student skills to analyze what is going around them and making arrangements while keeping learning priorities in mind

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Initiative: The skills of students to step forward with an idea and enjoy the satisfaction

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

11. What are your training needs for each one of the 21st Century Skills?
(Please refer to 1. I don't need, 2. I need a little, 3. I need a lot)

Critical Thinking: The careful analysis of something to better understand it.

1☐ 2☐ 3☐

Creative Thinking: The open ended invention and discovery of possibilities.

1☐ 2☐ 3☐

Collaborating: The team building, leading a group, allocating resources and responsibilities, evaluating the processes and products of a group, managing time, and resolving conflicts.

1☐ 2☐ 3☐

Communicating: The listening actively, reading, evaluating messages, speaking, turn taking, using technology in communicating and writing.

1☐ 2☐ 3☐

Information Literacy: The researching, writing consuming and producing information.

1☐ 2☐ 3☐

Media Literacy: The understanding of many ways information is produced and distributed.

1☐ 2☐ 3☐

Technology Literacy: Student skills for using the new technology to learn and evaluate the new information and use them to create effective and all-round communication.

1☐ 2☐ 3☐

Social Skills: Students' collaboration with others by means of cooperation, decision making, communication, using constructive criticism.

1☐ 2☐ 3☐

Problem Solving/Productivity: Student skills to produce more outputs by using the inquiry process and developing projects.

1☐ 2☐ 3☐

Leadership: Student skills for taking initiative by using social skills, flexibility, identifying goals, resolving conflicts for productivity.

1☐ 2☐ 3☐

Flexibility: Student skills to analyze what is going around them and making arrangements while keeping their goals at the forefront of their minds.

1☐ 2☐ 3☐

Initiative: Student skills to step forward with an idea and take the risk of bringing it into practice.

1☐ 2☐ 3☐

12. What is the importance of Interdisciplinary STEAM education in Schools? (Please refer to 1. Not Important, 2. Hardly important, 3. Not Sure, 4. Rather important, 5. Very important)

Interdisciplinary STEAM (Science, Technology, Engineering, Arts and Mathematics) Education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Project-Based Learning in STEAM Education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Engineering Design Processes in STEAM Education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Inquiry-based Learning Processes in STEAM Education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Usage of STEAM to solve real-life problems

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Assessment and Testing in STEAM education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Cooperative Learning Environments in STEAM education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Building a school culture in which everyone in the school is involved in STEAM education processes

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Cooperation and collaboration between teachers for STEAM education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Cooperation with Industry, Universities, other schools for STEAM education

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

13. What are your training needs in respect to cross-curricular STEAM education in Schools? (Please refer to 1. I don't need, 2. I need a little, 3. I need a lot)

Interdisciplinary (cross-curricular) STEAM education

1 ☐ 2 ☐ 3 ☐

Project Based Learning in STEAM Education

1 ☐ 2 ☐ 3 ☐

Engineering Design Processes in STEAM Education

1 ☐ 2 ☐ 3 ☐

Inquiry-based Learning Processes in STEAM Education

1 ☐ 2 ☐ 3 ☐

Usage of STEAM to solve real life problems

1 ☐ 2 ☐ 3 ☐

Assessment and Evaluation in STEAM education

1 ☐ 2 ☐ 3 ☐

Cooperative Learning Environments in STEAM education

1 ☐ 2 ☐ 3 ☐

Building a school culture in which everyone in the school is involved in STEAM education processes

1 ☐ 2 ☐ 3 ☐

Cooperation and collaboration between teachers for STEAM education

1 ☐ 2 ☐ 3 ☐

Cooperation with Industry, Universities, other schools for STEAM education

1 ☐ 2 ☐ 3 ☐

14. What technical features should the software for online STEAM training have?

There should be training scenarios appropriate for STEAM education.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

It should provide facility of adequate amount of practice and exercise relevant to STEAM education.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

STEAM activities and scenarios should be based on real-life problems.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

It should provide the facility for sufficient practice and exercise to students.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

It should allow collaboration with other learners.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

It should activate relevant prior experiences of learners.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

It should have a dashboard in which the instructor is given a list of common errors

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Appendix 2. Interview

STEAM EDUCATION PROFESSIONAL DEVELOPMENT NEEDS ANALYSIS INTERVIEW

If you teach your students science, technology, engineering, art or mathematics (STEAM), you are a STEAM teacher. In order to improve your STEAM professional development qualification, we need to get information from you through this needs analysis interview. Your responses to this survey will help us plan STEAM in-service training for you. The results will be shared with you, so you should write your current email in this form. Please read the questions and then write the appropriate answers in the blanks. The project team grants full disclosure and won't by any means reveal your identity.

Name:
Age: Gender: M ☐ F ☐
Email:
Province:
SubProvince:
Country:
School type*: Date: / /
(DD / MM/ YYYY)

*School type: Kindergarten, Primary School, Secondary School, High School or Vocational High School

1. How many years have you been teaching?

2. At what grade levels and STEAM (Science, Technology, Engineering, Art and Mathematics) subject area do you teach?

3. What are the STEAM education goals of your school for this year?

4. What kind of changes are needed in your school to meet the goals of STEAM Education?

5. How many hours of STEAM training did you attend in last years?

6. What knowledge gaps do you have about interdisciplinary STEAM education?

7. What training will help you close these training gaps about STEAM?

a. Face to face training
b. Online training

8. How long can you allocate time for online in-service trainings on STEAM Education?

9. If you could choose your top three priority topics for the 21st Century Skills, what would they be?

a. Critical Thinking
b. Creative Thinking
c. Collaborating
d. Communicating
e. Information Literacy
f. Media Literacy
g. Technology Literacy
h. Social Skills
i. Problem Solving/Productivity
j. Leadership
k. Flexibility
l. Initiative

10. What do you know about the following STEAM education learning and teaching methods?

a. Project Based Learning in STEAM Education

b. Inquiry-based Learning Processes in STEAM Education

c. Usage of STEAM to solve real life problems.

d. Assessment and Evaluation in STEAM education.

11. What are your needs for training about the following STEAM fields?

a. Robotics
b. Coding/ Computer Programming
c. 3D (Three-Dimensional) Printing
d. Cloud Computing
e. Energy Storage
f. Autonomous Vehicles
g. Fossil Fuel Extraction Technologies
h. Advanced Materials
i. Climate Change
j. Mobile Internet
k. Internet of Things
l. Artificial Intelligence
m. New Generation Genetic Studies
n. Renewable Energy
o. Plant Growing and Agriculture
p. Augmented Reality
q. Recycling
r. Virtual Reality
s. Space Sciences
t. Drone Design

12. What technical features should an online STEAM Training Simulation Software have?

13. What kind of resources and materials do you need with the simulation software for STEAM Education?

a. Robots Kits

b. Sensors, Electronic data collectors, recorders

c. Microcontroller platforms (Arduino, etc.)

d. Laboratory materials for experiments

e. Coding tools (Computers, etc.)

Appendix 3. Interview Analysis in the Case of Turkey

Table A1. Theme 1. The STEAM education goals of the schools/teachers for this year

Teachers	STEAM Education goal in teachers' words	Code (professional development; uncertain goals)
Teacher 1	The curriculum, in which the 21st century skills are developed, focused on finding solutions to daily problems by practicing and experiencing, will be followed.	Developing the 21st century skills
Teacher 2	To adapt and update STEAM teaching objectives. To guide students and teachers for the importance of understanding and using technology. Using more technology in the teaching environment rather than traditional methods.	Professional development (Understanding and using technology in teaching environment)
Teacher 2	To find solutions against learning problems with the integration of Inquiry Based Science Education and Project Based Learning in lesson plans.	Integrating various teaching methods (IBS & PBL)
Teacher 2	Improve the 21st century learning skills of students with STEAM based lesson plans.	Developing 21st century skills
Teacher 3	Each student (Total 300) carries out activities with a STEAM approach with a theme they want in 1 individual, 1 group.	Professional development (by practicing himself)
Teacher 4	Only two teachers out of 80 are aware of the fact that STEM is essential for our education. That's why there are no exact goals for STEM teaching at my school unfortunately.	Uncertain goals
Teacher 4	As for my goals, I am attending professional development MOOCs by European School Education and I personally aim to be a Scientix ambassador. And also, I have an Erasmus project application on STEM. If this project is approved, then for 2 years we will have great activities and work.	Professional development (MOOC; project)
Teacher 5	My school aims to give STEAM training to teachers in order to raise awareness of STEAM's importance and to use STEAM effectively during the next academic year.	Professional development (teacher training sessions)
Teacher 6	I have just come to school. There are currently no STEAM targets. I will raise awareness and introduce STEAM in the first teachers' board meeting.	Uncertain goals
Teacher 6	I will start practicing STEAM myself.	Professional development (by practicing himself)

Table A2. Theme 2. Changes needed in schools to meet the goals of STEAM Education

Teachers	The required change in teachers' words	Codes (Need for materials, training needs, change in vision)
Teacher 1	Our school is a village school. Internet connection is required at first.	Provision of Internet connection
Teacher 1	Also, a separate STEAM class must be created.	Need for materials (STEAM classroom)
Teacher 1	Up-to-date activities should be organized in this class on the condition that each class and branch can be used at least once a week.	Developing STEAM activities
Teacher 1	In addition, they should be integrated into the curriculum.	Curriculum Integration of STEAM activities
Teacher 1	Collaboration between teachers and students is also essential for STEAM.	Collaboration between teachers and students for STEAM Education
Teacher 2	Firstly, STEM teaching objectives need to be adapted and updated, in order to advance STEM education and initiate problem-solving through science.	Curriculum Integration of STEAM activities Teaching problem-solving
Teacher 2	Students should be guided for the importance of understanding and using technology. Teachers should use technology as a tool to develop problem solving capabilities of the students both in team and independent study.	(Using technology for) Teaching problem solving
Teacher 2	Teachers should employ project-based learning to identify the tasks that will enhance students' interpersonal skills and abstract thinking.	Integrating various teaching methods (Project Based Learning to improve skills)
Teacher 3	There is a need for strengthening technical infrastructure and facilitating materials.	Need for materials
Teacher 4	At first the vision should be changed. The management should see the importance of STEM activities.	Change in vision
Teacher 4	The school should support their teachers and students, and should provide them with the right equipment and training.	Need for materials Training needs
Teacher 4	Then all the school teachers should be aware of STEM importance and they need to volunteer to act.	Training needs
Teacher 5	My school needs a STEAM lab and materials. The school administration is trying to solve these problems.	Need for materials
Teacher 5	On the other hand, the teachers do not believe that they cannot integrate STEAM to their lessons.	Training needs
Teacher 6	My school first needs to see how STEM is implemented.	Training needs

Table A3. Theme 3. STEAM Education Training Experiences

Teachers	**STEAM training attended in the last year**	**Codes (MOOC, webinar, course, face-to-face seminar etc.)**
Teacher 1	I have been following STEAM courses very closely for 3 years. I received STEAM theoretical and practical training sessions from a University (2 months and 2 days).	Course
Teacher 1	I completed 4-week courses of "STEM is everywhere" from European Schoolnet.	MOOC
Teacher 1	Finally, I am attending the webinar of Yıldız Technical University, which started on 13.10. I am continuing the training course now. I have also participated in the presentations containing course contents/methods that can be added to STEAM.	Webinar
Teacher 2	59 hours of courses	Course
	10 hours of webinars by Scientix and Stem Alliance	Webinar
Teacher 3	Approximately 20 training sessions, seminars, courses etc. I participated in the activity.	Face-to-face seminar Course
Teacher 4	60 hours STEM Trainer Training/ 4 weeks Scientix course Stem is Everywhere/ 6 hours MEB (National Education Ministry courses) some online MOOCs	Face-to-face seminar Course MOOC
Teacher 5	More than 20 hours of STEAM training sessions	Face-to-face seminar/webinar
Teacher 6	I attended the STEAM training sessions twice.	Face-to-face seminar/webinar

Table A4. Theme 4. Required training contents and time for such in-service training

Teachers	Teachers opinion on what training will help them close the training gaps about STEAM	Code	Teachers beliefs on how much time they can allocate for online in-service trainings
Teacher 1	I may have problems in adapting the material usage and course outcomes. I also think there are parts I need to learn about how to conduct distance education.	Planning Distance Education	I can spare 3 weeks
Teacher 2	I need to improve my teaching skills in using technology in the field of robotics, coding, 3d printing, cloud computing, and Arduino.	Teaching methods (Robotics, Coding, 3D Printing, Cloud Computing)	2 hours per day
Teacher 3	I have to improve myself on the methods that will mobilize and motivate the class.	Teaching methods	I can spare 2-3 hours each week.
Teacher 4	As I am a teacher, I believe that I do not have any knowledge gap on how to implement and plan STEAM lessons. However, as I am an English teacher, some fields of science make the process difficult.	Planning	4 weeks / 2 hours a day
Teacher 5	I do not feel competent, especially in science and mathematics. Because of this, collaboration is very crucial. I always benefit from my colleagues' knowledge.	Planning (with focus on multidisciplinarity)	5-6 hours per week
Teacher 6	I have difficulty in the lesson plan phase.	Planning	2 weeks

Table A5. Required training type by participants

	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Face to face training	X	X	X		X	X
Online training	X			X	X	

Table A6. Teachers' top three priority topics for the 21st century skills

Ranking is noted according to teachers' order of choices, if available.

	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Critical thinking	X		X	3		X
Creative thinking	X	X		1	X	X
Collaborating				2		
Communicating						
Information literacy	X					
Media literacy						
Technology literacy		X				
Social skills			X		X	
Problem solving/ productivity	X	X			X	
Leadership						
Flexibility			X			
Initiative						X

Table A7. Theme 6. STEAM education learning and teaching methods known by teachers

	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Project-based learning (PBL)	A plan designed to be a project oriented, concrete or abstract product	PBL is the first step of STEAM education. They complete each other and Both PBL and STEAM help target learning and problem solving. Skills like collaboration, creativity, critical thinking, and problem solving are part of any STEAM PBL.	Providing consultancy during the performance of the task by creating a job description.	Well-known	Project-based learning in STEM education is an approach that meets the needs of students for business life, is useful in teaching different STEM subjects and meets learning outcomes by solving various problems.	To work as a team as a result of daily life problems. Creating products as a result of teamwork.
Inquiry-based learning	Questioning daily life, critical thinking, critical thinking, self-assessment-oriented approach.	Inquiry-based learning naturally fits with STEAM since it promotes critical thinking and innovation. Inquiry-based STEAM learning focuses on hands-on experiences and creative ways to solve problems.	Students reach the reasons of an invention or an applied method with questions, and technical and engineering skills are prioritized in this process.	Well-known	Inquiry-based learning includes a wide range of activities such as case studies, fieldwork, research or research projects.	Information is given first. Groups are then created. The daily life problem is determined. The outline is drawn. The cost is calculated. Evaluation work is done.
Use of STEAM to solve real-life problems	To reach solutions in different ways and approaches by going over the problems related to daily life. For example, by examining the question of how birds fly, the flight system of the aircraft can be examined.	To make Science, Math, Tech and Engineering more appealing for students, we should engage students in real world Stem problems. We should use 21st-century learning models (hands-on learning, collaboration, etc.).	Activities aimed at solving a problem that has become a problem in the student's immediate environment.	Well-known	With real word problems, students not only develop their academic skills but also their social skills. It is an important output that students produce solutions to the problems facing the world.	It should consist of real-life problems of children.
Assessment and Evaluation in STEAM education	It may differ depending on the study. Sometimes it can be performance-based, portfolio-based, sometimes learning rubrics, control charts, observation charts, proficiency tests, self-assessment or presentation.	We need rubrics in STEAM education for detailed evaluation. Rubrics help teachers to evaluate and give feedback for performance. What is more, they help students evaluate their own work and this gives students a sense of taking their own responsibility.	Evaluation of the process and product with alternative approaches	To some extent known	We cannot evaluate a method in which we expect creativity from students in a traditional way. I think it is the best way to prepare rubrics in accordance with the event. However, especially formative assessment should be our learning scenarios.	Absolutely. Our students should evaluate themselves.

Table A8. Training needs of teachers in STEAM fields

Training needs/ Teachers	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Robotics	X	X		X	X	X
Coding/ Computer programming		X				X
3D printing	X	X			X	X
Cloud computing		X			X	X
Energy storage	X	X	X			X
Autonomous vehicles	X				X	X
Fossil fuel extraction technologies	X					X
Advanced materials						X
Climate change	X					X
Mobile internet						X
Internet of thing					X	X
Artificial intelligence	X		X		X	X
New generation generic studies				X		X
Renewable energy	X					X
Plant growing and	X					X
Agriculture					X	X
Augmented reality	X					X
Recycling	X			X		X
Virtual reality	X					X
Space sciences	X	X	X	X		X
Drone design						

Table A9. Teachers' beliefs on technical features an online STEAM Training Simulation Software have

Features/ Teachers	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Online (Web-based and mobile)				X	X	
Being able to draw a specific path for each student's level of development	X		X			X
Using VR and AR					X	
Having a user-friendly interface	X				X	
Being suitable for group work						X
Being available for all branches of teachers	X	X				X
Serving as a tool for enhancing teaching and finding solutions to real-world problems		X				

Table A10. Resources and materials teachers need with the simulation software for STEAM Education

Materials/ Teachers	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Teacher 5	Teacher 6
Robots kits	X	X	X	X	X	X
Sensors, Electronic data collectors, recorders	X	X	X		X	X
Microcontroller platforms (Arduino etc.)	X	X	X			X
Laboratory materials for experiments	X	X	X		X	X
Coding tools (Computer etc.)	X	X	X	X		X