STEAM EDUCATION & THE GOLDEN RATIO

GUIDELINES FOR COOPERATION, COLLABORATION, AND PEER-LEARNING IN THE CLASSROOM

STEAM ing ahead

Fostering critical thinking, problem-solving and creativity

FEBRUARY 2024

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I. INTRODUCTION

The aim of the STEAMing Ahead project is to develop a comprehensive and detailed set of resources, strategies, and pedagogical methodologies for teaching STEAM using the Golden Ratio as a common reference to implement practical activities in the classroom that favour the achievement of key competences, mainly critical thinking, problem solving, teamwork, communication and negotiation skills, analytical skills, creativity, and intercultural skills.

We recognize that competencies can be applied in many different contexts and in a variety of combinations, both overlapping and interlocking. Aspects that are essential to one domain will also support competence in another.

A central goal of the project is to provide teaching staff with the tools they need to improve their capacity to implement innovative pedagogies that are constantly developing in the light of technical advances, changes in the demands of the wider economy, as well as shifts in perspective on what comprises a complete and rounded education.

The project has aimed at developing outcomes that support the acquisition of the key competencies outlined above, presenting them in a way that reflects their equal importance, while respecting the most direct connections to each of these competencies through the golden ratio: aspects that are essential to one domain will also support competencies in others.

In order to develop this common reference to carry out practical activities in the classroom using STEAM as a framework and the golden ratio as a guiding thread, four cycles have been implemented throughout the life of the project:

1. **Strategies, methodologies, and analysis:** its goal is to set out a methodological framework appropriate for curriculum development and the acquisition of educational resources to serve such a curriculum that can be applied in the three school Partners at a later stage.
2. **Curricula, resources, and assessments:** its goal is to develop a course curriculum that will apply strategies and methodologies from the first result, sourced online for use in the digital elements of the teaching, together with original audio-visual material created within the project.
3. **Courses, modules, and peer-learning activities:** its goal is to establish a holistic cooperation for the implementation of the curriculum created in the project, with enabling activities, the application of e-Learning material, at least two artistic or cultural events in each school and piloting of key parts of the curriculum created.
4. **Guidelines, publications, and recommendations:** its goal is to create a detailed report on the implementation of the curriculum in the classroom applying cooperation,

collaboration, and peer-learning, also including a set of best practice guidelines appropriate for teachers to think about their own implementation of STEAM.

Once the lessons plan was developed in the second cycle of the project, the third cycle focused on its practical implementation in the classroom simultaneously in three countries: Turkey, Portugal, and Italy.

The goal of this pilot phase in the third cycle, was to further the engagement of the schools in cooperation and network creation for their own development. At the heart of this pilot was the holistic cooperation between the three schools in the implementation of the curriculum created in the project, with enabling activities to support the schools in their cooperation from the other project partners.

The main objectives in the implementation of lesson plans were:

- To examine the suitability of the plans for the target student group.
- To discover the troubles and difficulties that teachers may experience while implementing a lesson suitable for the STEAM approach.
- To be able to determine students' opinions about the STEAM approach during and after the application process.
- To analyse the effect of the STEAM approach on students' scientific creativity, design thinking skills and problem-solving confidence, specifically during the application process.

Various data were collected before, during and after the implementation in order to determine the levels of achievement of the goals described above. In general, all set targets have been achieved. In addition, during the application process, important findings were obtained regarding both lesson plans and teachers' classroom guidance.

The most generally expected result before the application was the expectation of a positive impact on the scientific creativity, design thinking skills and problem-solving confidence of the students participating in the application. As a result of the application, it was determined that these skills and competencies increased in the majority of students, in line with expectations.

The following document reflects back on the work of the STEAMing Ahead project by presenting a detailed report of the pilot phase implementation, accompanied by a set of best practice guidelines appropriate for other teachers to think about their own implementation of STEAM in the classroom.

II. BACKGROUND

The STEAMing Ahead project guidelines result from analysing and reflecting on the STEAM practices carried in science, technology, engineering, mathematics, and arts out by teachers in the different primary schools involved in this project. They are therefore based on innovative effective and reflexive practices and reflect current educational research in this field.

The aim of this document is to reach, inspire, and support teachers, principals, and the school community by explaining guidelines resulting from good STEAM practices in the classroom, with a view to improving student learning and developing competencies inherent in the skills profile designed for students at the end of compulsory schooling.

What is STE(A)M education?

The integration of STEAM courses with non-STEM aspects, including Arts activities, has been developed as an effective pedagogical strategy known as STE(A)M teaching in contemporary schools. This innovative strategy aims to break down conventional academic boundaries and provide students with seamless, integrated learning, with the added value of artistic activities and productions.

According to Sanders (2009), STEAM teaching is a dynamic blend of STEM and non-STEM topics that establishes linkages between/among two or more STEM disciplines or STEM subjects and other academic fields. The essence is to weave a tapestry of knowledge that transcends specific topics, stimulates transdisciplinary thinking, and promotes a holistic view of the world.

One of the distinguishing characteristics of integrated STEM curriculum models is the emphasis on STEM content learning goals that are largely focused on one topic.

There are two fundamental differences in STEM education:

- Supports arts integration, linking an art form or scientific area to transdisciplinary.
- Promote problem- or project-based learning, as well as student research and experimentation.

In the STEAM approach, the integration of the arts can act as a source of motivation and innovation in primary school classrooms. Participation in arts-integrated learning improves children's physical, cognitive, social, and emotional skills. This involves building knowledge, developing, and training skills and attitudes, reading, oral and written communication and problem-solving skills, and critical thinking development and creativity.

Possible implications of the STEAM approach for young students and teachers:

- Improve academic success and cognitive functioning.
- Impacts on social and emotional learning.
- Mobilizing developmentally suitable approaches to improve instruction and results,
- Promoting successful arts integration.
- Leading to significant teachers' professional development.
- Raising professional satisfaction and allowing them to explore new ways of teaching and engaging students.

The STEAM approach is part of a socio-constructivist perspective on learning, presupposing a constructive rather than receptive process in which motivation and beliefs play an integral role in cognition and social interaction is fundamental to cognitive development, all in the context of knowledge, strategies, and expertise (Sandres, 2009).

III. PILOT PHASE

In the third cycle of the project, the lesson plans prepared in the second cycle were implemented. The application was carried out simultaneously in three different schools from three countries (Türkiye, Portugal, and Italy), from March to May 2023.

In total, 43 students and 14 teachers tested the lessons[1] plan developed by the STEAMing Ahead partnership. Each lesson plan was developed in accordance with the 7E model, and the suggested steps were explained in detail in a specific order, as linear application of the lesson plan was recommended.

The STEAM lesson plans effectively nurtured a learning environment that encouraged exploration, critical thinking, and practical application of knowledge, empowering students with essential skills for their academic and real-world pursuits during the period they were implemented.

This reflection demonstrates how the STEAM lesson plans provided a dynamic and engaging approach to learning, preparing students not just to absorb knowledge but also to apply it practically in real-world situations during the period they were implemented.

The ability to seamlessly integrate multiple disciplines (Science, Technology, Engineering, Arts, and Maths) into cohesive lesson plans was a standout feature. This interdisciplinary approach showcased the interconnectedness of subjects, offering a holistic understanding of real-world applications.

III.1. PREPARATORY STAGE

Prior to the application of the lessons plan, three teachers from the three participating schools travelled to Coimbra (Portugal) in November 2022to attend 3-day Learning, Teaching, Training Activity (LTTA) on Innovative Pedagogical Scenarios applying the Golden Ratio as a STEAM approach, to apply these practices in the classroom.

All teachers took part in this event hosted by the Escola Superior de Educação de Coimbra, during which they had the opportunity to delve deeper into the educational teaching practice of STEAM through a series of workshops:

- Workshop 1: STEAM in Visual Arts: creativity in children's development (Susana Ribeiro, ESEC/IPC).
- Workshop 2: Robotics for STEAM Education (Nuno Ferreira – ISEC /IPC Lab Robótica).

[1] STEAMing Ahead Project. *Themed STEAM Education: Lessons Plan. Moving the STEAM Approach Forward Through Teacher-Led Cooperation*, March 2023.

- Workshop 3: #AERSI robotics in the classroom (Francisca Pessoa e Rita Pereira – AE Rainha Santa Isabel – Coimbra).
- Workshop 4: Inquiry-Based STEM/STEAM Education (Dulce Vaz – ESEC /IPC).
- Workshop 5: Flipped Learning & Google Classroom (Marco Bento – ESEC/IPC).

Image 1. Teachers from Türkiye, Portugal, and Italy during the LTTA in Coimbra.

For the teachers participating in the pilot practices but that did not attend the LTTA in Coimbra, each country organized information meetings for its team and shared detailed information about the process. In addition, countries received answers to their questions and benefited from resource support through online meetings. University partners provided professional support to this process by sharing both theoretical and practical resources.

In addition, sharing the photo and video documents for each lesson plan used in the implementation process on the common STEAM libraries created in schools served as a guide for other teachers in practice schools and provided peer support between the implementation teams.

III.2. IMPLEMENTATION PROCESS

Once the implementation phase started, each school applied the lesson plans of two common themes (Saving water, War). Türkiye has additionally implemented lesson plans on the theme of radioactivity.

The timetable implemented in the each one of the schools was as follows:

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The application lasted 6 weeks and 11 students in the 4th grade participated in the application. The application was carried out outside school hours, in accordance with the interdisciplinary approach, with 6 teachers and one administrative staff.

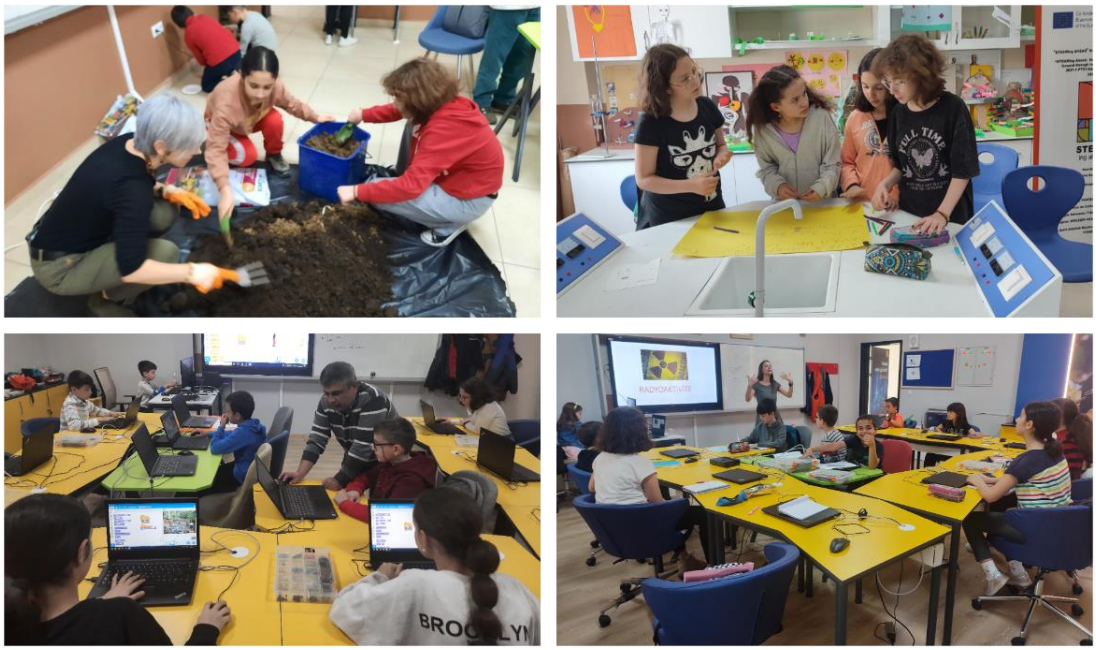

Image 2. Students of Sincan Şehit Abdullah Büyüksoy Bilim Ve Sanat Merkezi during the pilot phase.

Table 1. Timetable of the implementation of the pilot phase at Sincan Şehit Abdullah Büyüksoy Bilim Ve Sanat Merkezi.

LESSON PLAN	DATE	TEACHERS
Theme 1. Saving Water		
Rising Water Resistant Architecture	16.04.2023 9:30 - 12:20	Bilge Has Erdoğan Derya Ceylan
How can we make 'Urban Farming'?	16.04.2023 13:00 - 15:10	İlknur Efecan Ertaş Bilge Has Erdoğan
Importance of water for living things	30.04.2023 9:30 - 12:20	Bekir Sevinç Derya Ceylan
Technologies for Correct Use of Water in Agriculture	30.04.2023 13:00 -15:10	Selim Saraçoğlu Derya Ceylan
Water Awareness with Pantomime	07.05.2023 9:30 - 11:40	Derya Ceylan
Theme 2. War		

Psychological, Sociological and Economic Effects of War	07.05.2023 12:30 – 14:40	Elif Öznur Tokgöz Derya Ceylan
The Importance of Shelters in the War	20.05.2023 9:30 – 12:20	Bekir Sevinç Bilge Has Erdoğan
Creating a Public Announcement Advertisement About War	20.05.2023 13:00 – 15:10	Elif Öznur Tokgöz Bilge Has Erdoğan
Economic Effects of War	21.05.2023 9:30 – 11:40	Bilge Has Erdoğan Derya Ceylan
Theme 3. Radioactivity		
How Radioactive Are We Under the Effect?	21.05.2023 12:30 – 14:40	İlknur Efecan Ertaş Bilge Has Erdoğan
Usage Areas of Radioactive Substances	28.05.2023 to 4.06.2023 9:30 – 11:40	Elif Öznur Tokgöz Bilge Has Erdoğan
How Old Are Radioactive Materials?	28.05.2023 to 4.06.2023 12:30 – 14:40	Bilge Has Erdoğan Derya Ceylan

COLÉGIO SANTA EULÁLIA

The application lasted 10 days in 2 different weeks and 18 students in the 4th grade participated in the application. The application was carried in school hours, in an interdisciplinary approach, with the teacher of the class. In Portugal, 4th grade has only one teacher in classes.

Image 3. Students of Colégio Santa Eulália during the pilot phase.

Table 2. Timetable of the implementation of the pilot phase at Colégio Santa Eulália

LESSON PLAN	DATE	TEACHERS
Theme 1. Saving Water		
Rising Water Resistant Architecture	17.04.2023 9:00 - 12:20	Cátia Dias
How can we make 'Urban Farming'?	18.04.2023 9:00 - 12:20	Cátia Dias
Importance of water for living things	19.04.2023 9:00 - 12:20	Cátia Dias
Technologies for Correct Use of Water in Agriculture	20.04.2023 9:00 - 12:20	Cátia Dias
Water Awareness with Pantomime	21.04.2023 9:00 - 12:20	Cátia Dias
Theme 2. War		
Psychological, Sociological and Economic Effects of War	08.05.2023 9:00 - 12:30	Cátia Dias
The Importance of Shelters in the War	09.05.2023 9:00 - 12:30	Cátia Dias
Creating a Public Announcement Advertisement About War	10.05.2023 9:00 - 12:30	Cátia Dias
Economic Effects of War	11.05.2023 9:00 - 12:30	Cátia Dias

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The application lasted 6 weeks and 14 students in the 7th grade participated in the application. The application was carried out during school hours, in accordance with the interdisciplinary approach, with 7 teachers.

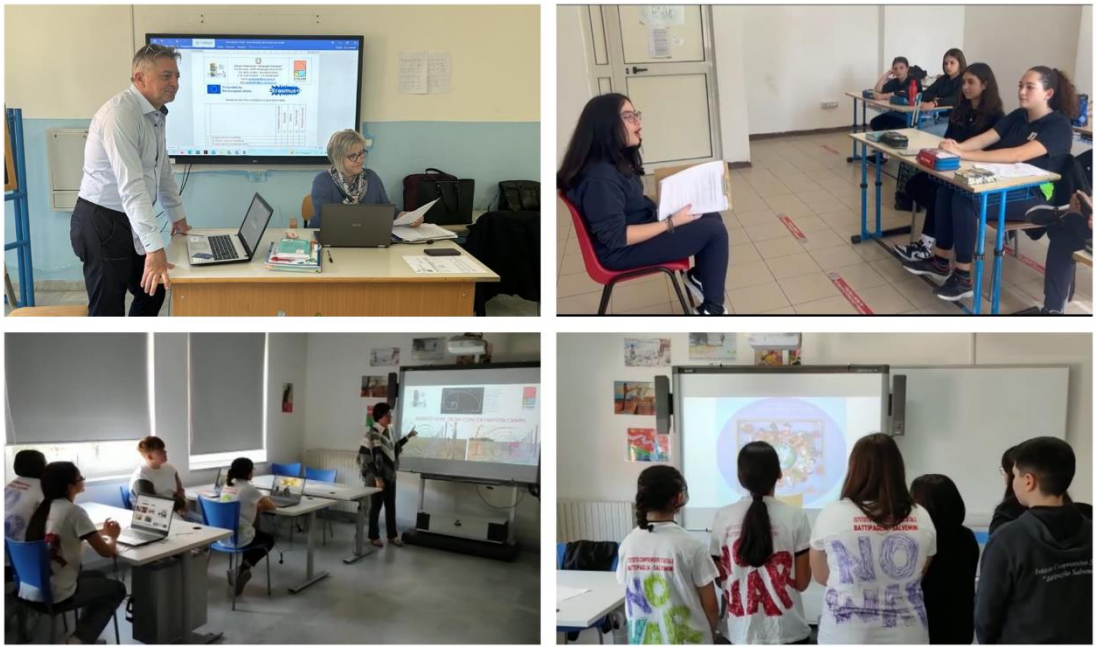

Image 3. Students of Istituto Comprensivo Battipaglia-Salvemini during the pilot phase.

Table 3. Timetable of the implementation of the pilot phase at Istituto Comprensivo Battipaglia-Salvemini.

LESSON PLAN	DATE	TEACHERS
Theme 1. Saving Water		
Rising Water Resistant Architecture	09.03.2023 16.03.2023	Susi Leo Mariantonietta Boffa Ornella Auletta Daniela Carlotti Franca Croce Giampaolo Naimoli Maria Spiezia
How can we make 'Urban Farming'?	21.03.2023	Susi Leo Mariantonietta Boffa Ornella Auletta Daniela Carlotti Franca Croce Giampaolo Naimoli Maria Spiezia
Importance of water for living things	30.03.2023	Susi Leo Mariantonietta Boffa Ornella Auletta Daniela Carlotti Franca Croce Giampaolo Naimoli Maria Spiezia

Theme 2. War		
Psychological, Sociological and Economic Effects of War	22.03.2023	Susi Leo Mariantonietta Boffa Ornella Auletta Daniela Carlotti Franca Croce Giampaolo Naimoli Maria Spiezia
The Importance of Shelters in the War	29.03.2023	Susi Leo Mariantonietta Boffa Ornella Auletta Daniela Carlotti Franca Croce Giampaolo Naimoli Maria Spiezia
Creating a Public Announcement Advertisement About War	04.04.2023	Susi Leo Mariantonietta Boffa Ornella Auletta Daniela Carlotti Franca Croce Giampaolo Naimoli Maria Spiezia

III.3. FEEDBACK MECHANISM, DATA COLLECTION AND EVALUATION

Following the implementation phase, the post-test involved applying scale tests to assess the scientific creativity, design thinking skills, and confidence in problem-solving to students. Additionally, interviews and focus groups were conducted using a structured form to gather feedback from both students and teachers regarding the application. This feedback will be detailed in furthers sections of this document.

Assessment within the STEAM context went beyond standardised tests. It included observation, portfolios, projects, and students' reflections on the learning process. It was essential to assess not only the final outcomes but also the creative process and acquired skills.

Three different measurement tools were used to test the success of the application. These; design thinking skills scale, problem solving confidence questionnaire and scientific creativity scale. Three scales were used as a pre-test before the application and as a post-test after the application. All documents can be consulted as annexes to this document.

Information regarding the analysis of the information collected from the measurement processes with the application carried out in each school is shared below.

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Design Thinking Skill Levels

Data regarding the design thinking skill levels measured before (pre-test) and after (post-test) the application can be seen in Table 4.

Table 4. Wilcoxon signed-rank difference test results regarding design thinking skill levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	2	4	8	-2.224	.03
Positive Ranks	9	6.44	58		
Ties	0				

If Table 4 is examined, there is a significant difference in the students' design thinking skills before and after the application. In other words, the design thinking skills of students studying based on the STEAM approach have increased.

Problem Solving Confidence Levels

Data on problem-solving confidence are shown in table 5. To determine the problem-solving confidence levels of the students participating in the application, the "Problem Solving Confidence Questionnaire" was applied before and after the application.

Table 5. Wilcoxon signed-rank difference test results regarding problem solving confidence levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	4	5.88	23.50	-.845	.40
Positive Ranks	7	6.07	42.50		
Ties	0				

According to Table 5, there was no significant change in the problem-solving confidence levels of the students who participated in the application. This may be due to the complex structure of problem-solving skills and the fact that they require long-term studies. In this study, the application process was limited to 6 weeks. This time may not have been enough for students' problem-solving confidence.

Scientific Creativity Levels

The effects of studying with the STEAM approach on students' scientific creativity levels were examined. In this regard, the "Scientific Creativity Test" was applied as a pre-test before the application and as a post-test after the application. The results of the measurements are shared in table 6.

Table 6. Wilcoxon signed-rank difference test results regarding scientific creativity levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	0	.00	.00	-2.94	.00
Positive Ranks	11	6.00	66.00		
Ties	0				

According to the results shared in Table 6, the scientific creativity levels of the students participating in the research differed significantly. In other words, the scientific creativity levels of the students who participated in the application increased. As included in the project goals, the STEAM program implemented with the integration of art into the STEM approach has made positive contributions to the creativity of the students.

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Design Thinking Skill Levels

Data regarding the design thinking skill levels measured before (pre-test) and after (post-test) the application can be seen in Table 7.

Table 7. Wilcoxon signed-rank difference test results regarding design thinking skill levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	0	0	0	-3.829	.00
Positive Ranks	18	9.50	171.00		
Ties	0				

With the measurements made before and after the application, it was concluded that the design thinking skill levels of the students changed significantly and positively. In other words, course applications with the STEAM approach increased students' design thinking skills.

Problem Solving Confidence Levels

Data on problem-solving confidence are shown in table 8. To determine the problem-solving confidence levels of the students participating in the application, the "Problem Solving Confidence Questionnaire" was applied before and after the application.

Table 8. Wilcoxon signed-rank difference test results regarding problem solving confidence levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Positive Ranks	14	9.04	126.50	-3.031	.00
Negative Ranks	2	4.75	9.50		
Ties	2				

With the measurements made before and after the application, it was concluded that the students' problem-solving confidence levels changed significantly and positively. In other words, course practices with the STEAM approach increased students' problem-solving confidence levels.

Scientific Creativity Levels

The effects of studying with the STEAM approach on students' scientific creativity levels were examined. In this regard, the "Scientific Creativity Test" was applied as a pre-test before the application and as a post-test after the application. The results of the measurements are shared in table 9.

Table 9. Wilcoxon signed-rank difference test results regarding scientific creativity levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	0	.00	.00	-2.94	.00
Positive Ranks	18	6.00	66.00		
Ties	0				

According to the results shared in Table 9, the scientific creativity levels of the students participating in the research differed significantly. As included in the project goals, the STEAM

program implemented with the integration of art into the STEM approach has made positive contributions to the creativity of the students

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Design Thinking Skill Levels

Data regarding the design thinking skill levels measured before (pre-test) and after (post-test) the application can be seen in Table 10.

Table 10. Wilcoxon signed-rank difference test results regarding design thinking skill levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	2	4	8	-2.224	.03
Positive Ranks	9	6.44	58		
Ties	0				

If Table 10 is examined, there is a significant difference in the students' design thinking skills before and after the application. In other words, the design thinking skills of students studying based on the STEAM approach have increased.

Problem Solving Confidence Levels

Data on problem-solving confidence are shown in table 11. To determine the problem-solving confidence levels of the students participating in the application, the "Problem Solving Confidence Questionnaire" was applied before and after the application.

Table 11. Wilcoxon signed-rank difference test results regarding problem solving confidence levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	1	2.00	2.00	-3.173	.00
Positive Ranks	13	7.92	103.00		
Ties	0				

According to the results shared in Table 11, problem-solving confidence levels of the students participating in the research differed significantly. In other words, problem-solving confidence levels of the students who participated in the application increased.

Scientific Creativity Levels

The effects of studying with the STEAM approach on students' scientific creativity levels were examined. In this regard, the "Scientific Creativity Test" was applied as a pre-test before the application and as a post-test after the application. The results of the measurements are shared in table 12.

Table 12. Wilcoxon signed-rank difference test results regarding scientific creativity levels before and after the application

Post-test – Pre-test	*n*	*Mean Ranks*	*Sum of Ranks*	*Z*	*p*
Negative Ranks	0	.00	.00		
Positive Ranks	14	6.00	84.00		
Ties	0				

According to the results shared in Table 12, the scientific creativity levels of the students participating in the research differed significantly. In other words, the scientific creativity levels of the students who participated in the application increased. As included in the project goals, the STEAM program implemented with the integration of art into the STEM approach has made positive contributions to the creativity of the students.

III.4. CHALLENGES, SOLUTIONS AND RECOMMENDATIONS FROM TEACHERS

At the end of the pilot implementation phase, four questions were asked to all participating teachers in the schools. The conclusions obtained from their feedback are detailed below.

- **Which activities worked better?**

The strength of the STEAM lesson plans lay in their interdisciplinary nature. They allowed students to see the connections between different fields of knowledge, demonstrating how science, technology, engineering, arts, and maths are intricately linked in solving real-world problems.

In this sense, hand-on activities in which students could physically participate were very successful, for example, those that made students use their creativity by designing and

conducting projects with everyday materials or experimenting with scientific and mathematical concepts and applying them in a practical way, as this engaged them and sparked their curiosity to explore further. This has also been demonstrated with activities that did not have a single correct answer, as they made them rationalize, reason, and make more entrepreneurial and creative applications.

On the other hand, activities that had a collaborative application and encouraged students to work as a team to solve a problem helped to foster critical thinking skills, as they tend to replicate real-life situations and scenarios where they must cooperate with each other.

Coding exercises or activities carried out with web 2.0 and 3D design tools compelled students to become more involved in the digital world and the opportunities it offers for them to grow and learn. This means that students learning level was increased because they could design and tackle a problem from a different angle.

The choice of materials and equipment was crucial for the success of the STEAM lesson plans. They were diverse, accessible, and safe, allowing students to experiment and apply concepts in a practical manner.

Some teachers have pointed out the usefulness of incorporating product-oriented activities, as it allows students to carry out a self-assessment during the development process that makes them recognize the knowledge they are acquiring, question their environment and collaborate with each other to tackle possible problems or deficiencies.

Lastly, although it is true that allowing students to use the classroom space freely was highly beneficial for them because it enriched their learning environment, it also posed a difficulty for teachers when trying to maintain the classroom discipline.

- **What are your observations about the participation of students and teachers?**

Managing the STEAM lesson plans required flexibility and skills to facilitate self-directed learning among students. It was important to set clear goals, allow independent exploration, and be available to guide and assist students as needed.

One thing that all and each of the teachers participating in the pilot phase have been very pleased with is the way in which the students have participated in the activities actively, willingly and without any absenteeism. This is even more valuable if we consider that the activities were carried out voluntarily and outside school hours.

Although it is true that both students and parents had a certain reticence and uncertainty during the first days because of facing something they did not know, during the following weeks their involvement and commitment increased significantly. The interactive, hands-on nature of STEAM activities captured interest and fostered a genuine passion for learning. This

makes it clear that the activities included in the lessons plan help students to maintain motivation and to participate actively in the educational dialogue.

Regarding the teachers, they were all very receptive and involved from the very beginning. Since they play a vital role in the implementation of the activities, their enthusiasm and commitment are transferred to their students. It is the teachers who have facilitated the learning through adaptability, encouragement of creativity and the development of a supportive leaning environment.

The flexibility of the STEAM approach was a strong point. Educators could adapt lesson plans to suit different learning styles and paces, encouraging independent exploration while providing guidance when needed.

By recognizing the students' individual needs and maintaining interest for the activities, teachers can create a positive rapport with students that enhances overall participation and enriches the STEAM learning experience.

- **What difficulties did you encounter?**

Regarding the difficulties encountered during the implementation process of the pilot phase, the three schools have reported the same or very similar ones.

The first one is time constraints, which in some activities meant that the time allotted was not enough to develop it in its entirety. If we also consider that this had to be harmonized with the daily classroom practice, it could sometimes be a challenge.

On the other hand, there was the challenge of effectively attending to students with very diverse needs. Occasionally, some behavioural problems may have arisen, but they were solved quickly and efficiently.

Some teachers also stated that when working in groups, there is a need for a working environment in which the groups do not influence each other, meaning that students perform better in larger classes.

Some of the other difficulties mentioned were limited resources (materials, technology...), inadequate teacher training and difficulties in assessing creative outcomes effectively. The organization of the space was pivotal for implementing the STEAM lesson plans. The classroom was adapted to accommodate various workstations, experimentation areas...

- **What advice would you give to other teachers who want to implement these activities?**

These are the main recommendations of the teachers who participated during the pilot phase:

- Extensive preparation and research may be required beforehand, so prior preparation is essential. Teachers must have the necessary theoretical and practical preliminary information, as well as the knowledge, skills, and materials of the methods and techniques to be used in the activities.
- Use available resources by making the most of existing materials, tools, and technology.
- In product-oriented activities, students' cognitive levels as well as their motor skill development levels should be taken into consideration.
- Activities should be organized and adapted according to the students' age, as well as to the number of students in the class and the educational level to which they belong within the school.
- Tailor to student's' interests. Incorporate STEAM activities that resonate with your students' interests. Sometimes a picture that attracts the attention of one group may not attract the attention of another group as much. In this case, further enrichment of the materials can make the application even more successful.
- Time adjustment is very important and shortcut options such as A and B should be made in every plan, as children may take more time that initially estimated when addressing difficult-to-answer questions. Also, lessons can also be supported with a virtual platform for retrospective access to all studies.
- Start Small and expand gradually: begin with manageable activities aligned with your curriculum.
- Encourage experimentation by embracing trial and error and fostering a culture of curiosity.
- Advocate for support: highlight the value of STEAM education and seek support from school administration if necessary.
- Celebrate achievements and recognize and celebrate student successes to foster motivation.
- Reflect and adapt by regularly evaluating the effectiveness of activities and adapting them, if necessary, based on feedback and in-class observations. Also, stay open to learning new techniques and tools through workshops and collaboration.

III.5. INPUT FROM STUDENTS

At the end of the pilot implementation phase, four questions were asked to all participating students in the schools. The conclusions obtained from their feedback are detailed below.

- **Do you think the training you attended was beneficial for you? If so, could you share what aspects?**

The feedback received from the students has been very positive. Not only have they enjoyed the variety of topics covered and activities undertaken, but they have also greatly appreciated the practical nature of the learning, especially in relation to the experiments and construction projects, as it has allowed them to see first-hand how the different subjects intertwine and work together to solve problems through a multi-dimensional approach, and it is important to note that one of the key elements highlighted by the students has to do with group work and collaborative dynamics.

Other elements that have stood out is how the arts have helped them to explore their creativity and generate new ideas, by, for example, realizing that creativity is not a skill just used for arts, but also for math or science.

We can affirm without a doubt, and this is what the students have expressed, that the activities have allowed them to improve their capacity for critical thinking, their abilities to carry out a research process, their efficiency in the use of digital and technological tools, their creativity, and their reasoning abilities. In fact, in some cases, they have even equated this process of learning with being a hero or a detective.

- **Do you think this education (STEAM) you have attended is different from the education you received at school? If your answer is yes/no, could you explain in what ways?**

Through the hands-on learning opportunities of the project, the students have felt that the classes were more of an opportunity to learn and satisfy their curiosity, rather than homework. At the same time, they feel more in control during their learning process, and this helps them to have a greater perspective and awareness of environmental and social issues.

On the other hand, it has also allowed them to understand in a practical way that in order to find solutions to complex problems, we often have to resort to the control of different subjects, always with a collaborative and multidisciplinary approach.

- **If you had a choice, would you want to replace the education you received at school with this education? Can you explain why?**

With respect to this question, the responses have been overwhelmingly in favour of the preference for STEAM education over what might be called "traditional education". By finding an active approach that puts them in the middle of the problem in order to find a solution, they feel more adventurous and are able to appreciate the interconnectivity of the world in order to have a more holistic conception of concepts, which they feel is not the case with the step-by-step approach where they are simply limited to listening.

For all these reasons, they emphasize that this type of learning is more compelling, engaging, and memorable, which leads them to a better understanding of complex concepts and to a greater retention of new knowledge.

- **Did you feel that there was more than one lesson in one application in the training you attended? For example, were you interested in both mathematics, informatics, and art in an activity?**

The students found it exciting to work on projects in which they could use their interests and skills in different disciplines, and they especially enjoyed those activities in which they could simultaneously apply mathematics, computer science and art. For example, to create computer art using mathematics, they coded programs to generate designs and explored the interconnection of these subjects. In other words, they had the opportunity to approach problems creatively in ways they had not done before.

Unlike traditional classroom dynamics in which the teaching content is predetermined, the pilot phase activities allowed them to appreciate the discovery of a stimulating new way of learning in which to explore the intersections between subjects for constant exploration and experimentation. These integrated, problem-based learning experiences allow them to apply their knowledge while continually seeking improvement.

IV. PEDAGOGICAL PRINCIPLES FOR A SUCCESSFUL IMPLEMENTATION

The use of STEAM can create a learning environment that encourages exploration, critical thinking, and practical application of knowledge. This helps students acquire essential skills for their academic and real-world success, based on the national curriculum and the competencies profile of the students. It can also guide teachers' pedagogical practices. After reflecting on its use, some guiding principles for educational practices have been highlighted by the teachers involved:

Collaboration learning: involves collaborative activities where students work together to explore and solve problems, fostering teamwork and communication skills. The interactive, hands-on nature of STEAM activities captures interest and fosters a genuine passion for learning.

Adaptability, Flexibility and Creativity: Educators must adapt lesson plans to suit different learning styles and paces, encouraging independent exploration while providing guidance when needed. Students integrate concepts from science, technology, engineering, and mathematics to create meaningful artwork, with an emphasis on outputs that have personal or aesthetic relevance.

Practical and experimental activities: STEAM lessons excel in promoting the practical application of knowledge and connecting learning to real-world applications and issues. Students were encouraged to apply theoretical concepts to real-world scenarios, fostering problem-solving skills and creativity through hands-on projects and experiments, making learning more relevant and meaningful.

Research and Inquiry-based learning: Students are engaged in open exploration and research in the contexts of science and arts, communicating about the procedures and results. Stimulated to use scientific and artistic approaches to ask questions, develop and experiment with meaning, and create and solve problems from real life.

Interdisciplinary Integration: The strength of the STEAM activities lies in their interdisciplinary nature. They allow students to see the connections between different fields of knowledge, demonstrating how science, technology, engineering, arts, and maths are intricately linked in solving real-world problems

Material and technology Integration: The adoption of materials and equipment is decisive for the success of the STEAM activities. They must be diverse, accessible, and safe, allowing students to experiment and practically apply concepts. Utilize technology to enhance learning experiences. Integrate tools such as computer software, simulations, and digital resources to facilitate exploration and experimentation.

Assessment for learning: Create a process for assessing not only knowledge but also different skills like problem-solving talents, creativity, and teamwork. Direct observation, presentations, projects, and portfolios are examples of a more comprehensive understanding of student progress, encompassing not just outcomes but also the learning process itself.

Flexible Learning Spaces: The classroom must be adapted to accommodate various workstations, experimentation areas, accessible materials, and room for student collaboration. Create flexible learning environments that support collaborative and hands-on activities. These spaces should be adaptable to accommodate different types of projects and activities.

Develop a growth mindset: one should focus on nurturing their ability to learn and improve. This can be achieved by embracing challenges, persisting through obstacles, and learning from constructive feedback. By cultivating a growth mindset, individuals can unlock their full potential and achieve their goals.

Community Engagement: Involve parents, community members, and local businesses in STEAM education. Establish constructive partnerships that provide students with exposure to real-world applications of STEAM concepts.

In conclusion, The STEAM dynamics are well-received among both educators and students. There is evident enthusiasm and notable engagement with this model, as it fostered creativity, critical thinking, and problem-solving practically and interactively.

Implementing the STEAM method requires a commitment to foster students' creativity, critical thinking, and teamwork while emphasizing the practical applications of their learnings. Developing and implementing a STEAM policy in basic education should involve a collaborative and strategic approach, including educators, administrators, parents, and the community. These activities can be carried out by a team of teachers, and there should be various moments of reflection in which students discuss and try to find solutions to the problems.

By promoting these activities, it's possible to experiment with new teaching approaches and improve effective learning and skills, impacting social and emotional learning, mobilizing developmentally suitable approaches to improve instruction and results, and promoting successful arts integration.

V. STEAM EDUCATION IN THE DEVELOPMENT OF PROFESSIONAL SOFT SKILLS

Everyday applications of STEAM range from professional workspaces to space agency mission control rooms, from factory assembly lines to mundane household tasks. Undoubtedly, students who receive a STEAM education are better prepared to cope with the demands of everyday life and find employment in a constantly changing and evolving, fully interconnected world where digitalization and creative thinking are traits that are increasingly in demand by companies.

As we have seen previously, the STEAM teaching and learning method is a global and creative approach that incorporates critical thinking into problem solving. It is no longer just scientific, mathematical, or technical. It also includes softer skills such as intuition, teamwork, and a socio-economic perspective.

While hard skills are job-related competencies and abilities that are necessary to complete work, soft skills are personal qualities and traits that impact how you work. Hard skills are often applicable to a certain career; soft skills are transferable to any type of job. Both are necessary for a successful career in any field[2].

The methods by which hard and soft skills are acquired and applied in the workplace are the main distinctions between them. Hard skills are frequently acquired through formal education or training. They include skills like operating a specific piece of equipment or performing CPR.

Soft skills, on the other hand, are more commonly regarded as interpersonal characteristics that enable you to communicate effectively with people and that you may have spent your entire life developing. While hard skills show that a candidate can do a job, soft skills are seen as giving a candidate the ability to succeed in that job.

These skills are essential for success in most jobs because they enable one to establish and maintain relationships, manage difficult circumstances, and meet goals, so soft skills can certainly make a person a long-term asset to employers.

While, for example, the importance of digital skills is generally recognized in the context of developing appropriate skill sets for employees, it is crucial to emphasize the value of human skills (soft skills) because robots will never be able to replace them. Furthermore, because these skills can impart flexibility and adaptability, which are competing qualities of the workforce of the future, the labour market recognizes and rewards them.

[2] Walden University. *What Is the Difference Between Hard Skills and Soft Skills?*

To meet the challenges of this new post COVID-19 era, universities and vocational education centres must anticipate and adapt to the changing educational needs of society as they move into a digital world. This is because students must become proficient in 21st-century workplace skills, or soft skills.

The recognition of soft skills' importance for the future facilitates a more profound comprehension of their necessity and provides impetus for actively pursuing their development. These skills are valuable because they can be applied to a variety of fields, allowing people to be flexible in the face of change and pursue lifelong learning, as workers can adapt to shifts in the labour market's demand.

So, it is no coincidence that the soft skills most in demand and valued today for career advancement are those developed and provided by STEAM education, as proven thought the pilot phase of the STEAMing Ahead project.

But which are they??

- ## Critical Thinking and Analysis

The future will only see a greater demand on our critical thinking skills because of our ongoing need to sift through enormous volumes of information, which isn't going to slow down. At its core, critical thinking is the ability to think introspectively and autonomously, as well as to understand the rational relationships between concepts and form an independent analysis of the facts, rather than simply absorbing information and listening to instructions.

Because synthesizing complex information and making unbiased, data-driven decisions requires analysis and being open to the possibility that ideas, arguments and conclusions do not fully capture the situation, critical thinkers are constantly trying to question ideas and assumptions, and they seek to identify, analyse, and solve problems systematically rather than by intuition or instinct.

This means that they can evaluate the strength of arguments and identify flaws in reasoning by considering multiple perspectives, which makes them more likely to pinpoint the short-term and long-term consequences of their decisions.

- ## Teamwork and collaboration

In today's world of work, with the emergence of remote and global teams, teamwork and collaboration are becoming increasingly crucial. The increasing prevalence of hybrid and remote working arrangements, which involve geographically dispersed team members and diverse teams consisting of office workers, contractors, and permanent team members, underscores the need for individuals who can effectively establish and nurture connections among team members and foster a shared sense of purpose.

Working towards shared goals with different personalities and having the ability to effectively exchange ideas, cooperate, assign tasks, and offer support when needed are necessary conditions for being an effective team member.

Collaboration improves relationships, productivity, and creativity in problem-solving, all of which have a positive effect on employee engagement, motivation, and satisfaction.

However, teamwork involves not only collaborating, but also respecting diverse perspective and utilizing the skills and strengths of each team member to achieve a common goal, requiring finesse, communication, and adaptability.

- ### Creative problem-solving

Problem-solving is a skill that transcends job descriptions. Finding someone with the ability to recognize a problem, come up with effective solutions, and carry out a plan of action is a difficult but necessary skill set.

Adding creativity to the process of problem-solving promotes the exploration of open-ended solutions and concentrates on the creation of innovative perspectives. Creative problem-solving facilitates the resolution of unconventional challenges and the overcoming of unanticipated hurdles, which can lead to innovative ideas that propel companies forward.

When an employee has strong creative problem-solving abilities, they are proactive in identifying the source of an issue and collaborate with others to explore various options before determining the best course of action. Soft skills related to problem-solving typically enable an employee to anticipate issues before they arise.

- ### Effective Communication

The foundation of all we do is communication, so many argue that this is the most import soft skill. Communication is the spark that enables individuals to form enduring relationships, collaborate, tackle challenges, and resolve problems. Having strong communication skills is beneficial in all facets of life, including both professional and personal life as well as everything in between.

But communication isn't just one skill; it's a combination of how you listen, speak, and write as well as your body language. Active listening, clear expression, and the capacity to communicate concepts and information succinctly are all components of effective communication.

- ### Adaptability and flexibility

While adaptability involves planning for the future and anticipating unforeseen events, flexibility is more immediate and involves accommodating others. In today's dynamic and

ever-changing business environment, both are valuable assets as they provide agility in the workplace, enable them to manage the ambiguity of the environment, and bring the ability to manage transitions and challenges by allowing people to stay ahead by adapting to change, learning new skills, and staying relevant. Adaptable employees help organizations recover quickly from setbacks and overcome unexpected challenges.

When assessing adaptability and flexibility, the most demanded qualities are those who allow workers to keep an open mind, being receptive to change, having a positive attitude and willingness to learn, having confidence to improvise when the situation requires it and adjust your style of working or method of approach to meet the needs of a situation or emergency.

VI. ANNEXES

DESİGN THINKING MINDSET SCALE[3]

Reference: Vignoli, M., Dosi, C., & Balboni, B. (2023). Design thinking mindset: scale development and validation. Studies in Higher Education, 48(6), 926-940.

#	QUESTION	1	2	3	4	5
1.	I feel comfortable with what is unknown					
2.	I like taking many chances also if it leads me to make mistakes					
3.	I see risks as opportunities to expand my project knowledge					
4.	During the design activity I dedicate a considerable amount of time to understand what users need					
5.	I can tune into how users feel rapidly and intuitively					
6.	I am comfortable to see problems from the users' point of view					
7.	I easily empathize with the concern(s) of other people					
8.	I am capable to recognize when there is the necessity to iterate one phase of the process					
9.	I can consider what I am doing from a broader perspective					
10.	I can understand which are the impacts on the external environment of the solution we are proposing					
11.	I am comfortable to develop new knowledge with other teammates					
12.	I am comfortable to work with people having diverse perspectives and abilities from mine					
13.	I like to spend time with people doing different work than mine					
14.	I am comfortable to see a problem like an opportunity to learn					
15.	I am comfortable to learn from experiences					
16.	I am comfortable to receive feedback and learn from them					
17.	I am comfortable to make prototypes to explore					
18.	I am comfortable transforming ideas into something tangible					
19.	I am comfortable transforming hypotheses into something to be tested					
20.	I look for something new in a new situation					
21.	I am curious about what I don't know					
22.	I generally seek as much information as I can in new situations					
23.	I am comfortable to build conclusions from incomplete information					
24.	I am comfortable to take decisions from a plausible hypothesis					
25.	I can foresee different outcomes of a project					

[3] 1- Strongly disagree, 2- Disagree, 3- neither agree nor disagree, 4- Agree, 5- Strongly agree.

26.	I think I can use my creativity to efficiently solve even complicated problems					
27.	I am comfortable to think something new, different from what already exists					
28.	I am sure I can deal with problems requiring creativity					
29.	I have the desire to change the status quo					
30.	I desire to create value with the final solution					
31.	I desire to have an impact on people around me					

PROBLEM SOLVİNG CONFİDENCE QUESTİONNAİRE[4]

Reference: Gok, T. (2012). Development of problem solving confidence questionnaire: Study of validation and reliability. Lat. Am. J. Phys. Educ. Vol, 6(1), 21.

#	QUESTION	1	2	3	4	5
1.	I like to solve to a problem					
2.	I enjoy solving a problem					
3.	I like to solve a numeric problem					
4.	I do my best to be successful in problem solving					
5.	I am interested in problem solving					
6.	I like to struggle with solving problem even if I cannot solve the problem					
7.	I like to solve problems from different sources					
8.	I struggle with a problem until I find the correct answer					
9.	I try too hard when I cannot solve the problem					
10.	I am sure that I can solve a problem					
11.	I am self-confident in problem solving					
12.	I am sure that I can solve even a difficult problem					
13.	I do my best for solving the problem no matter how difficult a problem					
14.	I lose track of time while solving a problem					
15.	I demoralize if I cannot solve a problem					
16.	I am stressed while solving a problem					
17.	I lose self-confidence if I cannot solve a problem					
18.	I am upset when I find incorrect answer of a problem					
19.	I am afraid of making numerical mistakes					
20.	Preconceptions prevent me from solving a problem					

[4] 1- Strongly disagree, 2- Disagree, 3- neither agree nor disagree, 4- Agree, 5- Strongly agree.

SCIENTIFIC CREATIVITY TEST

Reference: Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. International Journal of Science Education, 24(4), 389-403.

The test was designed for group administration. The time limit is 60 minutes. Requirements are the same as for other examinations: the examiner seeks to make the students feel at ease but also to work hard to complete the tasks. There is a general instruction printed at the top of the question paper: *"Today we would like you to demonstrate a very important ability – scientific creativity. You have 7 different tasks. Each task investigates different scientific skills, giving you the opportunity to excel at what you are best at! These tasks will enable you to use your creativity, explore new ideas and solve problems. Please try to complete all the tasks in one lesson (50 or 60 minutes). If you have questions about the tasks, please raise your hand and ask the examiner. Please write your school, year, class, name, sex and today's date on the answer sheet before you begin."*

ITEM	TASK
1	Please write down as many as possible scientific uses as you can for a piece of glass. For example, make a test tube.
2	If you can take a spaceship to travel in the outer space and go to a planet, what scientific questions do you want to research? Please list as many as you can. For example, are there any living things on the planet?
3	Please, think up as many possible improvements as you can to a regular bicycle, making it more interesting, more useful, and more beautiful. For example, make the tyres reflective, so they can be seen in the dark.
4	Suppose there was no gravity, describe what the world would be like? For example, human beings would be floating.
5	Please use as many possible methods as you can to divide a square into four equal pieces (same shape). Draw it on the answer sheet.
6	There are two kinds of napkins. How can you test which is better? Please write down as many possible methods as you can and the instruments, principles, and simple procedure.
7	Please design an apple picking machine. Draw a picture, point out the name and function of each part.

FOCUS GROUP INTERVIEW FORM FOR STUDENTS

Main questions	*Additional questions*	*Detailing questions*
1. Do you think the training you attended was beneficial for you? If so, could you share what aspects?	• Do you think it contributed positively to your creativity? • Do you feel a change in your critical thinking frequency? • Do you think that education affects your productivity? • Did the education you receive affect your school success? • Have you experienced a perceptible change in your level of knowledge? • Did it give you new perspectives?	• Can you explain? • Can you give an example?
2. Do you think this education (STEAM) you have attended is different from the education you received at school? If your answer is yes/no, could you explain in what ways?	• Did you have fun during the training? • Do you think that you can express yourself more clearly in this education? • Have you had the chance to catch any opportunity you could not find in the education you received at school?	• Can you explain? • Can you give an example?
3. If you had a choice, would you want to replace the education you received at school with this education? Can you explain why?	• In which aspects do you find education at school more effective? • In what ways did you find this training more effective?	• Can you explain? • Can you give an example?
4. Did you feel that there was more than one lesson in one application in the training you attended? For example, were you interested in both mathematics, informatics, and art in an activity?	• How did it make you feel to see different lessons in one activity? • Did teaching in this way have a positive or negative effect on your understanding? • If you have the choice, would you prefer to teach the lessons individually or to see them integrated in this way?	• Can you explain? • Can you give an example?

VII. REFERENCES

- Arduino Education. *How STEAM Education Develops Life Skills*.
- ARTS Education Partnership.
- B. Marr, *Future Skills: the 20 Skills and Competencies Everyone Needs to Succeed in a Digital World*, first ed., John Wiley & Sons, 2022.
- Corporate Finance Institute. *Communication Skills. Transferring information to produce a greater understanding*.
- COSpedia. *STEM vs Soft Skills – Which are More Important?*, 2 August 2023.
- Education Commission of the States.
- European Commission. *European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience*, 2020.
- Hydrogen Grand Prix Series. *What are 5 essential STEAM Education Skills?*
- K. Mullan, J. Wajcman, *Have mobile devices changed working patterns in the 21st century? A time-diary analysis of work extension in the UK*, Work. Employ. Soc. 33 (1) (2019) 3–20.
- M. Boyles. *What Is Creative Problem-Solving & Why Is It Important?*, 1 February 2022, Harvard Business Review.
- M. Danao & K. Main. *11 Essential Soft Skills In 2024*, April 20, 2023, Forbes.
- M. Poláková; J. Horváthová Suleimanová; P. Madzík; L. Copuš; I. Molnárová & J. Polednová. *Soft skills and their importance in the labour market under the conditions of Industry 5.0*, 27 July 2023.
- Sanders, M. E. (2009) *STEM, STEM education, STEMmania. The Technology Teacher*, 68(4). 20-26.
- School Specialty. *STEAM Skills in Everyday Life: Examples for the Classroom*, 23 January 2019.
- STEAMing Ahead Project. *Themed STEAM Education: Lessons Plan. Moving the STEAM Approach Forward Through Teacher-Led Cooperation*, March 2023.
- T. Roberts & J. Schnepp. *Building problem-solving through STEAM*. 2020, 79. 8-13.
- The University of Manchester. *Adaptability and flexibility*.
- University of Bradford. *Adaptability and flexibility*.
- Walden University. *What Is the Difference Between Hard Skills and Soft Skills?.*