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Full Papers

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Investigating the Impact of Indoor Plants on Indoor Air Quality through Computational Modeling

Abstract: Air is an essential life necessity to which people are exposed to every moment. Most of our day is spent in enclosed environments. The living environment directly or indirectly affects human health. Measures should be taken to improve air quality, especially in crowded places. The aim of the project is to examine various indoor plants using the developed air quality measurement device and promote the use of plant that have a positive effect on air quality in crowded environments. The developed prototype measures air quality in parts per million (PPM) against established standards. The device displays the values on the screen at specified times and provides a warning through 5 LEDs and a buzzer. The project is realized through a literature review, procurement and integration of the necessary materials, analysis of data collectedfrom the device, physical design of the project using three-dimensional modeling, conducting tests on different plants under the same ambient conditions and evaluating the data. In the research, the experimental method, which is of the quantitative research methods, is used to determine the effect of plants on air quality. Two groups are formed: the experimental group where air quality is measured while various indoor plants are placed, and the control group, where only air quality is measured. The species used in the study are Phalaenopsis Sp. (Orchid), Succulent-Cacti, Saint Pauliaionantha (African Violet) and Dracaena Marginata (Dragon Tree), which are the most purchased species in Zonguldak province. In the project, it was observed that the data differed from each other in the tests carried out with different plants in the same environment and conditions. As a result of the research, Phalaenopsis Sp. (Orchid), Succulent-Cacti were found to be the plants that improve air quality the most. African Violet and Dragon Tree were found to have less positive effect on air quality. The project development process was carried out in the following stages: "Planning," "Research," "Materials to be used,"

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"Testing," "Design," and "Integration and Implementation." With the developed prototype, accurate measurements were obtained, revealing the effect of plants on air quality."

Key words: *Air Quality, Indoor Plants, Programming, Weather.*

1. Introduction

According to the Regulation on Air Quality Assessment and Management (2014), air quality is determined according to the amount of sulfur dioxide, nitrogen dioxide, oxides of nitrogen (NOx), particulate matter, lead, benzene, carbon monoxide, ozone, arsenic, cadmium, nickel, benzo(a)pyrene. The National Air Quality Index (2022) data calculates an air quality index for 5 main pollutants adapted to the national legislation and limit values of the EPA Air Quality Index. These are particulate matter (PM10), carbon monoxide (CO), sulphur dioxide (SO2), nitrogen dioxide (NO2) and ozone (O3). Although outdoor air is affected by these pollutants, the situation is slightly different indoors. As communities have urbanized, people spend almost all of their days indoors, and poor indoor air quality has become an increasing health concern (Irga, Pettit, & Torpy, 2018). Especially in crowded areas without fresh air for a long time, the increase in CO2 value has a significant effect on people. When the amount of CO2 in indoor environments exceeds 1000 PPM, various health problems such as headache, fatigue and drowsiness occur (Şevik, Karakaş, & Karaca, 2013). When it exceeds 1500 PPM, throat irritation, runny nose and irritation, eye discharge and coughing occur (Ercan, 2012). In addition to these ailments, toxins can also enter the human body with polluted air and these toxins can cause many diseases such as diabetes, obesity, arthritis, hormone disorders, depression, infertility, allergies and cancer (Zencirkıran et al., 2018; Özçakır, 2022).
Plants used for aesthetic purposes in interior spaces undergo photosynthesis or respiration based on the light and temperature conditions of their environment. This process impacts the carbon dioxide levels in the air, directly affecting individuals in that environment. The project can be implemented in school, hospital, office, and home environments. In recent years, hospital settings have become increasingly crowded due to the influence of epidemics. By incorporating more indoor plants, polluted air can be purified.

In this study, researchers utilized an air quality measurement device that was designed and coded specifically for this purpose. The device measures air quality and displays the results on the screen. Additionally, LED lights were incorporated into the design to provide visual warnings that intensify as the air quality deteriorates. The Mq135 Gas Sensor was used as the air quality measurement sensor in the project. The study aims to investigate the impact of four indoor plants, which are the most favored by consumers in Zonguldak province, on air quality. These plants include Phalaenopsis Sp. (Orchid), preferred by 52.2% of respondents, Succulent-Cacti, preferred by 10.9%, Saint Paulia ionantha (African Violet), preferred by 8.7%, and Dracaena Marginata (Dragon Tree), preferred by 6.5% (Akça, 2021). By identifying plants that

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improve air quality, awareness can be raised regarding their usage in crowded spaces, particularly in hospital environments.

Indoor air quality has a direct impact on health. Monitoring air quality and activating ventilation systems or employing alternative natural methods can be particularly crucial in crowded spaces. The project aims to examine various indoor plants using the developed air quality measurement device, with the objective of encouraging the use of plants that have a positive effect on air quality in crowded environments, such as hospitals and schools.

1.1. Problem: Is it feasible to develop a device using a microcontroller board that can measure air quality at specific time intervals? Can indoor air quality be enhanced through the use of plants? Is the proposed system accessible, durable, sustainable, and cost-effective?

1.2. Hypothesis: The air quality in crowded indoor environments like hospitals and schools can be improved by incorporating a variety of indoor plants. This system has the potential to be cost-effective, environmentally friendly, and sustainable.

1.3. Importance of the project: Through a review of existing literature, it has been determined that there is currently no project that investigates the impact of indoor plants on air quality using a microcontroller-based device. This project analyzes the effect of the four most commonly purchased plants in our city on air quality. By utilizing a low-cost, versatile, and sustainable air quality measurement system, the project aims to bridge the gap in the literature by identifying plants that enhance air quality and suggesting their implementation in educational environments.

2. Method

2.1 Research Model

In the study, the researchers employed the experimental method, which is a quantitative research approach, to investigate the impact of plants on air quality. Two groups were established: an experimental group and a control group. The control group focused solely on measuring air quality, while the experimental group involved measuring air quality with the addition of various indoor plants.

For this particular study conducted in Zonguldak province, the researchers used Phalaenopsis Sp. (Orchid), Succulent-Cacti, Saint Paulia ionantha (African Violet), and Dracaena Marginata (Dragon Tree). These plant species were selected as they are the most commonly purchased plants in the region.

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Figure 1 *Indoor Plants Used in the Experiment*

2.2 Variables of the Study

Variables are indeed fundamental in experimental studies, particularly when investigating cause-and-effect relationships. In such studies, independent variables are manipulated in a controlled manner to examine their effects on dependent variables. In this study, the independent variables are the four plants (Phalaenopsis Sp. (Orchid), Succulent-Cacti, Saint Paulia ionantha (African Violet), and Dracaena Marginata (Dragon Tree)) that are the most preferred indoor plants in Zonguldak province. The dependent variable, on the other hand, is air quality. By analyzing the effects of the independent variables (plants) on the dependent variable (air quality), the researchers aim to determine the relationship between the two.

2.3 Environment of the Experiment

In the experimental setup, the Information Technologies Workshop is chosen as the environment. Within the workshop, two glass partitions are placed. Each glass partition has a volume of 0.3 m3 and dimensions of 38 cm x 82 cm x 1 m. These partitions are positioned in front of the window to ensure an adequate amount of natural light inside the space. Additionally, two devices are placed within the workshop, although the specific nature or purpose of these devices is not mentioned in the provided information.

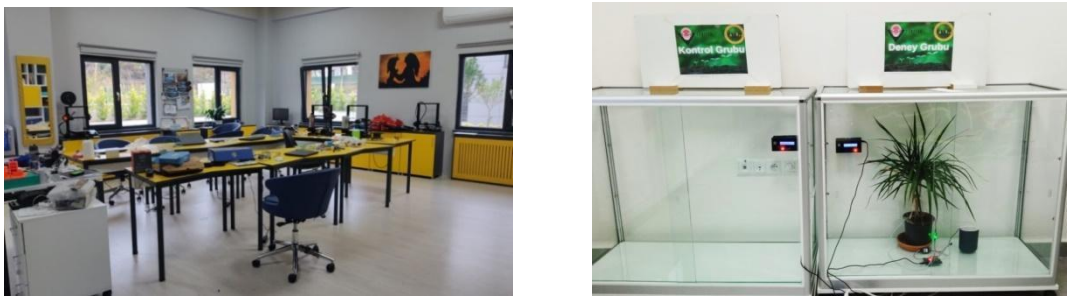

Figure 2 *Information Technologies and Software Workshop and Control-Experiment Setup*

2.4 Collection of Data

In the experimental group, the plants are replaced at 5-day intervals to ensure the freshness and consistent conditions of the plants throughout the study. All the results obtained from the air quality measurements are recorded for further analysis. To facilitate data management and analysis, the recorded data are saved in the Microsoft Office Excel program. This allows for efficient organization, manipulation, and statistical analysis of the collected data.

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3. Results

To address the first sub-problem of the research, a device was designed using a microcontroller board to measure air quality. The project development process was successfully carried out, resulting in a functional prototype. The device was designed using the Tinkercad program, and the box design was 3D printed using the Dremel 3D40 printer with PLA material.
The device incorporates five LEDs that illuminate based on the air quality readings, as well as a buzzer to provide a notification when the air quality becomes hazardous to health. For air quality measurement, an Arduino Uno card and an Mq135 air quality measurement sensor were utilized. The sensing part of the sensor was positioned outside the device by creating a properly sized hole on the box. An instant air quality display was integrated into the device using a screen.

Careful attention was given to securely placing the circuit inside the box using silicone adhesives. The device operates by lighting up one LED when the air quality is 500 PPM or below, two LEDs for air quality between 500 PPM and 750 PPM, three LEDs for air quality between 750 PPM and 1000 PPM, four LEDs for air quality between 1250 PPM and 1500 PPM, and all five LEDs when the air quality exceeds 1500 PPM. The buzzer is activated to provide a warning along with the illuminated LEDs in such cases.

Figure 3 *Prototype View*

For the second sub-problem of the research, the effect of Phalaenopsis Sp. (Orchid) on air quality was analyzed, and the findings are presented in Table 1.

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Table 1
Impact of Orchid on Air Quality

Day	Morning- PPM	Control PPM(S)	Afternoon-PPM	Control PPM(SC)
Day 1	30	70	32	71
Day 2	35	74	34	70
Day 3	42	70	40	68
Day 4	52	77	44	75
Day 5	30	65	36	70

As observed in Table 1, Orchid exhibited air quality improvement both in the morning and afternoon. The PPM values for the morning and afternoon were as follows: 30-32 on Day 1, 35-34 on Day 2, 42-40 on Day 3, 52-44 on Day 4, and 30-36 on Day 5.

Moving on to the second sub-problem of the research, the impact of succulents-cacti on air quality was investigated, and the findings are presented in Table 2.

Table 2
The Effect of Succulent-Cacti on Air Quality

Day	Morning-PPM	Control PPM(S)	Afternoon-PPM	Control PPM(SC)
Day 1	45	80	45	78
Day 2	43	74	42	70
Day 3	46	68	35	68
Day 4	50	78	46	75
Day 5	42	66	44	70

As indicated in Table 2, succulent-cacti demonstrated a positive effect on air quality during both the morning and afternoon periods. The recorded PPM values for the morning and afternoon were as follows: 45-45 on Day 1, 43-42 on Day 2, 56-35 on Day 3, 50-46 on Day 4, and 42-44 on Day 5.

Now, moving on to the examination of the effect of Saint Pauliaionantha (African Violet) on air quality, the findings are presented in Table 3.

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Table 3
The Effect of Saint Pauliaionantha (African Violet) on Air Quality

Day	Morning-PPM	Control PPM(S)	Afternoon-PPM	Control PPM(SC)
Day 1	54	70	56	71
Day 2	56	68	58	70
Day 3	68	70	60	68
Day 4	54	58	50	60
Day 5	55	65	60	74

As observed in Table 3, African Violet exhibited air quality improvement both in the morning and afternoon. The PPM values for the morning and afternoon were as follows: 54-56 on Day 1, 56-58 on Day 2, 68-60 on Day 3, 54-50 on Day 4, and 55-60 on Day 5.

Moving on to the examination of the effect of Dracaena Marginata (Dragon Tree) on air quality, the findings are presented in Table 4 for the second sub-problem of the research.

Table 4
Effects of Dracaena Marginata (Dragon Tree) on Air Quality

Day	Morning-PPM	Control PPM(S)	Afternoon-PPM	Control PPM(SC)
Day 1	64	70	56	71
Day 2	66	74	58	70
Day 3	68	70	60	68
Day 4	70	77	60	75
Day 5	62	65	58	70

As observed in Table 4, Dracaena Marginata (Dragon Tree) demonstrated a positive effect on air quality during both the morning and afternoon periods. The recorded PPM values for the morning and afternoon were as follows: 64-56 on Day 1, 66-58 on Day 2, 68-70 on Day 3, 70-60 on Day 4, and 62-58 on Day 5.

Regarding the third sub-problem of the research, which investigates the accessibility, durability, sustainability, and economy of the system, it can be concluded that the measurements were conducted efficiently and the device operated as expected. Therefore, the system can be considered easily accessible, durable, sustainable, and economical.

4. Conclusion and Discussion

In this study, a device capable of measuring air quality was developed using an Arduino Uno board, various sensors, and components. The effect of indoor plants on air quality was

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investigated using this device. The presence of plants in indoor environments was found to improve air quality, thereby positively impacting human health and enhancing safety.
The air quality sensitivity of the device was adjusted through programming, and the devices were successfully assembled and implemented. The prototype functioned effectively, providing the desired data for analysis.

Based on the research findings, it was observed that all four indoor plants used in the experiment contributed to improving air quality. However, the degree to which these plants improved air quality varied. Orchid was found to have the highest positive impact on air quality, while Dragon Tree exhibited the least improvement. Orchids and cacti, which are commonly preferred in office and indoor settings, were identified as the plant species with the most significant positive effect on air quality (Selim, Akgün, & Olgun, 2020; Akça, 2021). Although succulent-cacti did not improve air quality to the same extent as orchids, they still yielded better results compared to other plant species. Notably, these two species were found to enhance air quality primarily during the morning hours, suggesting a potential positive impact during nighttime as well. On the other hand, Dragon Tree showed minimal improvement in air quality during the morning hours, which could be attributed to increased CO2 levels resulting from nighttime respiration. This may lead to comparatively lower air quality during the day. African Violet was observed to have a lesser effect on air quality, possibly due to variations in volumetric size and leaf size compared to other plant species. Considering these factors, it can be inferred that African Violet has a comparatively lower impact on air quality.

Overall, the research highlights the positive influence of indoor plants on air quality, with Orchid and succulent-cacti demonstrating the greatest potential for improving indoor air quality in various settings.

The project's focus on creating an easily accessible and cost-effective prototype aligns well with its implementation in an educational environment. The design of the device allows for easy replication within the scope of an Information Technologies course. Additionally, it can be integrated with the achievements of the Science course, demonstrating compatibility with the Special Objectives of the Curriculum. This interdisciplinary application showcases a collaborative and project-based approach, making it a valuable addition to the education ecosystem.

The project was carried out by students from Bilsem (Science and Arts Center) Öyg1 (Development of Special Talents) group. These students utilized their knowledge from the robotic coding workshop at Bilsem (Science and Arts Center) to work on projects involving microcontroller boards. The students expressed their satisfaction with the project, highlighting the opportunity to take accurate measurements with the newly developed device, conduct examinations like scientists, set up an experimental environment for precise measurements, and monitor progress on a daily basis. Both students expressed their interest in participating in similar projects in the future. The examination focused on four of the most popular indoor plants in Zonguldak province. However, the sample can be expanded to include experiments with different indoor plants, allowing for further

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exploration and analysis.

Given the affordability and accessibility of the developed prototype, its usage in enclosed spaces can be expanded. Anyone can develop and utilize this device in school and home environments. By implementing it in educational settings, the device can raise awareness about air quality by providing real-time reports and serve as an educational tool due to its open-source code. It can be integrated into lessons related to plants, the environment, climate change, and health issues, offering valuable learning opportunities.

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STEAM Adventures in Early Childhood Illustrated Children's Books

Abstract: The 21st century demands individuals to possess problem-solving, critical thinking, scientific curiosity, self-renewal, and lifelong learning skills (Akgündüz et al., 2015). STEM education plays a crucial role in developing a qualified workforce (Bybee, 2013), and it has evolved into STEAM by incorporating art, design, entrepreneurship, and programming (Sağsöz, 2018). STEM education advocates an interdisciplinary approach to teaching science, technology, engineering, and mathematics. Over time, STEM has expanded to include art, design, entrepreneurship, and programming (Akgündüz et al., 2015). Children's books are valuable in aiding scientific concept comprehension and reducing anxiety. This study examines and analyzes six books by Feridun Oral, an acclaimed author and illustrator of children's books, from a STEAM perspective using a general framework model. The books analyzed target the 4-6 age group and have a significant number of print copies. Denise and Graff's classification is employed for the analysis. The findings of the study reveal that the most frequently mentioned STEAM dimension in the books is "creativity and imagination," followed by "inquiry," "solving social problems," and "innovation design process and products." Research supports the idea that providing high-quality illustrated storybooks during early childhood enhances children's STEAM skills (Tank et al., 2013; Ciecierski et al., 2016; Denise and Graff, 2016). To enrich children's experiences and provide them with diverse opportunities, it is suggested that book authors and illustrators prioritize design and production concepts. Additionally, teachers and parents should consider STEAM dimensions when selecting books.

Keywords: *Early Childhood Education, STEAM, Illustrated Books, Feridun Oral*

1. Introduction

The changes and developments in science and technology in the 21st century also have significant impacts on the economic, social, and political structures of countries, collectively referred to as the information age. To foster the development of nations, it is crucial to

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cultivate individuals who possess qualities such as problem-solving, critical thinking, scientific curiosity, self-renewal, and lifelong learning skills, which fall under the umbrella of 21st-century skills. Societies that integrate STEM education into their educational systems or update their education systems with STEM content hold a prominent position on the agendas of both developed and developing societies. Therefore, STEM education is believed to play a vital role in meeting the demand for a qualified workforce in the emerging economic order (Bybee, 2013).

STEM education promotes the teaching of science, technology, engineering, and mathematics in an interdisciplinary manner. Over time, STEM has expanded its scope to include fields such as art-design, entrepreneurship, and programming (Akgündüz et al., 2015). Georgette Yakman, highlighting the significance of the artistic perspective, states that the STEAM approach emphasizes art (Yakman, 2010; Gülhan and Şahin, 2018a). It can be argued that the STEAM approach, which primarily utilizes STEM for innovation purposes, aims to integrate artistic thinking skills into the innovation process (Watson & Watson, 2013).

Different approaches are observed in the analysis process of children's picture books (Nodelman, 1988; Sağsöz, 2018). In this study, the dimension of "presenting a different framework" was employed, distinct from these approaches.

When reviewing the relevant literature, it becomes evident that children's picture books that fictionalize mathematics, science, and engineering activities contribute to children's enhanced comprehension of scientific concepts (Gaston, 2018; Flevares & Schiff, 2014).

2. Methods

In this study, a total of six books written and illustrated by Oral, an accomplished author and illustrator of highly regarded children's books, both nationally and internationally, were selected as the sample. The analysis of these books was conducted from a STEAM perspective, using a general framework model. The study employed document analysis as one of the qualitative research methods.

The conceptual framework of the study was based on the sub-dimensions identified by Denise and Graff in their classification of children's picture books in 2016 within the scope of the STEAM approach. These sub-dimensions include "creativity and imagination," "innovation design process and products," "questioning," and "producing solutions to social problems."

The chosen books for examination were determined based on their popularity as best sellers and having the highest number of prints. All of the selected books were both written and illustrated by Oral.

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Table 1
Oral's Story Books

Books	First Publication Year	Number of Reprints
Kirpi ile Kestane	2009	12
Benekli Faremi Gördünüz mü?	2010	9
Kırmızı Kanatlı Baykuş	2012	10
Yağmurlu Bir Gün	2014	6
Farklı ama Aynı	2015	13
Bu Kış Kimse Üşümeyecek	2015	7

Table 1 shows the names, publication years and edition numbers of the books.

3. Results

The study employed a rigorous process for determining the themes within the STEAM dimensions. Each book was reviewed five times, and the author, drawing from relevant literature, completed the themes. Additionally, input was sought from two different experts to gather ideas and insights.

Upon examining the findings of the study, the most frequently observed STEAM dimension in the books was "creativity and imagination," followed by "questioning," "solution to social problems," and "innovation design process and products."

Here are some examples of expressions and themes within the respective dimensions:

Dimension: Creativity and Imagination

Expressions: liking, feeling happy, guessing, getting hungry, hearing the sound of music, being patient, quickly, hurrying, etc.

Dimension: Innovation Design Process and Products

Expressions: foraging for food, cutting branches, carrying in a saddlebag, drawing on the ground, cooking custard with spinach, etc.

Dimension: Solution to Social Problems

Expressions: encountering a problem, generating ideas, finding a solution, wondering, researching, presenting an idea, thinking for oneself, explaining in detail, etc.

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Dimension: Questioning

Expressions: research, experience, trying to understand, presenting ideas, thinking for oneself, noticing the difference, wondering, planning the future, making explanations, etc.

In some cases, expressions were found to be suitable for multiple themes, and they were included under both relevant themes. For example, the expression "generating ideas" was considered suitable for both the problem-solving and questioning themes.

The dimensions and their respective frequencies are presented in the table below:

Table 2
Oral's Books

STEAM Dimensions	***f***
Creativity and Imagination	187
Questioning	98
Solution to Social Problems	92
Innovation Design Process and Products	80

Please note that the table is incomplete, as the specific frequencies for each dimension are not provided in the provided information.

4. Discussion

STEAM education in early childhood plays a crucial role in shaping the future society. In order for countries to thrive in a sustainable and secure manner, it is essential to raise individuals who possess the qualities of problem-solving, scientific curiosity, self-renewal, critical thinking, and lifelong learning, which are recognized as 21st-century skills. Therefore, countries that incorporate a STEAM perspective into their education systems and prioritize the integration of 21st-century skills and their requirements in their educational policies will foster generations that are better prepared for the future.

When examining the relevant literature, it becomes evident that studies on children's illustrated books primarily focus on language development, early literacy, and academic progress. However, research also indicates that incorporating mathematics, science, and engineering concepts into children's illustrated books can enhance individuals' understanding of scientific principles.

There are studies that demonstrate the effectiveness of integrated picture book activities with STEAM dimensions in facilitating children's learning of science and math concepts (Gaston, 2018; Flevares & Schiff, 2014). Tank, Rynearson, and Moore (2018) utilized

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children's picture books in engineering design applications for kindergarten students, and the results indicated a significant increase in children's interest in engineering designs.

Children's picture books provide a valuable opportunity to integrate the concepts of science, technology, mathematics, and even art into early childhood classrooms and lessons. By incorporating STEAM elements into these books, educators can create engaging and interdisciplinary learning experiences for young learners.

5. Conclusion

To enhance children's life experiences and provide them with diverse opportunities, it is recommended that book writers and illustrators prioritize concepts related to design and production more frequently. Similarly, teachers and parents are encouraged to select books that align with STEAM dimensions. STEAM education plays a crucial role in fostering children's curiosity, creativity, and critical thinking skills, making it an important educational program.

Children's picture books serve as valuable educational resources frequently utilized by teachers in classrooms and by families at home. It is crucial to choose high-quality children's books that are suitable for children's developmental level, capture their attention, and offer valuable content.

By incorporating high-quality children's picture books from a STEAM perspective, children can be exposed to a broader range of STEAM dimensions, thereby promoting their engagement with and understanding of these concepts.

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The impact of STEAM on students' motivation in the foreign language classroom

Abstract: Motivation has long been considered as one of the fundamental factors in successful language learning. Gardner identifies it as a significant cause of variability in language success (Gardner, 1985). This study focuses on investigating the effect of applying an integrative STEAM approach in the French class on students' motivation. The sample for this study involved 12 middle school students studying French as a foreign language at the American School of Tangier, Morocco. The selected group underwent conventional instruction using textbooks, worksheets, and multimedia resources. Then, they were introduced to a STEAM-based unit for six weeks. To achieve the study goals, a modified motivational survey of 52 items adapted from Gardner's Attitude/Motivation Test Battery (AMTB) was used, in addition to conducting a questionnaire and focus group discussions to collect the students' perception and interpretation of their own learning experience before and after implementing the STEAM-based approach in the French class. The collected data was analyzed and interpreted using the qualitative method. The results of the analysis showed a significant increase in students' motivation in all aspects except for "Class Anxiety". The study recommended providing students with sufficient language scaffolding and more opportunities to learn content-related vocabulary in order to reduce their anxiety during speaking and writing activities.

Keywords: *STEAM education, French as a foreign language, inquiry, motivation.*

1. Introduction

Nowadays, societies around the world are gradually dependent on science and technology, to the extent that they have become an integral part of our lives. Therefore, a call-to-action has arisen for those who build in-school and out-of-school learning opportunities for young people

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to integrate interdisciplinary programs with a focus on STEM subjects (Science, Technology, Engineering, and Mathematics) in order to equip students with the skills and knowledge they'll need to be successful innovators in the future workforce. The origin of the STEM term was introduced in 1990 by the National Science Foundation (NSF) in the USA. It refers to a holistic approach that integrates Science, Technology, Engineering, and Math as access points to develop student inquiry, critical thinking, and collaboration skills. An emerging trend in STEM classrooms advocates the importance of integrating STEM and Arts into STEAM, with the "A" standing for Arts because it is believed that Arts add a helpful component (Sousa & Pilecki, 2018). However, few initiatives have explored the possibility of integrating STEAM into foreign language classrooms, even though language is part of Arts disciplines. In fact, language is not only a communication tool but also an important part of human life; it conveys ideas, reflections, and experiences. Additionally, the global economy is becoming increasingly international, so many jobs require knowledge of foreign languages and cultures, in addition to a deep knowledge of the STEM content. Therefore, we can emphasize its importance in STEAM education. Thus, adopting a cross-curricular approach can expand foreign language education from learning the language to learning through the language in order to prepare students to become global citizens capable not only of communicating in the target language but also actively participating in the global community, addressing global issues, and changing the world for the better. On the other hand, STEAM is considered one of the new methods that aim to boost students' motivation and engagement and provide meaningful learning experiences. In this context, this study aims to examine the impact of STEAM on students' motivation in the French class.

2. Methods

The study was conducted with a sample of 12 students, aged 12-14, who were enrolled in Grade 8 at the American school of Tangier. Out of the 12 students, nine (75%) were boys and three (25%) were girls. All of them were studying French as a foreign language. The sample was selected from the intermediate level classes at the middle school, as these students had been studying French for two years and had the ability to undertake cross-disciplinary projects in the target language.

The instruments used in this study were a foreign language questionnaire and a survey. The foreign language questionnaire aimed to collect general information about the participants, such as their age, gender, nationality, and linguistic background. It also gathered data about the students' motivation for learning foreign languages in general, through open-ended questions.

The data on students' motivation for learning French was obtained through two surveys administered to the total of 12 students, before and after the implementation of the STEAM-based instruction, in order to measure the possible change in the students' motivation. The survey utilized a five-point Likert-type scale ranging from "strongly disagree" to "strongly agree," with a neutral point "I don't know." The survey was adapted from Gardner's (2004)

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international version of the Attitude/Motivation Test Battery (AMTB) to assess the participants' attitudes and motivation.

3. Results

After the implementation of the STEAM instruction, a significant increase in the students' motivation and desire to learn French was observed.

Integrative motivation

The comparison between the results of the first and second surveys showed a higher level of integrative motivation in the second survey.

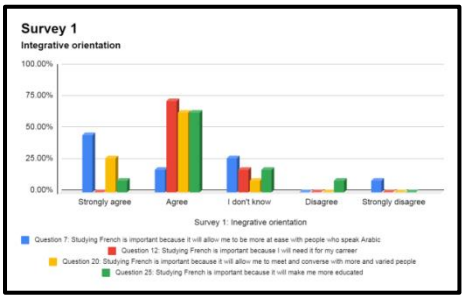

Figure 1

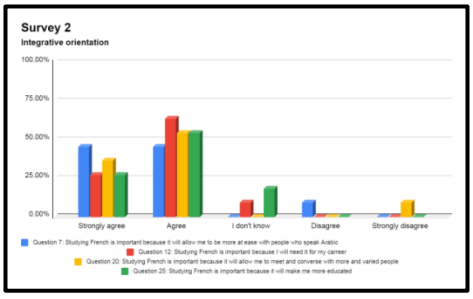

Figure 2

In the second survey, a higher percentage of students expressed certain beliefs and attitudes compared to the first survey:

- In the second survey, 91% of the students believed that learning French would allow them to be more at ease with people who speak French, compared to 63.7% in the first survey.

- Similarly, 91% of the students in the second survey believed that learning French is important because it would enable them to meet and converse with more diverse people, while this percentage was lower at 63.7% in the first survey.

- When it came to the desire for French native speaking friends, 72.7% of the students in the second survey expressed this wish, compared to only 27.3% in the first survey.

- Regarding the appreciation of French culture and people, 72.7% of the students in the second survey believed that studying French is important because it would enable them to better understand and appreciate the French way of life. In contrast, this percentage was lower at 45.5% in the first survey.

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- Additionally, 60% of the students in the second survey expressed appreciation for French speakers, recognizing their contributions to the world, whereas only 27.3% held this belief in the first survey.

- Finally, 54.5% of the students in the second survey stated that the more they know native French speakers, the more they like them, compared to 27.3% in the first survey.

These findings indicate a notable increase in positive beliefs and attitudes towards learning French, French culture, and interactions with French speakers after the implementation of the STEAM instruction.

Desire to learn French

In the second survey, there was an increase in the students' desire to learn French compared to the first survey. Specifically:

- In the second survey, 72.7% of the students expressed a strong desire to know all aspects of French, compared to 54.6% in the first survey.

- Similarly, 72.7% of the students in the second survey expressed a wish to be fluent in French, while this percentage was slightly lower at 63.7% in the first survey.

- Additionally, there was a slight decrease in the number of students who indicated that knowing French was not an important goal in their life, with 18.2% expressing this sentiment in the second survey, compared to 27.3% in the first survey.

These findings suggest an increase in the students' motivation and desire to learn French after the implementation of the STEAM instruction. The following quotes are examples of students' responses collected from the survey and focus group discussion:

"*I want to learn more about it, and be more fluent in it*" (AS).

"*It could be a goal that I need to achieve*" (AS).

"*I like learning French because it is a good language to learn, it helps you in life*" (S2).

"*I think French is a language that I need even though I don't think I'm going to use it in my job, and socially where I go*" (S7).

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Instrumental motivation

From this research, it is evident that the students are oriented towards both integrative and instrumental goals in their motivation to learn French. While there was a significant increase in integrative motivation, a slight improvement was also noticed in instrumental motivation.

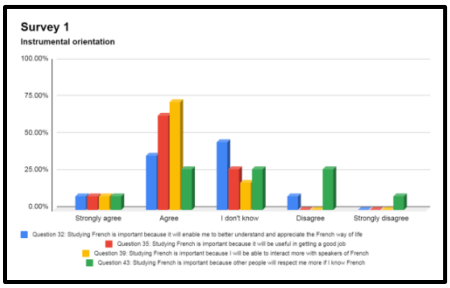

Figure 3

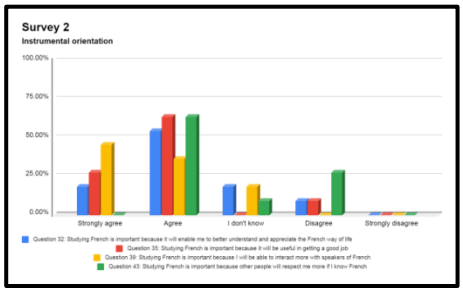

Figure 4

In the second survey, there was an increase in the students' belief in the importance of studying French for their future careers and job prospects. Specifically, 90.9% of the students expressed this belief, compared to 81.8% in the first survey. It is worth noting that there was a slight shift of 18.2% from agree to strongly agree in this aspect.

Moreover, in the second survey, 81.8% of the students (compared to 72.7% in the first survey) believed that studying French would make them more educated. This indicates an awareness among the students of the educational value associated with learning the language.

Additionally, a larger percentage of students recognized that studying French could help them gain respect from others. In the second survey, 63.6% of the students held this belief, whereas only 36.4% expressed the same belief in the first survey.

During the discussions, some students highlighted their instrumental orientation towards learning French. They mentioned practical reasons, such as the potential for better job opportunities, as a motivation for studying the language.

These findings suggest that while the primary focus of the research was on integrative motivation, the students also demonstrated an increased recognition of the instrumental benefits associated with learning French, particularly in terms of future careers, education, and gaining respect from others.

> "*I think it is a good language to learn, and it can help you develop.., or maybe you can travel to France and get a better job instead of Morocco*". (S1)

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Most of the students referred to foreign languages in general as an important skill for the future.

> "*I would love to learn as many languages as possible so I can get a good job in the future*". (AS)

> *"For me, I think learning foreign languages is good because I may use them when I grow up or when I am working in a company, I think I am going to use it*" (AS).

> "*Foreign languages can make everyone unique*" (AS).

French class anxiety

Among the various factors that can influence the language learning process, student anxiety is recognized as a significant aspect in the language classroom. It refers to a negative feeling of worry and nervousness that can hinder learning outcomes and decrease interest in engaging in learning activities (MacIntyre & Gardner, 1991). The findings of the present study revealed divergent responses from students in terms of anxiety and confidence.

On one hand, there was an increase in the level of class anxiety following the implementation of STEAM. In the second survey, 36.4% of the students expressed feeling embarrassed to volunteer answers in French class, compared to 18.2% in the first survey. Additionally, 63.6% of the students reported feeling anxious at times that other students might laugh at them, as opposed to 45.5% in the first survey.

On the other hand, a slight increase in students' confidence was observed. In the second survey, 54.6% of the students expressed feeling confident when asked to speak in the French class. Furthermore, the percentage of students who stated they never feel quite sure of themselves when speaking in French class decreased from 63.7% in the first survey to 54.6% in the second survey.

These findings indicate that while there was an increase in class anxiety among some students, there was also a slight improvement in their confidence levels. It is important for educators to be aware of these dynamics and implement strategies to address anxiety and enhance students' confidence in order to create a supportive and conducive learning environment.

4. Discussion

The overall findings of the study indicate that students' motivation levels improved following the implementation of STEAM instruction. This outcome supports the hypothesis that STEAM education can serve as a motivating approach and positively influence students' attitudes

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towards learning. However, the observed increase in students' level of class anxiety suggests that they encountered challenges related to vocabulary mastery and the use of the target language during STEAM-based instruction.

Given that the implementation of STEAM occurred within a limited timeframe of six weeks, it is recommended to allocate a longer duration to allow students to become accustomed to this method, which significantly differs from conventional approaches and requires high levels of engagement, participation, and production.

To address the students' recommendations for improvement, such as the need for more language scaffolding, it is essential for teachers to actively provide differentiated learning opportunities by:

1. Providing materials that are comprehensible and manageable for students.

2. Breaking down projects into smaller, more manageable tasks.

3. Facilitating collaborative scaffolding, allowing students to engage in dialogue and support one another.

By implementing these strategies, teachers can create a supportive learning environment that fosters language acquisition and reduces anxiety, thereby maximizing the benefits of STEAM instruction for students.

5. Conclusion

In conclusion, this study aimed to examine the impact of STEAM-based instruction on middle school students' motivation for learning French at the American School of Tangier, Morocco. The findings of the study indicate that the implementation of STEAM activities in the French class led to improvements in students' integrative and instrumental motivation. The students also demonstrated an enhanced desire and attitude towards learning French.

Although the study's sample size may not be extensive, the results provide valuable insights that can inform the development and implementation of relevant programs or activities to foster a more motivating learning environment. Students who possess adequate motivation are likely to become effective language learners and achieve higher levels of language proficiency.

These findings contribute to our understanding of the role of STEAM-based instruction in promoting students' motivation and language learning outcomes. Further research and implementation of STEAM approaches in language classrooms can provide additional evidence and contribute to the ongoing improvement of language education practices.

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Root Values and Behavior in Early Childhood: A STEM 5E Model Perspective Based on Teachers' Opinions

Abstract: This qualitative research study aimed to investigate teachers' views on how root values manifest in behavior when implementing the STEM 5E model in early childhood education. The research employed a case study design, utilizing purposive sampling. The participants included 10 preschool teachers voluntarily selected from public and private schools in Aydın province during the 2022-2023 academic year. Data were collected through semi-structured interviews based on expert opinions and were analyzed using content analysis, a qualitative data analysis method. The findings revealed that students demonstrated active engagement in internalizing various methods, approaches, and root values through the STEM 5E model. The teachers exhibited a good understanding of STEM 5E model applications and acknowledged its effectiveness as an instructional approach. The study concluded that students not only acquired fundamental skills and higher-order thinking abilities but also internalized and interpreted root values through experiential and hands-on activities, leading to enhanced active participation in the learning process. Based on the research findings, several suggestions were made. These included incorporating the STEM 5E Model in early childhood education to promote root value development, facilitating collaboration between diverse student groups and teachers to enhance the effectiveness of STEM practices, providing teacher training programs to support the integration of different approaches and methods for root value internalization, and organizing workshops to facilitate the implementation of these practices.

Keywords: *Root Values, Root, Teacher, Student, Behavior*

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1. Introduction

Early childhood is a crucial period for values education, as it lays the foundation for children's personal development and academic success. The acquisition of core values during this stage positively impacts students' lives and their ability to internalize these values from their interactions with teachers and peers (Kaplan, 2016, pp. 794-810). The Ministry of National Education emphasizes the teaching of ten basic values, including justice, friendship, honesty, and responsibility, to school-age children (MoNE, 2018).

In a previous study, we focused on the purpose of enhancing problem-solving skills through Philosophy for Children practices (Erkol et al., 2022). Building on that work, the current study aims to introduce values to students from early childhood, acknowledging that this period is characterized by children's inherent curiosity and receptiveness to stimuli. STEM education plays a significant role in developing thinking skills and establishing cause-effect relationships, promoting children's reasoning abilities and natural tendencies (Quigley & Herro, 2016; Bybee & Fuchs, 2006; Dejarnette, 2012).

Research consistently highlights the positive relationship between beliefs and attitudes towards program preparation and implementation (Lloyd, 2016). Children in early childhood demonstrate both concrete and abstract thinking, and teachers play a crucial role in fostering their development by integrating STEM and root values, generating interest, and facilitating active participation (Simoncini & Lasen, 2018).

This study focuses on examining the reflections of root values on behavior using the STEM 5E model in early childhood, specifically through the perspectives of teachers. By gaining insights from teachers, we aim to better understand how these values are acquired and integrated into students' lives during this critical stage.

2. Methods

The research utilized a phenomenology design to explore the teachers' perspectives on the reflections of behavior with the STEM 5E model in early childhood. This design allowed for a deeper understanding of the phenomenon and the identification of explanations, experiences, and examples that contribute to a better recognition and comprehension of the phenomenon (Creswell, 2013; Yıldırım & Şimşek, 2013).

The study group consisted of 5 volunteer preschool teachers and approximately 100 students, selected through criterion sampling, which involved reviewing predetermined situations and selecting participants who met specific criteria (Patton, 2018). Data collection involved semi-structured interviews with teachers who implemented the STEM 5E model in their classrooms to reveal the meanings and experiences associated with the phenomenon (Büyüköztürk, 2017).

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The interview questions aimed to gather teachers' opinions on various aspects, such as the common skills developed through the STEM 5E model and root values applications, specific examples of their applications that integrated the STEM 5E model and root values, the improvement of students' skills in early childhood in areas related to basic skills and high-level thinking, the role of the STEM 5E model in endearing, internalizing, and making sense of academic knowledge, the effectiveness of new methods and approaches in reflecting root values and enhancing high-level thinking skills in line with the demands of the 21st century, and the teachers' views on the reflections of students' behavior in relation to root values within the STEM 5E model.

To ensure the clarity of the interview questions, a pilot study was conducted with a group of teachers experienced in applying the 5E model in root values classes. The data collected from the interviews were thematically analyzed, and preliminary themes were identified by coding the changes in student skills as perceived by the teachers. The research design is a case study, focusing on five volunteer preschool teachers who employed the STEM 5E model to internalize root values as behaviors. The changes in students' behavior were evaluated from the teachers' perspectives based on data collected from approximately 20 students per teacher.

3. Results

The research findings highlight the positive impact of integrating root values with the STEM 5E model in early childhood education. The study gathered teachers' opinions on the benefits of incorporating root values in the 5E model, as well as the positive outcomes for both students and teachers. The research also included the experiences of teachers regarding the effects of this application on student behavior. Moreover, the study provided suggestions based on evaluation and analysis.

In this research, students engage in a questioning process stimulated by shared stories, followed by discussions and activities that promote philosophical thinking about the values embedded in the stories. By implementing an interdisciplinary approach within the 5E model and considering emerging concepts, the study anticipates the development of students' communication, cooperation, empathy, critical thinking, creativity, and listening skills. The application of root values with the STEM 5E model is found to be effective, supported by teacher confidence, students' experiential learning of concepts through activities, and the internalization of meaningful learning and behavior.

Existing literature, including studies by Baxter, Ruzicka, Baghetto, and Livebrooks (2014), Nadelson and Seifert (2013), and Nadelson et al. (2012), further supports the effectiveness of integrating root values with the STEM 5E model. It is evident that teachers with strong content and pedagogical knowledge have a greater impact on student learning, as

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demonstrated by previous research conducted by Darling-Hammond (2000), Darling-Hammond and Youngs (2002), Goldhaber (2002), Rice (2003), and Wayne and Youngs (2003).

These findings highlight the importance of incorporating root values into early childhood education through the STEM 5E model. Teachers' confidence, students' active engagement with concepts through hands-on activities, and the internalization of knowledge into meaningful behavior contribute to the success of this approach. The research emphasizes the significance of teacher expertise and pedagogical knowledge in facilitating effective learning experiences for students.

4. Discussion

The research findings suggest that the application of root values with the STEM 5E model in early childhood has a positive impact on students' behavior and learning. Teachers who possess strong content and pedagogical knowledge are more effective in facilitating student learning through these practices. The STEM 5E model enables the development of communication, cooperation, empathy, critical thinking, and creativity skills in students, while also promoting the internalization of root values such as respect, love, friendship, and responsibility. By engaging in activities that encourage problem-solving and technology skills, students become more confident in their abilities to solve daily life problems.

To further enhance the implementation of the STEM 5E model in early childhood, the following suggestions are provided:

1. Organize information seminars and workshops to raise awareness among educators about the importance of STEM in early childhood education.

2. Facilitate project-supported seminars to foster active participation and collaboration among various stakeholders involved in the education process, including schools, families, students, and teachers, to promote an integrated approach to root values and STEM practices.

3. Develop resources that incorporate the STEM 5E model for teaching root values, and encourage collaboration among diverse student groups and teachers to maximize the effectiveness of STEM applications.

4. Support teacher training programs that embrace different approaches and methods for internalizing core values.

5. Implement workshop applications that provide practical experiences and opportunities for teachers to further develop their skills and knowledge in integrating root values and STEM practices.

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By implementing these suggestions, educators and researchers can contribute to the effective implementation of the STEM 5E model in early childhood education and promote the development of students' skills and awareness in line with the demands of the 21st century.

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The Impact of STEAM Workshops on Teachers' Professional Development: A Comprehensive Analysis

Abstract: This study examines the impact of a three-day online workshop on Interdisciplinary Practices in STEAM and Innovation Development conducted for mathematics teachers in Türkiye. The workshop aimed to enhance teachers' knowledge and competencies in implementing the STEAM approach in their classrooms. A pre-test and post-test questionnaire, supplemented by open-ended questions, was administered to 184 workshop participants. The results indicate that the workshop effectively improved teachers' understanding of STEAM approach and their ability to develop meaningful and applicable STEAM experiences. These findings contribute to the development of training sessions, workshops, and capacity-building activities for teachers seeking to enhance their STEAM pedagogy.*

Keywords: *STEAM, professional development, teachers' training, STEAM workshops*

* Extended abstract is presented in the Appendix A.

1. Introduction

The integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) in education has gained recognition as an effective approach to fostering 21st-century skills, interdisciplinary learning, and digital competencies (Kim & Park, 2012; Rao et al., 2021).

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However, studies indicate that teachers often require professional development to effectively implement innovative approaches such as STEAM in their teaching practices (DeJarnette, 2018). This study aims to investigate the impact of a STEAM workshop on teachers' professional development in Türkiye.

Teachers are the key factors in facilitating learning environment to enhance students' 21st century skills and digital competencies through STEAM education. The research findings reveal that teachers need to improve their knowledge and skills to implement STEAM education (DeJarnette, 2018; Saralar-Aras, et al., 2020). To incorporate STEAM and robotics skills into their practice, teachers require effective STEAM trainings that encompass comprehensive STEAM knowledge, innovative learning approaches, and interdisciplinary teaching practices. With this aim, a three-day online workshop was conducted in June 2022 for teachers on STEAM and innovative approaches, in coordination with DGIET, MoNE Türkiye. To enhance teachers' STEAM competencies, the workshop covered contents aimed at improving teachers' educational approach in education transformation with a multidisciplinary approach, active learning practices in STEAM, creating authentic STEAM scenarios, and aligning STEAM scenarios with the national curricula. Teachers had the opportunity to work collaboratively and share their STEAM experiences with stakeholders.

The quantitative and qualitative findings from 184 teachers indicated the positive impact of the workshop on teachers' STEAM approach. Teachers have been found to improve their educational approaches in a way that implements innovative approaches, one of which is STEAM. Teachers have indicated a desire to increase their knowledge and competencies in creating STEAM scenarios and employing innovative teaching approaches. The workshops aimed to enhance teachers' professional development in STEAM are suggested based on the current study's findings. These workshops aim to increase not only teachers' knowledge and skills but also their motivation, self-efficacy, and communication among different stakeholders to foster experience sharing.

2. Methods

2.1 Participants

The research encompassed a cohort of 184 educators hailing from diverse academic backgrounds and spanning across various regions of Türkiye. These participants, hailing from different disciplines, collectively engaged in the "EDUSIMSTEAM Project Interdisciplinary Practices in STEAM and Innovation Development Workshop" held in 2022. Notably, the enrolled teachers represented an array of grade levels, adding depth and breadth to the study's participant profile.

To provide a comprehensive overview of the participants, Table 2.1 has been meticulously compiled to summarize the contextual details and background information

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pertaining to each individual. This inclusion serves to enhance the academic rigor of the study by facilitating a clearer understanding of the diverse teacher sample involved in the research process.

Table 2.1
Frequencies of participants' branches and grade levels

Teachers' branches		**Teachers' grade levels**	
Primary school	50	Primary (1-4)	59
Pre-school	11	Elementary (5-8)	70
Language	17	Secondary (9-12)	55
Science	32		
Mathematics	22		
Digital and technology	30		
Literacy & Social sciences & Arts	22		
Total	184		184

2.2 Data Collection

To assess the participants' knowledge and competencies pertaining to the STEAM approach, a pre- and post-test questionnaire was utilized. The questionnaire was developed by the Ministry of National Education (MoNE) and underwent validation by content experts to ensure its reliability and validity.

The questionnaire employed a Likert-type scale, whereby respondents were asked to rate items on a scale ranging from 1 (too low) to 5 (too high). In the pre-test questionnaire, participants responded to five Likert-type questions along with five open-ended questions. The post-test questionnaire, on the other hand, consisted of nine Likert-type questions and four open-ended questions. The inclusion of open-ended questions aimed to gather qualitative data that could be triangulated with the quantitative findings, enhancing the overall robustness of the study.

By employing this comprehensive questionnaire, the study sought to measure the participants' knowledge and competencies specifically related to the STEAM approach. The Likert-type questions provided quantitative data, allowing for the analysis of participants' perceptions and attitudes, while the open-ended questions allowed for more nuanced and in-depth qualitative insights.

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2.3 Data Analysis

The quantitative data obtained from the Likert-type questionnaire were subjected to descriptive statistical analysis. Measures such as mean and standard deviation were employed to summarize and describe the participants' responses. These statistical indicators provided insights into the central tendencies and variability of the participants' ratings on the Likert scale.

To ascertain the statistical significance of the differences between pre- and post-test scores, paired t-tests were conducted. This statistical analysis method allowed for the examination of whether any notable changes occurred in the participants' knowledge and competencies following the intervention. The paired t-tests enabled the identification of significant differences between the pre- and post-test scores, shedding light on the effectiveness of the STEAM approach.

Qualitative data gathered from the open-ended questions were analyzed utilizing thematic analysis, a widely-used method in qualitative research. Thematic analysis involved a systematic examination of the data to identify recurring themes, patterns, and meaningful categories. By carefully scrutinizing the participants' responses, researchers were able to extract and interpret the qualitative information provided, thereby gaining deeper insights into the participants' perceptions and experiences related to the STEAM approach.

This combined approach of quantitative analysis using descriptive statistics and paired t-tests, along with qualitative analysis through thematic analysis, allowed for a comprehensive exploration of the participants' knowledge, competencies, and perceptions regarding the STEAM approach, facilitating a more robust understanding of the study's findings.

3. Results

The analysis of the pre- and post-test questionnaire data yielded compelling results, highlighting a noteworthy improvement in teachers' knowledge and competencies pertaining to the STEAM approach subsequent to their participation in the workshop. The mean scores obtained from the post-test were consistently higher than those from the pre-test, signifying a positive impact on the participants.

Quantitatively, the results of the dependent sample t-test revealed a statistically significant mean difference between the pre-test ($M = 3.7$, $SD = 0.8$) and post-test ($M = 4.4$, $SD = 0.8$), $t(183) = 8.7$, $p < .001$. This indicates that the observed improvement in the participants' knowledge and competencies is not likely due to chance, but rather attributable to the intervention of attending the workshop. The effect size, as measured by Cohen's d, was found to be moderate with a value of 0.64. This suggests that the magnitude of the difference between the mean scores of the pre- and post-test is moderate, further substantiating the

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meaningful impact of the workshop on the participants' STEAM-related knowledge and competencies.

The qualitative analysis of the open-ended questions complemented the quantitative findings, providing additional insights into the participants' experiences and perceptions. These qualitative data reinforced and enriched the understanding of the participants' perspectives regarding the workshop and its impact on their teaching practices.

Table 3.1
The pre- and post-test questionnaire results

	M	SD	*t(183)*	*p*	Cohen's *d*
Pre-test	3.7	0.8	8.7	<.001	0.64
Post-test	4.4	0.8			

The qualitative findings from the open-ended questions strongly supported and reinforced the results obtained from the pre- and post-test questionnaires. The pre-test responses revealed that teachers recognized the need to enhance their knowledge and skills in STEAM, as indicated by the following excerpt: "The main scope of attending the workshop is to have more in-depth knowledge of STEAM, to share this knowledge with teachers around me, and to create useful projects in my own school for the next semester."

On the other hand, the post-test questionnaire responses indicated that teachers had indeed acquired a solid understanding of STEAM and had improved their teaching practices to incorporate STEAM and innovative approaches after attending the workshop. Participants acknowledged the effectiveness of the workshop in enhancing their knowledge and skills in STEAM, as exemplified by the excerpt: "I had the chance to gain STEAM knowledge and learn about the practices." Furthermore, teachers expressed the benefit of collaborating with different stakeholders, emphasizing the advantage of bringing together teachers from various disciplines to work interactively on STEAM studies: "One of the advantages of this workshop is to bring teachers from different disciplines together and make them work in interaction in STEAM studies."

These qualitative findings, in conjunction with the quantitative analysis, collectively indicated a positive impact of the workshop. The significant mean differences observed between the pre- and post-test results further affirmed the effectiveness of the workshop in enhancing teachers' knowledge and competencies related to the STEAM approach. The qualitative insights provided additional depth and context to the quantitative findings, reinforcing the overall conclusion that the workshop had a beneficial impact on the participating teachers' understanding and implementation of STEAM education and innovative teaching practices.

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In summary, both the quantitative and qualitative analyses concur in demonstrating a significant improvement in teachers' knowledge and competencies related to the STEAM approach following their participation in the workshop. The findings indicate a positive and meaningful impact of the workshop on the professional development of the participants, aligning with the goals of promoting interdisciplinary practices and fostering innovation in education.

4. Discussion

The findings of this study provide valuable insights into the impact of STEAM workshops on teachers' professional development. The significant improvement in teachers' knowledge and competencies related to the STEAM approach indicates that the workshop was successful in equipping them with the necessary tools and strategies to integrate STEAM in their classrooms. The workshop's focus on interdisciplinary practices and the development of STEAM learning scenarios played a crucial role in enhancing teachers' understanding and implementation of the STEAM approach.

One of the key benefits of the workshop was its ability to provide teachers with meaningful and applicable STEAM experiences. By engaging in hands-on activities, collaborative projects, and real-world problem-solving, teachers were able to firsthand experience the potential of the STEAM approach. This experiential learning approach not only deepened their understanding of STEAM principles but also provided them with the confidence to apply these principles in their teaching practices.

Moreover, the workshop's emphasis on innovation development was instrumental in fostering teachers' creativity and adaptability. STEAM education encourages students to think critically, explore multiple solutions, and embrace failure as a learning opportunity. By immersing teachers in an environment that promotes innovative thinking and problem-solving, the workshop helped them develop these skills themselves. This, in turn, would enable teachers to nurture these attributes in their students, preparing them for the challenges of the 21st century.

The qualitative data gathered through the open-ended questions provided additional depth and richness to the findings. Participants expressed their appreciation for the workshop's practicality and relevance to their teaching contexts. They highlighted the workshop's ability to bridge the gap between theory and practice, enabling them to envision how they could implement STEAM activities in their classrooms. Additionally, participants emphasized the importance of collaboration and networking opportunities during the workshop, as they were able to exchange ideas, share experiences, and learn from their peers. This aspect of professional learning communities further enhanced the effectiveness of the workshop.

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However, it is important to acknowledge certain limitations of this study. Firstly, the study focused exclusively on mathematics teachers, which may limit the generalizability of the findings to teachers of other subjects. Future research could explore the impact of STEAM workshops on teachers from different disciplines to gain a more comprehensive understanding. Secondly, the study only assessed immediate changes in teachers' knowledge and competencies. It would be beneficial to conduct follow-up studies to examine the long-term impact of the workshop on teachers' instructional practices and student outcomes.

5. Conclusion

In conclusion, this study highlights the positive impact of STEAM workshops on teachers' professional development, specifically focusing on mathematics teachers in Türkiye. The findings demonstrate that well-designed workshops can significantly enhance teachers' knowledge and competencies in implementing the STEAM approach. By providing meaningful and applicable STEAM experiences, the workshop successfully addressed the professional development needs of participating teachers.

The results indicate that the workshop's emphasis on interdisciplinary practices and the development of STEAM learning scenarios effectively supported teachers in improving their understanding and implementation of the STEAM approach. The experiential learning opportunities, collaboration and networking opportunities provided during the workshop further enhanced teachers' confidence and competence in integrating STEAM in their classrooms.

The findings of this study have important implications for the development of future training sessions, workshops, and capacity building activities aimed at improving teachers' STEAM pedagogy. Continued investment in teacher professional development is crucial to promote interdisciplinary approaches, foster 21st-century skills, and prepare students for the challenges of a rapidly changing world.

Overall, the findings of this study contribute to the growing body of research on the impact of STEAM workshops in teachers' professional development. Further research is encouraged to explore the long-term effects of such workshops and to investigate their impact on teachers from different disciplines and educational contexts. By continually enhancing teachers' competencies in the STEAM approach, we can ensure that students receive an education that prepares them to thrive in the increasingly complex and interconnected world of the 21st century.

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Appendix A.

Extended abstract: Contemporary educational needs require teachers to integrate different disciplines in an innovative learning environment. One way to facilitate learning environments to foster 21st-century skills, interdisciplinary approaches, and digital competencies is through the implementation of the STEAM approach in classrooms (Kim & Park, 2012; Rao et al., 2021). However, recent studies reveal that teachers need to improve their teaching competencies by implementing innovative approaches, including STEAM (DeJarnette, 2018). Therefore, teachers need professional development activities to empower their innovative teaching practices with the STEAM approach. With this aim, as part of the EDUSIMSTEAM project, a three-day online "EDUSIMSTEAM Project Interdisciplinary Practices in STEAM and Innovation Development Workshop" was conducted for teachers (teaching mathematics in different grade levels) in Türkiye in June 2022. The workshop participants consisted of 184 teachers from different regions of Türkiye. The data was gathered after the analysis of the pre- and post-test questionnaires developed by the MoNE and validated by content experts. Teachers were administered the questionnaire as a pre-test and post-test along with its open-ended questions. The pre- and post-tests were Likert-type questionnaires with item selections ranging between 1 (too low) and 5 (too high). The open-ended questions were for the triangulation of the data gained from the Likert-type questionnaires. The overall scope of the data collection was to gain participants' insight about the STEAM approach and the impact of the STEAM workshop. The workshop sessions, which were related to STEAM as an interdisciplinary approach and developing STEAM learning scenarios, were found to support participating teachers in improving their knowledge and competencies on the STEAM approach to provide teachers meaningful and applicable STEAM experiences. The current study is valuable to highlight the impact of STEAM workshops on the professional development of teachers.

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Findings of the study further enable the development of the training sessions, workshops, and capacity-building activities for teachers to improve their STEAM approach.

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Developing a Framework for Teacher Training in STEAM Education

Abstract: In this theoretical report, a framework for the integration of STEAM education into teacher training is offered. STEAM education can be seen as an interconnection of science, technology, engineering, arts, and mathematics disciplines (Saralar-Aras, 2021). The general description of study areas in STEAM challenges us to think outside the parameters of existing teaching programs and educational systems. There seems to be an international need for teachers to teach with technology considering the Covid-19 pandemic (Tiflis & Saralar-Aras, 2021, 2022). Technology alone is not enough for teachers to gain the necessary skills required for teaching. Therefore, a framework for teacher training in STEAM education with several parameters was designed from a STEAM approach perspective, called the EDUSIMSTEAM Teacher Training Framework. These parameters include STEAM competence (teachers' professional development [evidence], students' background knowledge, community of learning), learning scenarios (technology knowledge, technological pedagogical knowledge), computational thinking skills (SimuLearn), and career guidance (STEAM occupations). Implications for the curricula of mathematics, science, technology, arts, and engineering involve proposing a revision so that these parameters can be included and embedded. In the discussion at the International EDUSIMSTEAM Innovative Practices and Policy Making in STEAM Education Conference, where this work was presented, the framework was introduced to an international community, and feedback was gathered to improve the framework for adoption at the EU level.

Keywords: *STEAM Education, Teacher Needs, Teacher Training, Theoretical Framework.*

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1. Introduction

In recent years, the importance of integrating STEAM education into the curriculum has gained significant attention. The convergence of science, technology, engineering, arts, and mathematics has the potential to foster creativity, critical thinking, and problem-solving skills among students (Saralar-Aras, 2021). However, the effective implementation of STEAM education requires adequately trained teachers who can facilitate interdisciplinary learning experiences. This paper aims to present a framework for teacher training in STEAM education.

The COVID-19 pandemic has accelerated the need for educators to incorporate technology into their teaching practices. However, the mere use of technology is insufficient without a comprehensive understanding of how to leverage it for effective learning experiences (Tiflis & Saralar-Aras, 2021, 2022). Therefore, this study seeks to address the global need for teachers to develop the necessary skills and competencies to teach in a STEAM-focused environment.

The main objectives of this paper are:

- To propose the EDUSIMSTEAM Teacher Training Framework as a comprehensive approach to STEAM education in teacher training.
- To outline the parameters included in the framework, including STEAM competence, learning scenarios, computational thinking skills, and career guidance.
- To discuss the implications of the framework for the existing mathematics, science, technology, arts, and engineering curricula.
- To present the feedback gathered during the International EDUSIMSTEAM Innovative Practices and Policy Making in STEAM Education Conference.

This paper focuses on the development of the EDUSIMSTEAM Teacher Training Framework and its potential impact on teacher training programs. The implications for curriculum revision and the international reception of the framework are also discussed. The study does not delve into the specific implementation strategies of the framework in different educational contexts.

2. Method

A comprehensive review of existing literature on STEAM education, teacher training, and the integration of technology in education was conducted. This review informed the conceptualization and development of the EDUSIMSTEAM Teacher Training Framework.

Drawing upon the insights from the literature review, the EDUSIMSTEAM Teacher Training Framework was conceptualized. The framework encompasses key parameters that

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contribute to effective STEAM education, including STEAM competence, learning scenarios, computational thinking skills, and career guidance.

The framework was developed through iterative discussions and consultations with experts in STEAM education and teacher training. The goal was to ensure the inclusivity of relevant elements and the alignment with international standards and practices.

The EDUSIMSTEAM Teacher Training Framework was presented at the International EDUSIMSTEAM Innovative Practices and Policy Making in STEAM Education Conference. Feedback was gathered from a diverse group of international participants, including educators, researchers, and policymakers. The feedback received played a crucial role in refining and improving the framework.

3. Results

3.1 Overview of the EDUSIMSTEAM Teacher Training Framework

The EDUSIMSTEAM Teacher Training Framework is a comprehensive approach that addresses the specific needs of teachers in STEAM education. It consists of four parameters: STEAM competence, learning scenarios, computational thinking skills, and career guidance. Each parameter is essential for equipping teachers with the necessary knowledge and skills to facilitate effective STEAM learning experiences.

3.2 Description of Parameters

- ***STEAM Competence***

The STEAM competence parameter focuses on the professional development of teachers and the development of students' background knowledge. It highlights the importance of creating a community of learning where educators can collaborate and share best practices.

- ***Learning Scenarios***

The learning scenarios parameter emphasizes the integration of technology knowledge and technological pedagogical knowledge in the design of learning experiences. It encourages teachers to create engaging and interactive environments that foster creativity, problem-solving, and interdisciplinary connections.

- ***Computational Thinking Skills***

Computational thinking skills are crucial for students to thrive in a technology-driven world. This parameter introduces the concept of SimuLearn, which integrates computational thinking into STEAM education through simulations and modelling activities.

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- ***Career Guidance***

The career guidance parameter highlights the importance of exposing students to various STEAM occupations and providing them with opportunities to explore potential career paths. It aims to inspire and motivate students to pursue STEAM-related fields.

4. Discussion

The discussion section of this paper aims to delve into the implications and potential impact of the EDUSIMSTEAM Teacher Training Framework for STEAM education and teacher training. It explores the integration of the framework into existing mathematics, science, technology, arts and engineering curricula, highlighting the need for a more interdisciplinary and integrated approach. Additionally, this section examines the challenges and potential solutions associated with implementing the framework, considering factors such as resource constraints, resistance to change, and varying levels of technological infrastructure. Furthermore, it presents the feedback received during the International EDUSIMSTEAM Innovative Practices and Policy Making in STEAM Education Conference, discussing the recommendations and insights shared by an international community of educators, researchers, and policymakers. By addressing these key aspects, the discussion provides a comprehensive analysis of the framework's potential to enhance teacher training and foster effective STEAM education practices.

4.1 Implications for Mathematics, Science, Technology, Arts and Engineering Curricula

The EDUSIMSTEAM Teacher Training Framework has significant implications for the revision of existing curricula in mathematics, science, technology, arts, and engineering. It calls for a more integrated and interdisciplinary approach that incorporates elements of STEAM education into each discipline.

4.2 Integration of the Framework into Teacher Training Programs

To effectively implement the EDUSIMSTEAM Teacher Training Framework, it is essential to integrate its parameters into teacher training programs. This integration can be achieved through professional development initiatives, curriculum revisions, and the establishment of supportive learning communities.

4.3 International Feedback and Recommendations

During the International EDUSIMSTEAM Conference, the EDUSIMSTEAM Teacher Training Framework received valuable feedback from a diverse group of international stakeholders. The feedback highlighted the need for adaptability to local contexts, the importance of ongoing support for teachers, and the integration of inclusive practices.

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5. Conclusion

In conclusion, this paper has presented the EDUSIMSTEAM Teacher Training Framework as a comprehensive approach to integrate STEAM education within teacher training programs. The framework addresses the pressing need for teachers to adapt their pedagogical practices in response to the challenges posed by the COVID-19 pandemic and the increasing demand for technology-driven learning environments. By incorporating parameters such as STEAM competence, learning scenarios, computational thinking skills, and career guidance, the framework equips educators with the necessary knowledge and skills to facilitate engaging and interdisciplinary STEAM learning experiences. Moreover, the implications of the framework for the existing mathematics, science, technology, arts, and engineering curricula have been discussed, emphasizing the importance of revising curricula to embed STEAM principles and practices. Additionally, the feedback received during the International EDUSIMSTEAM Innovative Practices and Policy Making in STEAM Education Conference has provided valuable insights and recommendations to improve and refine the framework. Moving forward, it is crucial to continue adapting the framework to local contexts and conducting further research to assess its impact on teacher training and student outcomes. The EDUSIMSTEAM Teacher Training Framework holds immense potential to shape the future of STEAM education, nurturing the skills and competencies needed for the next generation to thrive in an increasingly complex and interconnected world.

5.1 Summary of Findings

The EDUSIMSTEAM Teacher Training Framework provides a comprehensive approach to STEAM education within teacher training programs. Its parameters, including STEAM competence, learning scenarios, computational thinking skills, and career guidance, aim to equip teachers with the necessary skills and knowledge to effectively implement STEAM education.

5.2 Significance of the EDUSIMSTEAM Teacher Training Framework

The framework addresses the global need for teacher training in STEAM education, particularly in response to the challenges posed by the COVID-19 pandemic. It emphasizes the integration of technology, interdisciplinary learning, and career guidance to foster creativity, critical thinking, and problem-solving skills among students.

5.3 Future Directions and Recommendations

Moving forward, it is essential to continue refining and adapting the EDUSIMSTEAM Teacher Training Framework to suit local contexts and evolving educational needs. Further research is needed to assess the framework's impact on teacher training and student outcomes, as well as to explore effective implementation strategies.

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Solving Real-Life Problems through Computational Thinking: A STEAM Approach

Abstract: This paper presents a study conducted in the Republic of Türkiye, focusing on the use of computational thinking in solving real-life problems through a STEAM (science, technology, engineering, arts, and mathematics) approach. The research aimed to develop teachers' awareness and skills in implementing STEAM education by conducting four-day workshops, where mathematics teachers collaborated to create STEAM projects. The paper provides an overview of the workshop methodology, presents the thematic analysis of the projects, and discusses the teachers' motivations and objectives. The results highlight the teachers' focus on topics directly relevant to their daily lives and their intention to apply for projects to solve these problems in reality. The paper concludes by emphasizing the significance of raising awareness about real-life problems and their potential solutions through STEAM education.*

Keywords: *Mathematics teachers, Mathematics Mobilization, Learning Scenarios, STEAM workshops.*

***** *Extended abstract is presented as Appendix A.*

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1. Introduction

The integration of computational thinking into STEAM (science, technology, engineering, arts, and mathematics) education has gained significant popularity as a means to foster the development of 21st-century skills, including creativity, collaboration, communication, and critical thinking. Educators increasingly recognize the value of enabling students to work in groups and apply computational thinking strategies to solve real-life problems within a STEAM framework (Ministry of National Education [MoNE], 2016; Saralar-Aras & Esen, 2021). STEAM education emphasizes the integration of various disciplines, blurring the traditional boundaries between science, technology, engineering, arts, and mathematics.

This study aims to explore the potential of computational thinking in addressing real-life problems through STEAM education. By offering a four-day workshop program, our objective was to enhance teachers' understanding and skills in implementing STEAM projects. We sought to cultivate a generation of students with a passion for invention, a curious mind-set, and the ability to make new discoveries to tackle real-life challenges.

The primary objectives of this study were to assess the effectiveness of the workshop program in raising awareness of STEAM education, facilitating the creation of STEAM learning scenarios, and developing STEAM projects. Additionally, the study aimed to examine the real-life problems selected by teachers, the objectives they derived from the STEAM disciplines, and their intentions to pursue projects that could address these problems in real-world contexts.

Understanding the factors that influence teachers' selection of real-life problems and their integration of computational thinking in STEAM projects holds immense significance for the advancement of STEAM education (Harris & De Bruin, 2018; Park et al., 2016). By analysing the outcomes of the workshops and the teachers' intentions to apply for projects, we can gain valuable insights into the potential impact of STEAM education in addressing real-life challenges. This research contributes to the broader understanding of how computational thinking, within the context of STEAM, can empower students to become proficient problem-solvers and innovators in the 21st century.

2. Method

This section outlines the methodology employed in this study to investigate the integration of computational thinking in solving real-life problems through a STEAM approach. We conducted a series of workshops in the Republic of Türkiye, as part of Mathematics Mobilization (MoNE, 2022a, 2022b), involving mathematics teachers who were interested in implementing STEAM projects. The workshops provided a structured four-day program aimed at raising awareness of STEAM education, creating STEAM learning scenarios, and developing STEAM projects. A total of 12 workshops were conducted, with each workshop

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accommodating 60 to 100 mathematics teachers. Participants were divided into small groups of 6-7 teachers, fostering collaboration and teamwork. Throughout the workshops, teachers engaged in hands-on activities, discussions, and presentations to enhance their understanding and application of computational thinking within the context of STEAM projects. The final day of the workshop was dedicated to group presentations, where teachers showcased their STEAM projects and the learning scenarios they had developed. This section details the workshop program, the participants, and the data collection methods utilized for analysing the teachers' selection of real-life problems and their integration of computational thinking elements.

2.1 Workshop Design

The workshops were designed as a four-day program, following the Scientix project teaching and learning methodology. The participants included mathematics teachers from different educational levels. The workshops aimed to raise awareness of STEAM education, facilitate the creation of STEAM learning scenarios, and guide teachers in developing their own STEAM projects.

2.2 Participants

The workshops involved a total of 60 to 100 mathematics teachers in each of the 12 workshops conducted. The teachers were divided into groups of 6-7 individuals to foster collaboration and teamwork in working on their STEAM projects.

2.3 Data Collection

Data collection included various activities conducted during the workshops. These activities encompassed project proposal development, documentation of group activities, and the final presentation of STEAM projects and learning scenarios.

2.4 Data Analysis

Thematic analysis was employed to analyse the real-life problems chosen by the teachers and the objectives derived from STEAM disciplines. The analysis focused on identifying common themes, patterns, and frequencies of topics and objectives.

3. Results

3.1 Workshop Attendance and Group Formation

The workshops saw active participation from a significant number of mathematics teachers, with 60 to 100 individuals attending each workshop. The teachers were divided into small groups of 6-7 participants to foster collaboration and promote effective teamwork.

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3.2 Thematic Analysis of Chosen Real-Life Problems

The thematic analysis of the chosen real-life problems focused on identifying common themes and patterns among the teachers' selections. The analysis aimed to uncover the areas of focus and relevance that influenced their decision-making process. The themes found, frequencies, and summaries of sample projects are the following:

Theme 1. Energy & Saving (f=42)

- ***Project 1. Kinetic Energy Harvesting: Empowering Education through Motion****:* The project focuses on utilizing the motion energy produced by students during their physical activities to generate electrical energy. By employing advanced technologies, this initiative aims to create a sustainable and renewable source of power within educational institutions.

- ***Project 2. Illuminating a Sustainable Future with IllumiCare****:* This project aims to address the issue of light pollution by implementing innovative strategies and technologies. By raising awareness, promoting responsible lighting practices, and developing efficient lighting solutions, the project aims to mitigate the negative impacts of excessive artificial light on the environment, wildlife, and human well-being.

- ***Project 3. Embracing the Warmth of the Sun for Solar Heat Innovations***: The project aims to provide sustainable heating solutions by utilizing solar energy. By integrating solar heating technologies into buildings and implementing energy-efficient designs, the project aims to reduce reliance on fossil fuels and promote renewable energy sources for warmth and comfort.

Theme 2. Transportation / Way Finding (f=30)

- ***Project 1. Inclusive Pathways Initiative***: This project aims to construct barrier-free ramps at schools, accommodating multiple levels to ensure accessibility for students with special needs. By incorporating multiple levels and accessible design principles, these ramps will provide a safe and inclusive environment, enabling students of all abilities to navigate their school surroundings independently and with dignity.

- ***Project 2. Multi-Sport Arena Project****:* This project aims to establish a state-of-the-art sports facility that caters to a wide range of athletic pursuits. This comprehensive arena will feature adaptable spaces, high-quality equipment, and versatile layouts to accommodate various sports such as basketball, soccer, volleyball, and more. By providing a dedicated space for sports activities, the project aims to promote physical fitness, team spirit, and healthy competition among students, fostering a well-rounded educational experience.

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- ***Project 3. Navigating Pathways at the Village Hospital****:* The project is an initiative focused on optimizing wayfinding systems within the hospital premises. By employing effective signage, color-coded maps, and user-friendly technology, the project seeks to streamline the navigation process for patients, visitors, and hospital staff. This improvement will enhance operational efficiency, reduce wait times, and create a more comfortable and stress-free environment for all stakeholders involved in healthcare services at the Village Hospital.

Theme 3. Computation & Machine (f=48)

- ***Project 1. Automated Dehydration System:*** The project focuses on designing a fruit and vegetable dryer that utilizes computational algorithms to optimize the drying process. This project aims to enhance efficiency, reduce energy consumption, and preserve the nutritional value of produce, benefiting farmers and food processing industries.

- ***Project 2. Smart Harvest Preservation System:*** This project aims to develop an innovative fruit and vegetable dryer that employs advanced mathematical models and machine learning techniques. By leveraging real-time data and predictive analytics, this system ensures optimal drying conditions, resulting in improved shelf life, reduced food waste, and enhanced product quality.

- ***Project 3. Robotic Waste Management Solution:*** This project centres around creating an intelligent garbage collector robot. Equipped with mathematical algorithms and machine vision capabilities, this robot navigates autonomously, efficiently collecting and sorting waste in various environments. This project aims to revolutionize waste management processes, promoting cleanliness, sustainability, and resource optimization.

3.3 Project Samples related to Computational Thinking

The section provides examples of STEAM projects created by the teachers, specifically those that incorporated computational thinking. It explores how computational thinking was applied in these projects and the potential impact of these approaches in solving real-life problems.

In the STEAM projects created by the teachers, computational thinking was applied through various approaches and methodologies. One example of computational thinking in action was the development of algorithms and programming solutions to solve real-life problems. Teachers leveraged coding languages and platforms to create software applications or simulations that addressed specific challenges. For instance, in the context of navigating large buildings or areas like hospitals and parks, teachers designed algorithms that utilized mapping and location-based technologies to provide efficient and user-friendly navigation

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systems. These projects demonstrated how computational thinking can be employed to streamline complex tasks and enhance navigation experiences in real-life settings.

Another way computational thinking was applied in the projects was through data analysis and modelling. Teachers collected relevant data related to the identified real-life problems and utilized computational tools and techniques to analyse and interpret the data. They employed statistical analysis, visualization tools, and machine learning algorithms to uncover patterns, make predictions, and gain insights that could inform decision-making and problem-solving. For instance, in addressing environmental concerns in local communities, teachers developed models that analysed air quality data and simulated the impact of various interventions to reduce pollution levels. By incorporating computational thinking, these projects offered valuable insights and evidence-based strategies for addressing pressing environmental challenges.

The potential impact of these computational thinking approaches in solving real-life problems is significant. By employing algorithms, programming, and data analysis, teachers enabled more efficient and effective problem-solving processes. These projects provided practical solutions to challenges that directly impact people's daily lives, such as navigating complex spaces or addressing environmental issues. The application of computational thinking allowed for the development of innovative and technology-driven solutions that have the potential to enhance the quality of life and improve the well-being of individuals and communities.

Furthermore, these projects showcased the power of computational thinking in fostering critical thinking, creativity, and collaboration among students. By engaging in computational problem-solving processes, students were encouraged to think analytically, develop logical reasoning skills, and work collaboratively to address complex challenges. The projects also highlighted the interdisciplinary nature of computational thinking, as teachers integrated concepts and approaches from various STEAM disciplines to create holistic solutions. This interdisciplinary and problem-based approach not only deepened students' understanding of the subject matter but also nurtured their ability to apply computational thinking principles in a real-world context.

Overall, the incorporation of computational thinking in these STEAM projects demonstrated its potential to drive meaningful change and address real-life problems. By utilizing algorithms, programming, data analysis, and modelling, teachers empowered students to become innovative problem solvers, capable of making a positive impact on society. The projects showcased the practical applications of computational thinking and its potential to transform various domains, from navigation systems to environmental sustainability. The integration of computational thinking in STEAM education has the capacity to prepare students

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for the challenges of the 21st century, equipping them with the skills and mind-set needed to tackle complex problems and contribute to a better future.

3.4 Teachers' Intentions to Apply for Projects

The findings reveal the teachers' intentions to apply for projects, such as Erasmus and TÜBİTAK (Scientific and Technological Research Council of Türkiye) projects, to address the real-life problems identified during the workshops. This section explores the motivations behind their intentions and discusses the potential implications of these projects in real-world applications.

The findings reveal that one possible motivation for teachers' intentions to apply for projects is the desire to provide practical solutions to the real-life problems they have identified. By engaging in external projects such as Erasmus and TÜBİTAK projects, teachers can access additional resources, funding, and expertise that can support the implementation of their STEAM projects on a larger scale. These projects offer an opportunity for teachers to collaborate with other professionals and institutions, enhancing the potential for impactful and sustainable solutions to the identified problems.

Another motivation for teachers' intentions to apply for projects is the potential for professional growth and recognition. Participation in external projects allows teachers to showcase their expertise and innovative teaching practices. By successfully addressing real-life problems through their STEAM projects, teachers can demonstrate their competence and effectiveness in integrating computational thinking and STEAM education. This can lead to professional recognition, career advancement, and opportunities for further collaboration and dissemination of their work. The potential for personal and professional growth serves as a strong motivation for teachers to apply for external projects and further contribute to the advancement of STEAM education.

These motivations highlight the teachers' commitment to making a meaningful impact beyond the classroom walls. By seeking external project opportunities, teachers demonstrate their dedication to addressing real-life problems and their willingness to go beyond traditional teaching approaches. The potential benefits of accessing additional resources, expertise, and recognition motivate teachers to pursue these projects as a means to make a broader and lasting contribution to their communities and society as a whole.

4. Discussion

4.1 Teachers' Focus on Daily-Life Relevant Topics

The discussion section explored the teachers' inclination to select topics that directly impacted their daily lives, such as navigating large buildings or areas like hospitals and parks. The

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analysis investigated the reasons behind this focus and considered the benefits of addressing problems with immediate relevance to teachers' experiences.

One possible reason for the teachers' inclination to select such topics was their personal relevance (as in Gonzalez Thompson, 1984; Lortie, 2008). The teachers chose topics that directly affected their own lives because they could relate to the challenges and issues associated with those topics. By addressing problems that they encountered or observed in their daily lives, the teachers developed a stronger personal connection to the projects, which likely increased their motivation and engagement.

Another factor contributing to the focus on topics with immediate relevance was the desire for authenticity and contextualization in the learning process, as previously reported by Quigley et al. (2020). By selecting topics that had direct impact on their lives, the teachers were able to create authentic learning experiences for their students. Tackling real-life problems that students could directly relate to provide a meaningful context for learning, making the educational content more relatable and applicable to their lives.

Furthermore, the practical application of the chosen topics played a role in the teachers' decision-making process. By focusing on problems with practical applications, such as navigating large buildings or areas, the teachers demonstrated the real-world significance of computational thinking and STEAM education. This approach helped students understand how the skills and knowledge they acquired could be applied in practical settings, fostering a deeper understanding and appreciation for the subject matter, confirming previous research (e.g., Quigley & Herro, 2019; Quigley et al., 2020).

The teachers' selection of topics that directly impacted their daily lives also contributed to increased student engagement. By addressing real-life problems that were relevant to their own lives and surroundings, the teachers were able to enhance student engagement and motivation. As expected (Quigley & Herro, 2019; Quigley et al., 2020), the immediate relevance of the projects created a stronger connection between the students' lives and the learning process, leading to heightened interest and enthusiasm.

Additionally, the feasibility of implementation likely played a role in the selection of these topics. The teachers may have believed that topics directly relevant to their daily lives were more accessible and manageable within their educational setting. They may have considered these topics to be more feasible to implement as STEAM projects, allowing them to achieve tangible outcomes. This was previously considered in early childhood education but barely was a part of middle school education (Alam, 2022).

In conclusion, the teachers' inclination to select topics that directly impacted their daily lives, such as navigating large buildings or areas like hospitals and parks, was influenced by factors such as personal relevance, authenticity, practical application, student engagement, and

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feasibility of implementation. By focusing on familiar and practical problems, the teachers created engaging learning experiences that promoted a deeper understanding of computational thinking and its applications in real-world scenarios.

4.5 Limitations and Further Research

The discussion section addresses the limitations and challenges encountered during the workshops and the development of STEAM projects. It examines factors that may have influenced the teachers' choices and discusses the potential impact of these limitations on the feasibility and effectiveness of the projects.

4.5.1 Limitations

One of the limitations of the workshops and the subsequent development of STEAM projects was the time constraint. The four-day duration of the workshop program may have limited the depth and complexity of the projects that teachers could undertake. The compressed timeline may have restricted the ability to fully explore and implement more intricate computational thinking elements and strategies. A longer workshop period could provide teachers with additional time to delve into advanced concepts and experiment with more sophisticated approaches.

Another limitation relates to the availability of resources and support for teachers. The successful implementation of STEAM projects often requires access to specific tools, materials, and technological resources. Limited resources or inadequate support from the educational institutions or authorities could hinder the teachers' ability to fully realize their envisioned projects. The lack of necessary equipment or materials may have restricted the scope and implementation of certain ideas, potentially limiting the overall effectiveness of the projects.

Furthermore, the workshops' focus on mathematics teachers may have limited the range of perspectives and interdisciplinary approaches within the STEAM projects. While mathematics undoubtedly plays a significant role in computational thinking, the integration of other STEAM disciplines, such as arts and engineering, could have enriched the projects further. Future workshops could involve teachers from various disciplines to foster interdisciplinary collaboration and explore the full potential of STEAM education.

Additionally, the study acknowledges that the selection of real-life problems by the teachers may have been influenced by individual biases or preferences. The choice of topics directly impacting their daily lives could have been subjective and may not represent a comprehensive range of real-life problems that could be addressed through computational thinking. This limitation highlights the importance of encouraging teachers to explore a diverse range of problems and consider their broader societal impact.

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Further Research

To address the limitations identified in this study and advance the understanding and implementation of computational thinking in STEAM education, further research is warranted. Some avenues for future research include:

1. Long-term Impact: Conducting follow-up studies to examine the long-term impact of the workshop program on teachers' pedagogical practices and their students' learning outcomes. Investigating the sustained integration of computational thinking and STEAM projects beyond the workshops can provide insights into the lasting benefits and challenges encountered in real-world classroom settings.

***2. Interdisciplinary Collaboration*:** Exploring the benefits of interdisciplinary collaboration in STEAM projects by involving teachers from different subject areas. Examining the synergies and challenges of integrating multiple disciplines within a STEAM framework can enhance the effectiveness and richness of the projects.

3. Resource Accessibility: Investigating the availability and accessibility of resources, tools, and support for teachers to facilitate the implementation of STEAM projects. Identifying strategies to overcome resource limitations and ensuring equitable access to necessary materials can contribute to the scalability and sustainability of STEAM initiatives.

4. Student Outcomes: Assessing the impact of computational thinking and STEAM projects on students' learning outcomes, including their 21st-century skills development, creativity, problem-solving abilities, and subject-specific knowledge. Examining the effects of different project designs, assessment methods, and instructional strategies can inform best practices for optimizing student learning and engagement.

5. Teacher Professional Development: Investigating the effectiveness of professional development programs in preparing and supporting teachers in implementing computational thinking and STEAM projects. Exploring various models, formats, and delivery methods of professional development can inform the design of comprehensive and impactful training programs.

By addressing these research areas, future studies can contribute to the refinement and expansion of computational thinking and STEAM education, fostering a generation of students equipped with the necessary skills and mind-set to tackle real-life problems and thrive in the 21st-century world.

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6. Conclusion

The study sheds light on the use of computational thinking in solving real-life problems through a STEAM approach. The results indicate that teachers focused on topics with direct relevance to their daily lives, and they expressed intentions to apply for projects to solve these problems in reality. This study highlights the potential of STEAM education in raising awareness of real-life problems and fostering solutions through collaborative efforts. By integrating computational thinking and leveraging the interdisciplinary nature of STEAM education, teachers can equip students with the skills needed to address complex challenges in the 21st century.

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Appendix A.

Extended abstract: The popularity of solving real-life problems through computational thinking increased in STEAM (science, technology, engineering, arts and mathematics) education. There is a common belief that teachers can develop their students' 21st century skills including creativity, collaboration, communication and critical thinking by enabling their students to work in groups, particularly, to solve real-life problems with STEAM approach (MoNE, 2016; Saralar-Aras & Esen, 2021). In this context, STEAM education has been considered as a learning model based on full harmony between science, technology, engineering, arts and mathematics by eliminating the distinction between these disciplines (MoNE, 2016). With STEAM Education, teachers may raise a generation who have dreams of inventing, and who can ask questions, investigate, and make new discoveries in order to solve real-life problems at all levels from kindergarten to higher education. With the knowledge that STEAM approach might help increase students' 21st century skills, we developed a four-day STEAM workshop programme for teachers to start their own STEAM projects and create their STEAM learning scenarios. This paper presents findings of STEAM workshops conducted in the Republic of Türkiye, using the Scientix project teaching and learning methodology, as a part of the Mathematics Mobilization of the Ministry of National Education (2022a, 2022b). Workshops involved teachers who created STEAM projects to solve real-life problems. In each workshop out of 12, 60 to 100 mathematics teachers participated, and were divided into groups of 6-7 to work together on a STEAM project after the four-day programme devoted to raising awareness on STEAM education, creating STEAM learning scenarios, and developing STEAM

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projects. On the final day of the workshop, groups of teachers presented their STEAM projects and the STEAM learning scenarios. We thematically analysed the real-life problems chosen by the teachers, and chosen objectives from STEAM disciplines. In this presentation, we shared the frequencies of the topics, project samples directly related to computational thinking, real-life problems chosen, and discussed possible reasons for choosing them. The results showed that teachers focussed more on the topics that could directly affect their daily lives, for example, navigating in large buildings/areas such as hospitals and parks. They also reported that they may actually plan to apply for projects (e.g., Erasmus and TÜBİTAK projects) to solve these problems in reality. It is hoped that the awareness of real-life problems, and the ways of solutions could be of any use.

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Integrating STEAM in Math Education: Impact on Motivation and Anxiety

Abstract: Mathematics is perceived as daunting and challenging for most students (Živković, Pellizzoni, Doz, Cuder, Mammarella & Passolunghi, 2023). Since STEAM deals with science, technology, art and mathematics holistically, it is claimed that it has a positive effect on the effectiveness of learning and the development of learners' motivation as well as their interest (Kim, Kim, Nam, & Lee, 2012; Inomjonovna, 2023). Mathematics can be taught based on the STEAM learning model by integrating it with other disciplines and establishing a connection with real life. So the math can become more interesting.

The goal of this study is to help students see mathematics as relevant to their daily lives, rather than just as a series of disconnected problems to be solved to find the correct answer. For this purpose, a five-day training, supported by TÜBİTAK (Scientific and Technological Research Council of Türkiye), was given to 26 6th and 7th grade students living in İzmir. Educational content was designed in the form of STEAM activities related to mathematics and based on inquiry. The concept of fractals and the discovery of fractals through a nature trip, the recognition of the process of fishing with the Desmos program, fuzzy logic and technological product design, painting with fractals, and writing stories and poems were carried out. Likert-type scales of motivation, anxiety, and STEM attitude were applied to the students before and after the instruction. Students were asked to write a diary about the subjects they found easy and difficult. A paired sample t-test was performed to compare the pre-test and post-test results of the scales. An independent samples t-test was conducted to determine the anxiety and motivation level of the students according to gender.

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It was found that there was a significant difference between the pre-training (Mean=1.96) and post-training (Mean=1.55) anxiety levels, with the average anxiety decreasing. In terms of motivation, there was a significant difference after the training (Mean=4.36) compared to the pre-training (Mean=3.96). The average motivation levels of the students increased after the training. According to the STEM attitude scale, there was a significant difference after the training (Mean=4.0) compared with the pre-training (Mean=3.6), with the students' averages increasing after the education.

Students stated that the subjects were related to real life, and they enjoyed the activities because they experienced and discovered themselves. They also mentioned having the opportunity to deal with problems and conduct research. Considering the STEAM model, it has been found that educational activities, which integrate different disciplines and provide students with the opportunity to experience them firsthand, are effective in reducing students' anxiety about mathematics and increasing their motivation.

Keywords: *STEAM, Mathematics, Math anxiety, Math motivation.*

1. Introduction

Problems encountered in today's world are complex. These new world problems need to be solved by different disciplines with creative thinking (Körtesi, Simonka, Szabo, Guncaga & Neag, 2022). Especially, mathematics plays an important role in understanding and utilizing a lot of rapidly changing information (Kim, Kim, Nam, & Lee, 2012). On the other hand, mathematics is perceived as daunting and challenging for most students (Živković, Pellizzoni, Doz, Cuder, Mammarella & Passolunghi, 2023). Math anxiety can have an effect on one's performance, interest, and success.

Since STEAM deals with science, technology, art, and mathematics holistically, it is claimed to have a positive effect on the effectiveness of learning and the development of learners' motivation and interest (Inomjonovna, 2023; Kim, 2012). Mathematics can be taught based on the STEAM learning model by integrating it with other disciplines and establishing a connection with real life. This can make math more interesting. The STEAM learning model can be supportive in promoting creativity and problem-solving skills.

Although there have been many studies on mathematics anxiety and motivation (Li, Cho, Cosso, & Maeda, 2021; Süren & Kandemir, 2020), no study has been encountered that specifically determines the motivation of students and the changes in their anxiety levels with the activities to be carried out within the scope of the TÜBİTAK (Scientific and Technological Research Council of Türkiye) 4004 Nature Education and Science Schools Support program. It is thought that this study will serve as a guide for future researchers and educators in developing the content of their educational activities, provided that the students' anxiety and motivation towards mathematics change positively with the activities conducted within the scope of the project.

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With the project, it is aimed to make students realize that mathematics is interesting as a discipline from life, to show its connections with other disciplines, and to realize active learning in students by revealing many different fields of mathematics. Within the scope of the research, it is aimed to examine the students' anxiety and motivation towards mathematics.

2. Methods

In order to reduce the students' anxiety about mathematics and increase their motivation, they were trained by academicians and teachers for 5 days from morning to evening. In this training program, the subjects of mathematics taught at the high school level are discussed. These topics are fuzzy logic, graph theory, scutoid, topology, encryption methods, ratio-proportionality with Desmos program, financial literacy, area calculation with Monte Carlo method, fractal geometry and its reflections in nature. The reason for choosing these topics was that these mathematical concepts take place in our daily lives, and we interact them without realizing it. In order to show that mathematics is a part of our daily life and to prevent mathematics from appearing scary while doing this, these concepts were handled as simply and practically as possible. While the subjects were being handled, activities for the guided inquiry model were designed. Activities were initiated based on daily life problems.

“Mathematics Anxiety Scale for Primary School Students” developed by Recep Bindak (2005) was used to determine students' math anxiety. The scale is a 5-point Likert type consisting of ten items. Construct validity and factor analysis were ensured. The Cronbach Alpha coefficient for the internal consistency of the scale was found to be 0.84. The reliability coefficient calculated by the test split method was found to be 0.83 with the Sperman-Brown correction.

In order to determine students' motivation towards mathematics, the "Mathematics Motivation Scale", which was developed by Pintrich et al. and adapted for use in his doctoral thesis by Aktan, S., & Tezci, E. (2013), was used. The Mathematics Motivation Scale consists of 27 items in 5-point Likert type. The Cronbach Alpha coefficient was found to be 0.910.

The central focus of this research article revolved around examining the interplay between academic success, motivation levels, and anxiety levels among 6th and 7th grade students in the field of mathematics. In order to shed light on this intricate relationship, the present study formulated the following sub-problems.

1. Do 6th and 7th grade students' anxiety about the math lesson differ significantly in the context of the pre-test and post-test?

2. Does the motivation of 6th and 7th grade students towards mathematics lesson differ significantly in the context of pretest and posttest?

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3. Do 6th and 7th grade students' anxiety about math lesson differ significantly according to gender?

4. Do 6th and 7th grade students' motivations for mathematics lesson differ significantly by gender?

For statistical analyses, IBM SPSS Statistics 29.0 was used. We assumed a normal distribution of the data (Wilcox, 2012).

Paired sample t-test was performed to compare the pre-test and post-test results of the scales. Independent samples t-test was conducted to determine the anxiety and motivation level of the students according to gender.

Here is an example of an activity called “Fuzzy Logic”. Fuzzy logic is a mathematical discipline that interprets our behavior and decisions to solve complex problems we encounter in daily life. Values and intermediate values that we use in daily life such as very little, little, small, medium, large are included in fuzzy logic (Hellmann, 2001). This activity starts with the question “How do you like your steak?” “Well done?” “Rare?”. With this question, we wanted to draw attention to the uncertain situations that we encounter in our daily life.

We made the students discuss the question than we introduced fuzzy logic. Then, we asked students to think a problem that they encountered in daliy life and created a product based on fuzzy logic. They discussed and made a poster about their product. They paid attention to the artistic design of their products. At the end of this activity, their awareness was raised about how fuzzy logic was effective in solving daily life problems by combining art and technology.

At the end of each day, the students were given a diary. In line with the questions in the diary, the students wrote down the activities they had the most difficulty with and enjoyed the most. They were also asked what the reasons for their difficulties might be and how they could learn better.

3. Results

In this section, the mathematics motivation and anxiety levels of 6th and 7th grade students were analyzed. The answers of the students were made according to gender and grade level before and after the intervention.

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Table 1
Pretest-posttest Anxiety scores

Group	N	Mean	Sd	t	df	p
Anxiety_pretest	26	1.9692	.75300	2.481	25	.020
Anxienty_posttest	26	1.5538	.54276			

The paired samples t-test was conducted to examine whether there was a significant difference in Mathematics anxiety between pretest and posttest. The test revealed a statistically significant difference between pretest and posttest ($p < 0.05$). The post test (Mean = 1.5538, Sd =.54276.) reported significantly lower level of anxiety than the pretest (Mean= 1.9692 , Sd =75300) (see Table 1).

Table 2
Pretest-posttest Motivation scores

Group	N	Mean	Sd	t	df	p
Motivation_pretest	26	3.9644	.59143	-3.878	25	.001
Motivation_posttest	26	4.3661	.40644			

The paired samples t-test was conducted to examine whether there was a significant difference in Mathematics motivation between pretest and posttest. The test revealed a statistically significant difference between pretest and posttest ($p < 0.01$). The post test (Mean = 4.3661, Sd = .59143) reported significantly higher level of anxiety than the pretest (Mean= 3.9644 , Sd = .40644) (Table 2).

Table 3
Anxiety pretest scores

Group	N	Mean	Sd	t	df	p
Female	15	2.2667	.81650	2.871	21.763	.009
Male	11	1.5636	.41297			

In the anxiety pretest, there is a statistically significant difference in favor of males in terms of anxiety scores between males (Mean=1.5636) and females (Mean=2.2667) ($p < 0.05$) ((Table 3). In the anxiety posttest, there is statistically significant difference in favor of males in terms of anxiety scores between males (Mean=1.2909) and females (Mean=1.7467) ($p < 0.05$).

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However, when the pretest and posttest scores of the females were compared, the anxiety level of the females decreased.

Table 4
Motivation pretest scores

Group	N	Mean	Sd	t	df	p
Female	15	3.7037	.59408	-3.021	24	.006
Male	11	4 3199	.37342			

In the motivation pretest, there is a statistically significant difference in favor of boys in terms of motivation scores between males (Mean= 4.3199) and females (Mean=3.7037) ($p < 0.05$) ((Table 4). In the motivation posttest, there is statistically significant difference in favor of males in terms of motivation scores between males (Mean=4 .5522) and females (Mean= 4.2296) ($p < 0.05$). However, when the pretest and posttest scores of the females were compared, the motivation level of the females increased.

4. Discussion

Considering the STEAM model, it has been found that educational activities in which different disciplines were integrated and students had the opportunity to experience themselves were found to be effective in reducing students' anxiety about mathematics and increasing their motivation.

Students stated that the subjects were related to real life, they enjoyed the activities because they experienced and discovered the activities themselves, and they had the opportunity to deal with problems and do research.

5. Conclusion

It can be said that the STEAM approach is effective in reducing students' anxiety about mathematics and increasing their motivation. Providing opportunities to students in which they could relate to real life increase students' interest in mathematics. Developing the programs for the STEAM learning model with mathematics and examining their effects on students after their implementation may be the subject of future research.

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Unlocking Mathematical Concepts: Exploring the Use of Escape Rooms for Math Teaching in STEAM Education

Abstract: Escape rooms are interactive learning activities that present challenges and puzzles for students to solve to achieve a specific learning objective or "escape" the room. They are increasingly being used in educational settings to enhance student learning and engagement, providing an immersive, hands-on experience that promotes teamwork, problem-solving, critical thinking, and communication skills. Virtual escape rooms have become popular due to the COVID-19 pandemic. In math education, escape rooms can be designed to help students understand mathematical concepts and apply them to solve puzzles and challenges. This study investigated the experiences of teachers who have used escape rooms to teach math, the benefits and challenges associated with the use of escape rooms, and the impact of this approach on student engagement and learning outcomes. The results suggest that escape rooms can be an innovative and effective tool for teaching math concepts in a fun and engaging way, promoting problem-solving skills, and encouraging teamwork and collaboration among students, while also supporting the experiential learning process.

Keywords: *Escape rooms, Math teaching, STEAM education, Problem-solving skills, Collaboration.*

1. Introduction

Escape rooms in education are interactive learning activities that take place in a controlled environment, typically a themed room or series of rooms, where students are presented with a

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set of challenges or puzzles to solve to "escape" the room or achieve a specific learning objective (Babo, et. Al., 2023). These challenges can be physical, such as unlocking a door, or mental, such as solving a math problem. Escape rooms can be used in a variety of educational settings, from high school classrooms to university courses, to enhance student learning and engagement (Doleshal, 2022). They provide students with an immersive, hands-on experience that encourages teamwork, problem-solving, critical thinking, and communication skills (Babazadeh & Frigerio, 2021) Virtual escape rooms have become popular recently due to the use of online learning due to covid-19 pandemic (Rosillo & Montes, 2021).

In the context of math education, escape rooms can be designed to help students understand mathematical concepts and apply them to solve puzzles and challenges. Escape rooms provide a fun and interactive way to engage students in learning as they are arranged in the form of a game (Maskeliūnas, et. al., 2020; Oyesiku, et. al., 2018). Studies have shown that digital escape rooms can improve student engagement and motivation, leading to better learning outcomes (Bayer & Sorenson, 2021; Taraldsen, 2022). Digital escape rooms promote critical thinking and problem-solving skills, as students must use these skills to solve the puzzles and challenges presented. This can lead to improved problem-solving abilities that can be applied in real-world situations. Furthermore, they enhance collaboration skills, as students must work together to solve puzzles, improving communication and teamwork, which can enhance social and interpersonal skills.

Digital escape rooms also have the potential to support personalized learning. The puzzles and challenges can be designed to meet the needs of individual learners, providing a more personalized learning experience. Also, escape rooms promote active learning, where students are actively engaged in the learning process. This helps students to develop critical thinking, problem-solving, and communication skills. The use of escape rooms can help students to retain information better; it supports the experiential learning process. Additionally, they provide an alternative assessment method to traditional exams, allowing students to demonstrate their understanding of course material in a more engaging and interactive way. Additionally, digital escape rooms can be applied to a wide range of disciplines, making them a versatile teaching tool. The use of digital escape rooms in education has numerous benefits, including increased engagement, improved problem-solving and collaboration skills, and personalized learning. Moreover, they provide an alternative assessment method that can be applied to various subjects. With careful planning and development, digital escape rooms can be an effective tool for enhancing student learning outcomes and promoting academic success.

This study explores the use of digital escape rooms as an innovative and engaging approach to teaching mathematics to university students. The study presents the design and implementation of a digital escape room for a university course and evaluates its effectiveness through a survey of participating students. The results of the study suggest that digital escape rooms can be highly engaging and motivating for university students, promoting critical

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thinking, problem-solving, and collaboration skills. The study also highlights some of the challenges and considerations involved in the design and implementation of digital escape rooms in mathematics education.

2. Method

The methodology of digital escape rooms involves several steps, including:

1. Defining the learning objectives: The first step is to identify the learning objectives and desired outcomes of the digital escape room experience.
2. Designing the storyline and theme: Develop a storyline and theme that aligns with the learning objectives and engages learners in the experience.
3. Creating the puzzles and challenges: Develop puzzles and challenges that are aligned with the learning objectives and provide opportunities for learners to apply their knowledge and skills.
4. Mapping the learning path: Map out the sequence of puzzles and challenges that learners will follow during the escape room experience.
5. Incorporating feedback mechanisms: Incorporate feedback mechanisms, such as hints or clues, to help learners progress through the escape room experience.
6. Testing and evaluating: Test the escape room experience with a sample group of learners to evaluate its effectiveness and identify areas for improvement.

The methodology of digital escape rooms can be adapted and customized based on the specific needs and requirements of different learning contexts and audiences.

3. Case Study

The designed digital escape room is created using Google Forms and covers a portion of the Mathematics 2 university course related to integrals, including indefinite integrals and definite integrals, improper integrals, and double integrals. The escape room consists of a series of challenges or puzzles based on the Lock and Key pattern, where the players must solve each puzzle to find the key that unlocks the next door to progress to the next puzzle. The game is designed to test not only mathematical knowledge but also skills like logic and searching for information on the Internet. The escape room comprises 12 rooms (see examples in Figure 1 and Figure 2) and obstacles, each covering a specific topic related to integrals. The players need to complete all puzzles and challenges within 100 minutes. The game is played on the Zoom platform, where players are divided into teams, and each team is allocated a breakout room. The lecturer can monitor the gameplay and provide assistance if required. The game is designed to enhance university students' learning experience and facilitate the application of mathematical knowledge in a fun and interactive way.

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4. Results

The digital escape room was organized during the COVID-19 lockdown period in the spring semester of 2021, with a team of 21 university students from the Kaunas University of Technology, Faculty of Electrical and Electronics Engineering, Informatics and Mathematics, and Natural Sciences participating. The escape room covered the content of the Mathematics 2 university course related to integrals, their applications, improper integrals, and double integrals. Three university lecturers organized the escape room, and all three participated remotely via Zoom to assist their students. The game was designed to enhance university students' learning experience, teamwork, and communication skills. The evaluation of the digital escape room was conducted through a questionnaire distributed to the participating university students.

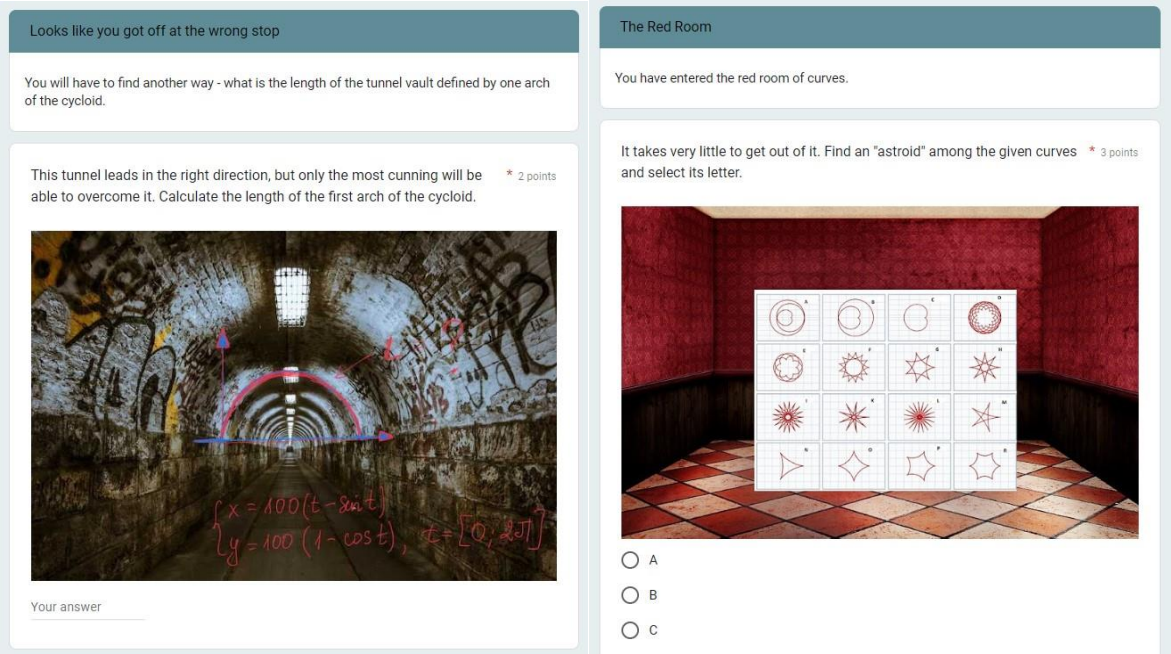

Figure 1 *Examples of rooms with questions and answer options*

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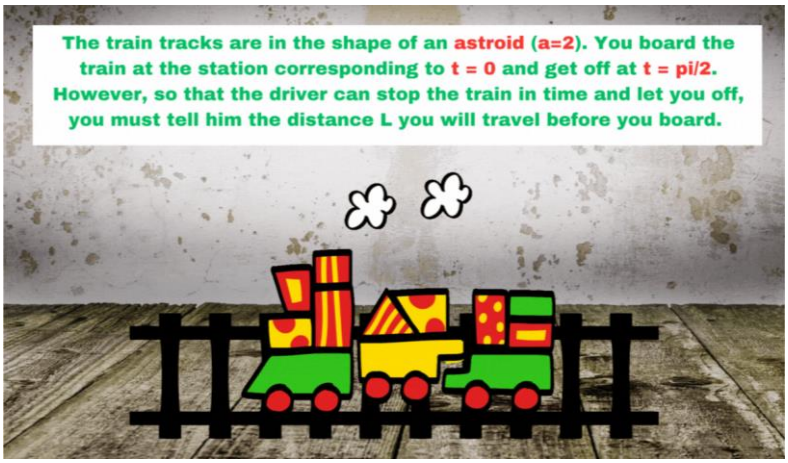

Figure 2 *Example of a mathematical question*

The study evaluated the engagement level of university students with digital escape rooms in a math course through an online questionnaire distributed in the Moodle environment. A total of 77 university students who participated in a digital escape room were surveyed, and the results were statistically analyzed to assess the effectiveness of digital escape rooms in promoting engagement and learning outcomes. The majority of respondents had not participated in a digital escape room before, and the mean score for the engagement level was 4.2 out of 5, indicating that the experience was highly engaging for most university students. The standard deviation suggested that engagement levels varied somewhat among the students. The detailed results of this study were described in (Sidekerskienė & Damaševičius, 2023).

5. Discussion

Digital escape rooms are a unique learning experience that can promote critical thinking, problem-solving, and collaboration skills in STEM education. By immersing learners in an interactive and engaging virtual environment, digital escape rooms can break down barriers and promote inclusivity in STEM education. This approach has been positively received by lecturers who have reported that digital escape rooms make math teaching more fun and engaging, particularly for students who may struggle with traditional methods. Digital escape rooms also encourage collaboration, problem-solving, and communication skills among students.

Moreover, this approach provides a low-stakes environment for students to practice their problem-solving and critical thinking skills, which can be applied to other areas of their academic and personal lives. The game-like experience of digital escape rooms incentivizes students to complete puzzles and tasks, leading to a highly motivating and effective learning experience. Digital escape rooms are becoming popular in math teaching due to their unique and engaging learning experience that promotes critical thinking and problem-solving skills (Taraldsen, et. al., 2022).

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However, challenges related to technical issues, accessibility, design and implementation, assessment, and cost should also be considered. The benefits of using digital escape rooms in math teaching include engaging and motivating students, promoting critical thinking and problem-solving, individualized learning experiences, collaborative learning opportunities, and flexibility.

6. Conclusions

This study has demonstrated that digital escape rooms can be an effective and engaging instructional approach for teaching mathematics to university students. By creating an immersive and interactive learning environment, digital escape rooms can promote critical thinking, problem-solving, and collaboration skills. The positive feedback from university students and lecturers suggests that digital escape rooms can address the traditional view of STEM education as difficult, boring, and intimidating, promoting inclusivity and engagement among learners from diverse backgrounds. However, it is important to consider the challenges related to technical issues, accessibility, design and implementation, assessment, and cost. With careful planning and consideration of these factors, digital escape rooms can offer a unique and effective way to teach mathematics and prepare university students for the challenges and opportunities of the 21st century.

There are still many opportunities for future works to expand and improve upon this method. One potential avenue for innovation is to explore the use of virtual and augmented reality technologies to create even more immersive and interactive digital escape rooms. This could provide students with a more realistic and engaging experience, which could further enhance their learning outcomes. Another stream of research may include the inclusion of artificial intelligence tools such as chatbots for smart classroms (Wogu, et. al., 2022). Furthermore, future works could investigate the effectiveness of digital escape rooms in promoting inclusive and equitable learning outcomes. By examining the use of digital escape rooms with diverse student populations, researchers could identify ways to make the approach more effective and accessible for all learners.

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Seeking success for an Educational Robotics-Oriented STEAM course in MOOCs

Abstract: Massive Open Online Courses (MOOCs) can be particularly helpful in providing a big number of learners (teachers, students, and even schoolchildren) with relevant material for subjects of STEAM (Science, Technology, Engineering, Arts, and Mathematics). On the other hand, we still need to consider how to apply STEAM in online platforms for educational robotics (r-learning) and make sure that teachers have the necessary recuses abilities, and understanding of the environment. Educational robotics transfer to the online environment may rise some challenges related to the specifics in this field.

The aim of the paper is to present the main factors, which we have to consider seeking success for educational robotics-oriented STEAM courses in MOOCs implementation.

After the systemic literature analysis, we identified 13 elements (6 key elements and 9

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sub-elements) that are important for teachers' professional development in the STEAM field. These elements were adopted during piloting training in MOOCs. Quantitative and qualitative methods were applied main factors, which can lead to success for an educational robotics-oriented STEAM course in MOOCs: teachers' role, learners' role, robotics kits usage, and the importance of the platform features for STEAM-driven learning content.

Keywords: *MOOCs, STEAM, educational robotics, teacher's role, learner's role, robotics kits.*

1. Introduction

Educational robotics is one example of a STEAM methodology that can help students develop the new skills and competencies they need to address challenging social issues. The "A" component of STEAM education that adds to its effectiveness is r-learning.

Since robot usage in the educational process makes the process more engaging and beneficial: moving away from traditional teaching approaches toward more innovative and effective. When students can touch and use different robotics kits, they education process become more palpable and intelligible.

STEAM implementation process requires a holistic approach; this means all necessary elements integration from teachers continues pedagogical development to learners' knowledge and skills acquisition and implementation in professional areas solving real- life problems.

Therefore, it is important to consider methodological characteristics and how to ensure teachers' professional development with all the requirements for 21st-century skills when we want to transfer content and methods from offline to online environments trying to incorporate r-learning in MOOCs. It is important to think about the student's/leaners role in this process, preferences, identity, needs, and motivation as well. Another aspect, which is important how to provide a consistent STEAM implementation process ensuring all the necessary aspects of the STEAM ecosystem, involving all main stakeholders.

This paper consists of 5 parts: *literature analysis* gives a brief overview of the main frameworks, models, and methods, which were applied for the Two-cycle STEM-Driven Conceptual Model (2CSTEAM) preparation; the *methodological* part presents methods, which were used after piloting training in order to get insights from trainees and mentors about piloting training; *results* part discloses the main elements, which could lead to the successful educational robotics-oriented steam course in M; *discussion and conclusion* part provides the interpretation of the results and emphasizes the importance of the research.

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2. Literature review

In order to find an answer to how to integrate educational robotics-oriented STEAM courses in MOOCs, we conducted systemic literature analysis and at first identified the main frameworks which can be used for STEAM teacher's professional development such as Digital Competence Framework for Educators (DigCompEdu) (Punie, 2017) A Highly Structured Collaborative STEAM Program: Enacting a Professional Development Framework (Bush et. al., 2016) Kolb's Experiential Learning Cycle as a Base of Teacher Training Framework (Kolb, 1984; Kolb & Kolb, 2009), STEM- driven conceptual model (Burbaitė, et. al., 2018; Kolb, 1984;)and theories and models appropriate for this field: Meaningful learning model (Jonassen, et. al., 1999)and Activity Theory (Engeström, 2001).

The 13 elements identified, which are important for teachers' professional development in the STEAM field (Figure 1).

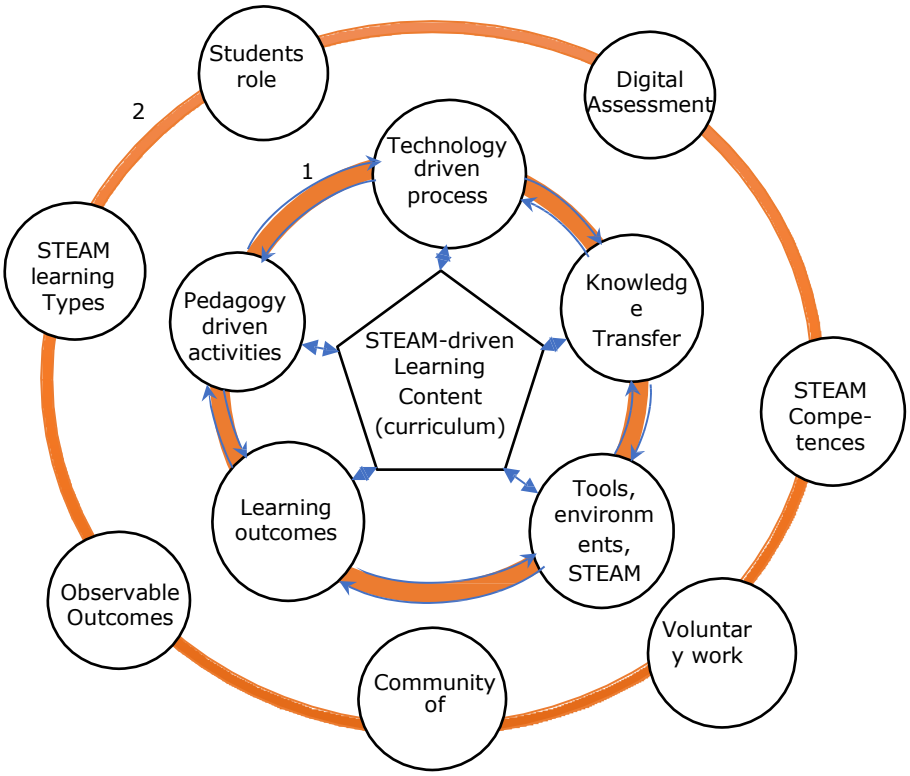

Figure 1 *Two-cycle STEM-driven conceptual framework (2CSTEAM)*

Based on our literature analysis results the Two-Cycle STEM-driven Conceptual Framework (2CSTEAM) was prepared. The key elements of the framework such as digital equipment (tools, environments, STEAM library), learning outcomes, pedagogy-driven activities, technology-driven processes, and knowledge transfer channels are important for

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STEAM-driven learning content. Two-sided arrows are used to connect the elements of the first cycle. The sub-elements such as STEAM learning types (educational approaches), Learners' role, Digital Assessment, Teachers' competencies in the STEAM field, Voluntary work, Community of Learning, and Observable Outcomes belong to the second cycle.

We incorporated Boyle's (2009) layered learning design when building the framework.

3. Methods

The study seeks to investigate how MOOCs may be designed using the Two-Cycle STEAM-driven Conceptual Framework elements and to identify the main elements which may ensure success education robotics implementation.

The pilot training course was presented on MOOCs involving four units: 1) Introduction to integrated STE(A)M teaching & relevant teaching methods; 2) STEAM subjects and how STEM careers are contextualized at school; 3) Subject-specific details for teachers; 4) Robotics. The pilot teacher training was conducted on the Moodle platform (https://steam.eba.gov.tr/) and was accessible to Spanish trainees from the 3rd of November to the 5th of December 2021 and Turkish trainees from the 27th of September to the 25th of October 2021, respectively (MoNE, 2022). 129 trainees (teachers) received certificates after the training. 227 out of the 252 teachers who started the questionnaire eventually finished it.

The target audience for the pilot study was trainees (teachers) who took part in the pilot study. 466 trainees (teachers) from Spain and Türkiye were enrolled to the course. There were 6 mentors from Spain and 18 mentors from Türkiye.

In order to collect trainees' opinions regarding the training content in MOOCs qualitative method was implemented. The trainees had to answer 29 questions using a Likert scale from 1 (strongly disagree) to 7 (strongly agree). It was binary questions as well.

On the 7th of January 2022, the focus group was organized in order to get insights about an educational robotics-oriented STEAM course in MOOCs. The meeting covered seven discussion questions and provided Spanish and Turkish mentors' opinions about the key elements.

4. Results

After the analysis of qualitative and quantitative data, we identified the key elements, which are important in seeking success for Educational Robotics-Oriented STEAM courses in MOOCs (Figure 2). These elements are the Teacher's role, Platform, Robotic kits, Learner's role, and STEAM-driven learning content.

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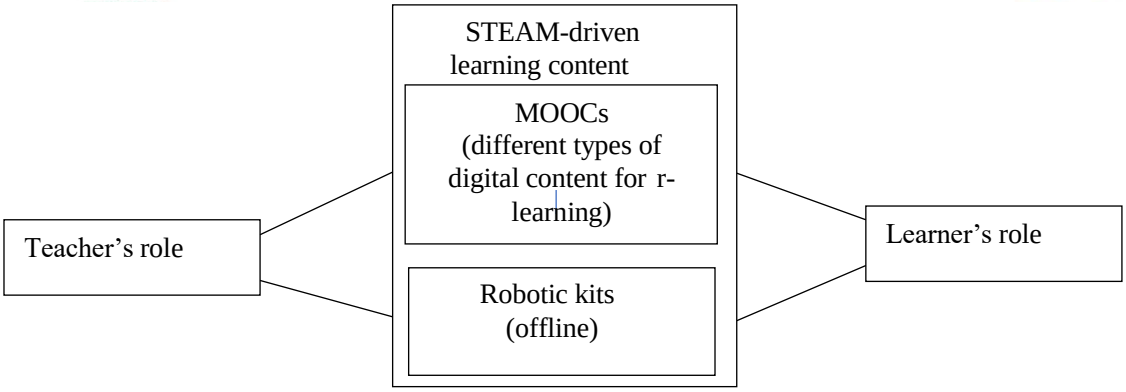

Figure 2 *Key elements for Educational Robotics-Oriented STEAM course in MOOCs*

Teacher's role. In the STEAM field, we emphasize the student-centric approach and position as a mentor. Both the teacher (mentor) and the students share the responsibility for the results of the learning process (Kolb & Kolb, 2009). This aspect (responsibility) may lead us to understand that teachers' role in the STEAM learning process decreases. But when we look at the pedagogical STEAM-driven model (Burbaitė, et. al., 2018). We see that teachers have to get a deeper understanding of pedagogical aspects, technological aspects, and training content aspects and know how to integrate them into a unified whole.

Learner's role. If we want to ensure a smooth learning process on MOOCs, first we have to evaluate the basic level of knowledge of the learner (beginner, intermediate, advanced); we should know whether the learner has the necessary abilities and preferences for the particular course (Burbaitė, et. al., 2022). Of course, motivation plays an important role in the learning process as well [14]. In search of better results in educational robotics courses, students should have a basic understanding of the principles of STEAM and robotics.

Robotic kits. When students can touch and use different robotic kits, they gain knowledge by working with palpable and intelligible materials. The capability to provide learners with different kits and ensure tangibility becomes very important, but it requires additional recuses.

One of the solutions is to provide learners with some detailed instructions/training content by text or as a video when they work with Arduino. Learners will have a clear view and confidence when they will have an understanding of how to go through every task step by step. Of course, for learners, it will be useful to have in their hands' kits of Arduino. When students work with Arduino, sometimes hybrid training can help better achieve the results compared to online training.

When learners work with Thinker CAD, they can do all the tasks online, by watching the instructions. There is no need for tangible robotic kits. Thus, to seek success, it is necessary to choose the appropriate training model.

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STEAM-driven learning content. In secondary school, teachers are typically only permitted to teach one subject; hence, it is crucial to use an integrated, transdisciplinary, or multidisciplinary approach. The STEM and art disciplines are combined in the STEAM teaching and learning strategy, which can help students become better at asking questions, solving problems, and thinking creatively. The shift from STEM to STEAM can offer fresh perspectives and new terms for thinking across disciplines. It is important to think about how the content can be transformed into a digital environment as well.

Features of the platform. The use of MOOCs should be simple and not distract learners from educational activities. The platform should be intuitive, i. e. is friendly to users, show learners' progress, provide detailed info about the tasks, differentiate content according to the levels (beginner, intermediate, advanced), ensure communication among mentor and learners, ensure communication among learners (in the forums), ensure to integrate different types of materials, and provide different tools for evaluation. Of course, before starting every course and seeking success, it is important to test all the features of the platform.

5. Discussion and conclusion

In this paper, we define the main elements, which are the basis for STEAM courses oriented towards educational robotics in MOOC implementation. These elements are related to the teacher's role, the learner's role, robotics kits usage, the platform features which will ensure different types of STEAM-driven content.

Rabalais (2014) claims that the goal of the STEAM approach is to determine how success in STEM (Science, Technology, Engineering, Math) and the arts are related. To encourage students to participate in instructional projects incorporating science, technology, engineering, art, and mathematics, schools are fostering a STEAM-oriented environment [16]. The "A" component of STEAM education that adds to its effectiveness is r-learning.

Other elements of the Two-Cycle STEAM-driven Conceptual Framework are important as well and we hope that future studies will evaluate the impact of these aspects in correlation with the 21st-century skills in the STEAM educational process.

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The Opinions of Teachers and Mentors' on EDUSIMSTEAM Pilot

Abstract: The 'Fostering STEAM Education in Schools' (EDUSIMSTEAM) project is a project that aims to increase 21st century skills in both teachers and students. STEAM approach; enables critical thinking, questioning, and integration of art and STEM fields from 21st century skills. STEAM approach enables individuals to use creativity and to gain an interdisciplinary and holistic perspective (Educationcloset, 2018; Cook, 2012; Belardo, 2015; Turner, 2017). The 'Fostering STEAM Education in Schools' (EDUSIMSTEAM) project aims to increase 21st century skills in both of teachers and students. The EDUSIMSTEAM project is carried out in Türkiye, in the scope of the project simulations were prepared and presented on the Riders platform. EDUSIMSTEAM project, offered in the Simulearn platform; had two main themes: "Street Lighting Systems Mission" and "Mars Mission". In each prepared simulation, the tasks specified in the instructions are requested to be completed by the participating teachers. While performing the tasks, simple, existing code packages are brought together in various versions and used in accordance with the purpose. In this study; opinions of mentors and participant teachers were received regarding a digital EDUSIMSTEAM application implemented on the Riders application. Teachers working in Denizli, Türkiye participated in the pilot implementation. The branches of the participating teachers; preschool, classroom, informatics, science, English, Turkish, chemistry, biology, geography, visual arts. The opinions of the teachers participated in the pilot application were taken with Google forms. Among the participants, preschool teachers stated that the prepared simulation environment was over the

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level of preschool students. However, it can be used to raise awareness about light pollution. Secondary and high school teachers; stated that EDUSIMSTEAM simulation applications are an innovative and creative examples as they enabled transfer of STEAM applications to the digital simulation environment. Simulations can be used by integrating them into course curricula and topics. Students and teachers stated that digital readiness levels are important in the process of completing the tasks. Also stated that the trial-and-error process is actively used in simulations, can be effective in gaining digital competence as well as the STEAM philosophy for both teachers and students. Simulation of "Street Lighting Systems Task" was understandable and easy to implement, but "Mars Mission" had various difficulties during the simulation application process.

Keywords: *EDUSIMSTEAM, RİDERS, Teachers' -mentors' opinions*

1. Introduction

The 21st century is considered as the age of technology (Erol & Çayak, 2023). Digitalization, which started in the millennium and progressed rapidly, has experienced a digital revolution in education with the pandemic. Research shows that digitalization in education is a necessity of the age and it is effective in gaining competencies such as questioning, critical thinking skills, developing digital competencies, and acquiring problem-solving skills, which are among the skills of the 21st century. Internet, online courses, tablet and the use of some technological products or materials, which have limited access in education in the millennium age, are among the indispensable elements of education that are more easily accessible and widely used today. For this reason, all stakeholders of education widely use digital elements by integrating them into education also in curriculum, and gains expected by students (Raja & Nagısaki, 2018). Technological tools such as the internet, computers, tablets, mobile phones and digital education materials used today have become an integral part of education (Collins & Halvenson, 2018).

While digital transformation is taking place in education, it is inevitable that teachers will be transformed in terms of duty and profession in this process, where it is thought that individuals with increased awareness will take on their own learning responsibilities more and that independent learning is prioritized. As Robertson (2020) emphasizes, teachers who are busy with students of the 21st century need to include digitalized student-centered practices in their teaching process by making changes in their teaching strategy and pedagogical thoughts in order to meet their needs (Kocaman-Karoğlu, Bal-Çetinkaya, & Çimşir, 2020).

Today, there are many researches on the integration of technology and regarding STEAM approach, which enables critical thinking through integration of art and STEM fields in order to foster students' 21st century skills. With the STEAM approach, it is aimed that

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individuals can use their creativity and have an interdisciplinary and holistic perspective (Educationcloset, 2018; Cook, 2012; Belardo, 2015; Turner, 2017). The 'Fostering STEAM Education in Schools' (EDUSIMSTEAM) project aims to increase 21st century skills in both teachers and students. Within the scope of the EDUSIMSTEAM project, the SimuLearn platform, in which STEAM and digital environment are integrated with each other, has been experienced by teachers from different branches via edusimsteam.eba.gov.tr in March. Especially after the COVID-19 pandemic, digital applications developed in the field of education have accelerated and become widespread all over the world. For this reason, the use of digital competencies, which are among the 21st century skills, has come to the fore. EDUSIMSTEAM simuLearn platform is an innovative platform where STEAM and digital applications are brought together.

Benefits of coding education in stem-based applications (Güleryüz, Dilber& Erdoğan, 2020) noted that establishing an algorithm and coding enabled to think analytically on the basis of computational thinking, make operations by considering the programmatic and variables, reaching the solution for the problems in the shortest way, looking at the events and problems from different perspectives. Also being able to think systematically and creatively, learning a real programming (coding) language are ensured. Many studies have been found to support these findings regarding STEM education (Bakırcı & Kutlu, 2018; Çevik & Özgünay, 2018; Özbilen, 2018; Yıldırım, 2018). When these studies are examined, it is noteworthy that there are studies to determine teachers' STEM awareness and their views on STEM education. However, it is noteworthy that teachers' opinions are not taken for digital STEM applications.

Within the scope of the EDUSIMSTEAM project carried out in Türkiye, simulations prepared and presented. Pilot applications of the prepared simulations were carried out with participating teachers who volunteered on the basis of provinces. The purpose of this research is to get their experience and opinions of different branches of teachers who voluntarily participated in the pilot application of the EDUSIMSTEAM SimuLearn platform.

2. Methods

The case study method, which is one of the qualitative research designs, was used in the research. According to Creswell (2007), case study; it is a qualitative research approach in which the researcher examines one or more limited cases over time with data collection tools (observations, interviews, audio-visuals, documents, reports) that includes multiple sources, and defines situations and themes depending on the situation. Case study is a method in which a single situation or event is examined in depth longitudinally, data is collected systematically and what is happening in the real environment is examined. The research was planned in accordance with the case study, with a single criterion sample, which is one of the qualitative research designs.

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50 teachers are in Denizli, Türkiye participated voluntereed in the pilot implementation of the project. The branches of the participating teachers are included; pre-school, primaryschool, informatics (ICT), science, English, Turkish, chemistry, biology, geography and visual arts. The opinions of the teachers also mentors of Denizli who participated in the pilot application were taken by Google forms.

The opinions of the teachers who participated in the pilot application were obtained with the Google forms prepared by the researchers. An survey was prepared by the researchers to get the opinions of the teachers who experienced the simulation application. In the opinion form; there are a total of 10 questions consisting of 3 questions based on demographic information (branch, gender-professional year in teaching) and 7 pre-structured questions about SimuLearn application platform.

The data obtained in the research were analyzed descriptively, and the findings were presented in the form of frequencies, percentages, graphics and tables.

3. Results

In SimuLearn platform there are two main teams one of named "*Future Cities; Detecting Ineffective Street Lighting"* and the other *""Mars Mission; Rock Maze Navigating Robot Development".* 50 voluntary participants of teachers and 2 mentors (one is primary school teacher, one is middle school teacher) were enrolled in different branches including pre- school (16 participants), primary school (9 participants), secondary (middle)- gifted school (21 participants), high school (6 participants). The participants of 8 are science, 9 are primary school,16 are pre-school, 3 are Turkish language, 3 are geography, 3 are English language, 5 are ICT, 1 is Visual arts, 1 is physics, 1 is Maths, 1 is chemistry, 1 is biology teacher. 23% of the participants are males and 77% of them are females.

The opinions of teachers' and mentors' about simuLearn received through Google forms are as in followings:

Pre-school teachers stated that the simulations were high above the student level. However, they said that it can be used to raise awareness about light pollution and Mars mission in students. Pre-school teachers stated that the simulations were interesting but difficult to implement in younger age groups such as in pre- schools.

Primary school teachers and one of the mentor's stated that students can gain 21st century skills through simulations. Especially problem solving, critical thinking, development of digital competencies, using and transferring scientific process skills in digital environment are some of them. In addition, it is stated that students who experience simuLearn platform and the missions, could take the basis of coding teaching with the block-based code system at the

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basic level. At the same time, they noted that by coding with the block-based code system, students can try as many times as they want and reinforce what they have learned and they also can gain an immediate feedback about what they have done, what is working or not.

Middle school, high school and gifted school teachers and one of the mentors stated that SimuLearn simulation applications are innovative and creative. The platform and simulations are useful for transferring STEAM into a digital platform. In addition, they are available for integrating into course curricula and topic items of the curricula implementing in schools. They noted that EDUSIMSTEAM SimuLearn simulations improved digital competences in the process of completing the provided tasks. Teachers and one of the mentors noticed that EDUSIMSTEAM Simulearn simulation applications are innovative, useful, online, coding, attractive simulations aim to foster STEAM approach for both teachers and students in a digital platform.

4. Discussion

STEM in the world regarding the use of coding education in science education within the scope of education especially keeping up with the digital age, an advanced the subject of following technology and its application in the field stands outcome (Güleryüz, Dilber& Erdoğan, 2020). Güleryüz, Dilber & Erdoğan (2020) in their research figures out that the attitudes and motivations of teacher candidates towards coding education have improved positively. Similarly, the opinions of teachers' and mentors' who have experienced the simuLearn are also found commonly to be positive. At the same time, it is seen that they also emphasize that Edusimsteam platform can easily improve the students 21st century skills, digital literacy and coding skills.

When the literature is examined; in the fields of robotics and coding education researches have shown similar results (Datteri, Zecca, Laudisa & Castiglioni, 2013; Gültepe, 2018; Şenol & Demirer, 2017). Unlike the results given above, teachers and mentors participating in the simuLearn stated that simulation of "Future Cities", "Street Lighting Systems Task" was more understandable and more easier to implement. They noted that various difficulties had came across during the "Mars Mission" simulation such as coding the block directions.

5. Conclusion

The opinions of teachers' and mentors' on EDUSIMSTEAM SimuLearn pilot application are; it is found to be innovative, attractive, useful for practising STEAM. It is useful for enhancing 21st century skills such as critical thinking, problem solving, scientific skills process and digital

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competencies either coding or digital literacy. It is noted about the platform as testable and triggering imagination.

Teachers and mentors participating in the EDUSIMSTEAM SimuLearn pilot process stated that simulation of “Future Cities”, “Street Lighting Systems Task” was more understandable and more easier to implement. They noted various difficulties teachers had came across during the "Mars Mission" simulation such as coding the block directions.

As for the last word, John Dewey stated “If we educate today's children with yesterday's methods, we will steal from their tomorrows.” Keeping this sentence in mind, the main task of us as teachers should be to prepare young generations for the future with appropriate materials in accordance with the requirements of the new age. For this reason, in our increasingly digital age, we can guide our students as teachers, who have been in contact with digital from the moment they were born, with innovative applications such as the EDUSIMSTEAM SimuLearn platform and simulations. We can enable them to adapt to the new age by using these digital tools.

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