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EXAMINING EXPERT OPINIONS ON STEAM EDUCATION: A CASE STUDY

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Abstract

The purpose of this study was to examine the opinions of experts on STEAM education. Four experts working in a STEM center and six academicians who gave education and conducted studies in the field of STEM in a state university education faculty participated in the study. The participants were selected on the basis of purposeful sampling. The research data were collected through structured interview forms. There were 12 open-ended questions in the interview forms. The data obtained at the end of the study were analyzed using the qualitative analysis techniques of thematic analysis. According to the results, the experts reported that STEAM education had an important place in the education system; that it gave students a holistic perspective; and that it was especially effective in the development of 21st century skills. The participants found it very important to add art to STEM education. They emphasized that art was very important in the development of students' visual, aesthetic and design skills. In addition, they stated that art should be used in processes requiring visuality and design. Moreover, the participants mostly pointed out that STEAM activities could be carried out in every field and environment. The experts participating in the study stated that they mostly preferred STEAM books, scientific publications and internet resources to learn about STEAM education. They reported that STEAM activities could be used with many methods and techniques of constructivist theory, especially project-based learning. The participants in the study emphasized that teachers willing to carry out STEAM activities should receive training from experts and develop their 21st century skills. The participants expressed the age of starting STEAM education as the pre-school age in general, and they thought that the implementation processes of STEAM activities were not easy for various reasons. In STEAM training practices, some of the participants considered themselves as sufficient, and some as inadequate. They also stated that the current conditions in learning environments were insufficient for STEAM applications.

Keywords: STEAM education, STEM experts, opinion

1.Introduction

As it is known, there have been very important changes in science and technology recently. The reflections of this change are noticed in every area of daily life. What is expected from 21st century individuals is to keep up with this dizzying change. In particular, individuals should be equipped for technological developments and constantly renew themselves. If they fail to renew themselves, they will not be able to keep up with the current era or achieve any progress because there is a competition in this direction in the world. Productive societies can now be more active and decisive in the world. For example, societies that produce and market their products to the world are economically stronger and more independent. For this, great importance is given to production in developed societies. There are some basic needs for effective production. STEM education (Science, Technology, Engineering and Mathematics),

which first emerged in the United States in order to meet these needs, aims to teach one STEM discipline by integrating it with another STEM discipline in line with the interests and life experiences of students and teachers, and it aims to develop a critical and relational perspective towards problems (Çorlu, Capraro and Capraro, 2014; US Department of Education, 2010; Şahin, Ayar and Adıgüzel, 2014; cited in Yıldırım and Gelmez-Burakgazi, 2020). STEM education emerged because of the need to approach problems with a holistic perspective in individuals (Bybee, 2011). For this, starting from the basics, students are provided with training within the framework of acquiring the 21st century skills. Among these skills are primarily critical thinking, cooperation, communication and creative thinking skills. In order to gain these skills, new methods and techniques were developed and put into practice in many areas, especially in formal learning environments. Among these is the STEM approach, which is based on interdisciplinary relations and which has become very popular recently. The initials in STEM refer to science, technology, engineering and mathematics in English. In recent years, the letter "A" has been added, and it is seen that the colorful and dynamic effect of "art" was not ignored while bringing these disciplines together. In this way, STEM took its place in the literature as STEAM. The fact that the aesthetic and visual effect found in nature and in human exists in learning environments will provide an invigorating and movement effect in the learning products to be revealed by the students.

1.1.STEAM Approach

As mentioned above, the STEAM approach is an educational approach that emerged with the addition of art to STEM disciplines, namely to the areas of science, technology, engineering and mathematics. In studies on STEAM education, it was emphasized that aesthetics, as well as creativity and design, will make an important contribution to the education process (Eger, 2013; Azkın, 2019). STEAM education is a holistic education that purposefully includes current fields and subjects (Park and Ko, 2012; cited in Azkın, 2019). Art emerges as a locomotive force with the effect of creativity and design on STEM disciplines, which naturally coexist in project and product design processes. Learning environments can become flexible, exciting and more fun as students integrate art into the process because with art, the limits of students' imaginations can expand and they can feel the relaxing effect of art in learning environments. Stating that STEAM was a bridge combining science and art, Belardo (2015) pointed out that science and art were similar in many ways and explained how STEM could turn into STEAM in class. With STEAM education, significant contributions are made to the physical, intellectual and cultural world of students and to the development of their self-efficacies such as critical thinking and problem solving (Çorlu and Aydın, 2016). In addition, when students enter the business world, they can easily adapt to the qualifications required by business life, thanks to these superior skills (Erdoğan, 2020).

1.1.1. STEAM approach in Turkey

The abbreviations of the words of Science, Technology, Engineering, Art and Mathematics, which are mostly used as STEM in Turkey, were transferred into Turkish as FETEMM. In fact, although the letter S in the English abbreviation covers both science and social fields, it was transferred to Turkish in this way. Later, considering the dimension of art, the STEM approach started to be used as STEAM education. Unfortunately, studies in the field of STEM, or STEAM as it is now known, were started quite late. In Turkey, there was no strategic action plan prepared for STEM education by the Ministry of National Education in 2015 and before (Çavaş, Ayar, Bula Turuplu and Gürcan, 2020). Between 2013 and 2014, the curriculum was changed, and activities and studies were included to make teachers, students and the school environment more active in the education process, to transfer knowledge, to increase creativity, and to create lifelong learning habits and experience (MEB, 2018). Since 2016, the importance given to STEM or STEAM has started to increase in Turkey, and the

Ministry of National Education revealed the requirements for integrating STEM into the education system by publishing the STEM Education Report and prepared an action plan with nine items (Türk, 2019).

The number of young people in Turkey is quite high when compared to developed countries. This is considered to be a very important advantage in order to have an effective place in production in the world. Starting from pre-school, qualified individuals can be raised with STEAM trainings, which will then allow becoming an important power in the world, especially in the economic field. Therefore, it is thought that importance should be given to STEAM education especially in the business world. According to the STEM report published by TUSIAD (2017), the young population in Turkey has an important potential, and initiatives and innovation will increase with the development of innovative thinking in order to reveal this potential. In addition, the same report suggests that a workforce of individuals who are creative, innovative and capable of interdisciplinary thinking and who have the necessary skills in technology and digitalization should be created by providing these young people with the STEM infrastructure. Moreover, TÜSİAD determined STEAM as one of the priorities, emphasized the importance of STEAM education and the need for STEAM workforce in the information society, and aimed to help take the necessary steps together with experts in order to increase the interest of the young population in STEAM issues and to raise their knowledge and skills in this field (Azkın, 2019).

1.2. Importance of the Study

As mentioned above, it was seen that STEM/STEAM education in Turkey has been given more importance by the Ministry of National Education since 2016, both through the arrangements in the course content and the related studies carried out. Furthermore, STEM centers have been opened in many provinces of Turkey in recent years, and they continue to open. Teacher and student trainings are provided in these STEM centers. In addition, there are many academic studies conducted by scientists in the literature. When these studies were examined, it was generally seen that they were conducted in the form of surveys (Gürliyenkaya Baş, 2020; Baran et al., 2020) experimental research (Uştu, 2019; Şahiner and Ünlü Koyunlu, 2022) and document analysis (Sakdiah, et al, 2022; Çavaş et al., 2020). Also, it was seen that the studies examined the cognitive and affective effects of STEAM applications on students after experimental procedures (Bozkurt, 2019; Yıldırım, 2021), pre-service teachers' views about STEAM education (Yıldırım, 2021) and general tendencies of STEAM studies (Gülhan, 2022; Aguilera and Revilla, 2021). However, in both national and international literature, the number of studies which discussed the opinions of field experts about STEAM applications was quite limited. However, it was thought that various problems might be experienced in the perception and execution of STEAM education, whose importance is gradually increasing more and more in Turkey as well as in the world. Katz-Buonincontro (2018) stated that there was an important gap in STEAM applications. STEAM experts and educators have an important role in forming the theoretical framework of how STEAM should be applied in the classroom, in developing the related curriculum and/or in ensuring its implementation (Land, 2013, cited in Kahya and Özdilek, 2021). Therefore, it was thought that taking the opinions of field experts about STEAM applications could contribute to the execution of these applications with better quality in learning environments. In this study, based on these deficiencies in the literature, the experts working in STEM centers and the instructors who gave education and conducted studies in the field of STEM at universities were asked for their opinions about STEAM education. It is thought that the results obtained in the present study could provide guidance and ideas to educators and students who conduct STEAM education, who want to take STEAM education, who want to carry out studies on STEAM education.

1.3. Purpose of the Study

In this study, the purpose was to examine the views of STEM education experts about the STEAM approach and applications. In addition, the findings obtained at the end of the study are thought to enrich the related literature and to provide the interested audience with a resource that they can make use of in their future scientific studies.

1.4. Research Problem

In this study, the data were collected based on the problem of "What are the opinions of STEM education experts about the STEAM approach and applications?"

2. Method

In the study, the special case research design, which is one of the qualitative research methods, was used. The special case study is an empirical research design that explores a contemporary phenomenon in depth and in a real-life context, when the boundaries between the phenomenon and the context are not clear (Yin, 2009, cited in Kahya and Özdilek, 2021).

2.1. Participants

While selecting the participants in the study, experts working in the STEM center and faculty members who did a postgraduate thesis in the field of STEM education at a state university, who made scientific publications and who gave lectures and took part in STEM commissions were taken into consideration. Four of the ten participants in the study were in the position of trainers in the STEM center. In addition, one of the six academicians participating in the study was the founder and director of the STEM center of a state university. The remaining academicians, on the other hand, studied in the field of STEM and took part in the monitoring and evaluation commission of STEM center activities. Four of the participants were male, and six were female.

2.2. Data Collection Tool

In this study, the Form for Field Experts' Opinions about STEAM Education made up of 12 open-ended questions developed by the researcher was used as the data collection tool. While developing the data collection tool, the literature on the subject was first reviewed, and an item pool consisting of questions investigating the opinions about STEAM education was created. The preliminary opinion form including 18 questions was reduced to 12 questions in line with the expert opinion. As a result, the opinion form was made ready for data collection.

2.3. Data Collection

The interview form, which was made ready for application by the researcher, was sent to the field experts via e-mail. The time to answer the questions in the interview form was estimated to be approximately 40 minutes.

2.4. Data Analysis

The data obtained in the study were presented as a report using the thematic analysis technique. The thematic analysis, which was carried out in line with the deductive approach, is based not only on the descriptive and contextual analysis of the qualitative data obtained from research on a subject but also on determining the tendencies and getting results (Çalık and Sözbilir, 2014). Thematic analysis studies are a rich source for researchers who lack the opportunity to make a general evaluation of the studies in the field and to reach all the resources in the field (Ültay and Çalık, 2012). The analyses were conducted by the researcher and by another faculty member who was an expert in field education. Based on the data obtained in the study, the themes were first identified using the deductive approach. Next, the categories, which were the sub-themes for these themes, were created, and the codes for these categories were determined. In this process, the participants were coded with symbols such as K1 and K2. In order to ensure the reliability of the data analysis, the consensus among the coders was calculated with the Miles-Huberman reliability coefficient, and it was found to be 0.90.

3. Findings

The data obtained in the study were analyzed, and the findings are reported in Tables below. The views of the participants about the importance of STEAM education are presented in Table 1.

Table 1. *Results of analysis regarding the theme of importance of Steam education*

Category	Codes	f
21st century skills	Acquiring the 21st century skills and revealing these skills .	6
	Development of imagination	1
	Development of communication and cooperation skills	1
	Development of critical, creative and analytical thinking skills	2
	Contributing to the problem-solving skills	1
	Preparing projects and developing the ability to produce these projects	1
	Allowing the emergence of new competencies in the Industry 4.0 era	1
Importance of design	The higher need for engineering processes than ever	1
	STEAM education including the engineering design process	1
	Importance of design-based teaching activities	1
Reflections on science education	Providing the opportunity to strengthen science knowledge	1
	Providing a different perspective to science education	1
	Allowing the production of rational and applicable solutions	1
	Contributing positively to the interest and motivation in science education	1
	Being the most effective approach to science education	1
Reflections on daily life	Daily life and school as a whole	3
	Allowing schools to turn into living spaces	1
	Providing information transfer to the current life	2

As seen in Table 1, the STEM education experts reported why they found the STEAM approach important. The views of the participants revealed that they generally emphasized the 21st century skills, the importance of the design dimension in the STEAM approach, and its positive reflections on daily life and science education.

Some of the participants' opinions were as follows:

"STEM education was determined as an education policy in the United States for the first time with the aim of integrating technology into science and mathematics education, and then it spread throughout the world. STEM education is a useful approach in terms of providing students with the 21st century skills and creating products by using these skills." (P3)

"Engineering processes are needed more than ever in today's contemporary educational understandings. As STEAM education is an education that includes the engineering design process, it is quite important for all countries to carry out teaching activities with the design process in accordance with their own education policies and at the required level." (P1)
"It is because STEAM is an interdisciplinary education method. Through STEAM education, individuals have the opportunity to strengthen their science knowledge as well as develop their transferable skills, that is, the skills that they can use in real life. In addition, the added art dimension makes a positive contribution to students' interest and motivation in science education and offers a different perspective to science education." (P2)

The opinions of the experts participating in the study about the role of art in STEAM education are given in Table 2.

Table 2. *Results of analysis regarding the theme of the importance of art in STEM education*

Category	Codes	f
Contributions	Allows original designs	6
	The effect of aesthetic and visual details on the development of students	4
	Providing a holistic perspective	2
	Developing creativity	3
	Contributing to originality, flexibility, fluency, harmony, aesthetics	2
	Acting as a bridge between STEM and real life	2
Reasons	Impressiveness of aesthetics, visuality and design	6
	Being the basis of creativity in STEAM activities	4
	Artistic activities being an indispensable, necessary element of STEAM	2
	Other	8
Phase	In the design process of the product	5
	In any dimension of the process	4
	At the step of drawing attention and transfer	1

(Other codes: The tendency of "human" towards searching the artistic and the "beautiful" (1), beginning of engineering with art and design (1), Art within science and science within art (1) ensuring permanence (1) art being in all areas of life (1) application constituting the basis, (1) visualizing mathematics (1) making presentations effective in patterns and cycles in nature (1)).

According to the findings in Table 2, the participants stated that art made quite an important contribution to the STEAM approach. The participants reported that art should be in the STEAM approach for original designs and that visuality, design and presentation were effective. In addition, it was revealed that the participants had various views about the stage of integrating art into STEM. Some participants stated that art could be integrated at the design and product creation stages of the process, while others thought that it could be integrated at any stage. The opinions of the participants in relation to this theme are presented below:

"By including art and design into STEM education, students can approach to problems with a holistic perspective. By integrating art into the fields of science, technology, engineering and mathematics, the creativity of art and design makes a significant contribution to the educational process. The first step of products developed in the fields of engineering and technology begins with art and design." (P4)
"Art can be the driving force of STEM, and the art dimension can serve as a bridge between STEM and real life. Through the art dimension, students can establish the relationship between other disciplines and real life." (P2)
"From the visualization of mathematics to the design of an innovative product, art can be used effectively in the patterns and cycles that exist in nature, or for the purpose of making a presentation effective. The stage at which it will be put into force is related to the weave of the activity." (P7)
"It would be appropriate to use art and STEAM education at the stage of transforming projects into products." (P6)

The views of the participants about the reflections of STEAM education on the students are given in Table 3.

Table 3. *Results of analysis regarding the theme of reflections of STEAM education on students*

Categories	Codes	F
Personal effects	Holistic structure	4
	Effective Learning	4
	Self-discovery	2
	Engagement in school	2
	Intrinsic motivation	2
	a different perspective	2
	Other	8
Influence on the 21st century skills	Cooperation	5
	Critical approach	5
	Creativity	4
	Communication skill	3
	Responsibility	2
	Productivity	2
	Entrepreneurship	2
	Dreaming	1
	Respect	1
	Problem solving	1

Transferring to daily life and its effect on other areas	Putting knowledge intro practice	3
	Solving real life problem	2
	Development of future generations	1
	Understanding the role of art in education	1

(Other codes: Positive interest and attitude towards lessons, learning to be a happier, freer and more independent learner, willingness to participate in projects, Development of one's intellectual and cultural world, Time perception change, Occupation choices, Following current developments)

According to the findings in Table 3, the experts who took part in the study mostly stated that the STEAM applications developed a holistic perspective in the students, allowed them to discover themselves, helped achieve effective learning and increased their intrinsic motivation. In addition, the participants reported that the STEAM applications were effective in the development of the students' 21st century skills, especially cooperation, critical thinking and creativity. Moreover, the participants emphasized that the STEAM activities enabled the students to use their academic knowledge in daily life. The expert opinions about this subject were as follows;

"STEAM education applications are important in terms of creating a holistic structure of the knowledge that students have in the fields of science, technology, art, mathematics and engineering. STEAM education applications allow students gain an entrepreneurial qualification." (P1)

"They will be more interested in the lesson, have a higher sense of belonging to the school and become happier and free, and success will help them develop their skills in cooperation, critical thinking skills, sense of responsibility, creativity and communication and contribute to their development in the process." (P10)

"It contributes to the development of many skills simultaneously. Although it is not suitable for every outcome, when used effectively, it gives the chance to reveal new ideas and to put forward products by activating their 21st century skills. It allows students to work collaboratively to produce a common design while respecting other ideas. Thanks to the idea of integrating art and other disciplines, they approach problems from different perspectives and try to find appropriate solutions and can transfer this process to their general lives." (P8)

The opinions of the participating experts about the areas that they considered suitable for STEAM applications are presented in Table 4.

Table 4. *Results on the theme of areas that STEAM applications were suitable*

Codes	f
In science lessons	1
Applied activities and those which will allow putting forward a product	1
In all areas	8

According to the findings in Table 4, a significant majority of the experts participating in the study stated that STEAM applications were applicable for every field. In addition, it was revealed that they placed little emphasis on science lessons and applied activities. The opinions of the participants were as follows;

"STEAM education aims to enable students to use what they have learned in science and mathematics lessons together with engineering and technology in daily life. STEAM education

can also be given in social fields (law, sociology and geography etc.) to facilitate daily life." (P1)
"Since one of the STEAM elements is "science", STEAM can be applied to any field: Vocational courses, science education, social sciences, art courses, mathematics etc." (P4)
"Actually, since STEAM is an approach, it is not appropriate to make such a distinction. It can be applied to every field and discipline if the basic principles are taken into account." (P 2)

The opinions of the experts about the methods and techniques suitable for STEAM education are given in Table 5.

Table 5. *Results of analysis regarding the theme of methods and techniques suitable for STEAM education*

Category	Codes	f
Appropriate to the constructivist theory	Project-based learning	7
	Based on research-inquiry	6
	5E model	5
	Other	13

According to Table 5, a significant majority of the experts participating in the study emphasized project-based learning, inquiry-based learning and the 5E model in STEAM applications. The opinions of the some participants about this theme were as follows;
"Activities can be carried out with problem-based learning, project-based learning, cooperative learning method, context-based approach, learning-by-doing approach, research-inquiry method, and argumentation method. It is known that these methods and techniques, STEAM-based activities, are beneficial in terms of developing students' imagination, collaborative working environment, creativity and problem-solving skills." (P1)

"STEAM activities can be done with methods such as 5E learning model, inquiry, project-based learning, and problem-based learning." (P6)

"Steam activities can be carried using a wide variety of methods and techniques such as discussion method, lecture method, problem-solving method, and project-based teaching method." (P5)

The views of the participants about the age of starting STEAM education are presented in Table 6.

Table 6. *Results of analysis regarding the theme of the starting age for STEAM education*

Category	Codes	f
Pre-school	Discovering oneself	1
	Development	1
	Self-confidence	1
	The imagination being most active	3
	The period most appropriate to creativity	4
	Easy and fast learning	3
Elementary school	As they are in a period of concrete operations	2

According to the findings in Table 5, a very significant majority of the participants stated that STEAM education should be started from the pre-school period because in this period, individuals have the highest knowledge and learning speeds as well as because creativity can develop most in this period. In addition, some of the participants stated that it would be more appropriate to start STEAM education in primary school as it is the concrete operational period. The opinions of the some experts about this were as follows;

"In my opinion, students can start STEAM activities at a young age, and pedagogically appropriate activities can be applied from a young age. Children have the chance to learn more easily and quickly at younger ages, so entertaining STEAM activities can be organized for students without too much cognitive load, and children's life skills can be developed from this age on." (P4)

"STEAM education should start at preschool age because it is the age when the imagination of individuals is most active, and this is a suitable age for them to transform their imagination into creative ideas, to learn to question and to think critically." (P7)

"Students should start this from kindergarten because I think it is the period when students' perceptions are most open, and they get information the fastest. For this, knowing STEAM will help develop themselves much more." (P3)

The opinions of the experts about the resources they used for STEAM education are presented in Table 7.

Table 7. *Results of analysis regarding the theme of resources used by experts for STEAM education*

Category	Codes	f
To get information	STEAM-related books	5
	Education reports	1
	Internet	2
	Scientific studies	6
	Museums, art centers	1
To do practice	Laboratory tools,	2
	Recycling materials,	1
	Curriculum prepared by Ministry of National Education,	1
	web 2.0 tools,	1
	digital applications,	1
	Pinterest	1
	Lesson plans on websites	2

According to the findings in Table 7, a significant majority of the experts who participated in the study stated that they used scientific research and books to get information about STEAM education and that they used STEAM lesson plans in laboratories and websites for their practices. The opinions of the participants in this regard were as follows;

"I usually use external sources. Pinterest offers very good sample applications in this context." (P9)

"We use the curriculum developed by the Ministry of National Education, open-source lesson plans shared on the Internet, and web 2.0 tools. In this respect, we can structure the learning scenario suitable for the desired outcome."(P7)

"Usually, scientific research resources (articles, theses, education reports, etc.)." (P8)

The views of the participants about the difficulty of STEAM applications are given in Table 8.

Table 8. *Results of analysis regarding the theme of difficulty of STEAM applications*

Category	Codes	F
Difficult	Inadequate physical conditions	3
	Lack of teacher's qualifications	4
	Exam-oriented education systems	3
	Understanding of traditional education	2
	Socio-economic difference	1
	Inequality between students	1
	Perception of imaginary STEM	1
	Being away from STEAM outcomes	1
	Perception of unnecessary education	1
	Preparation	1
	Need for pilot application	1
	Differences between students	2
	Need for the use of digital tools	1
	Need for effective process design	2
	Being time-consuming	1
	Being difficulty to integrate disciplines	2
Not difficult	Good planning	2
	Removing prejudices	1
	Belief in an innovative education approach	1
	Very simple materials	1
	An appropriate curriculum	1
	Taking STEAM education	1
	Individual effort	1

According to the findings in Table 8, most of the experts participating in the study found STEAM applications difficult. As reasons for this, they emphasized the lack of physical conditions, lack of teachers' qualifications and exam-oriented education systems. On the other hand, some participants reported that STEAM applications could be prepared using simple materials with the effective planning and effort of the teacher. The opinions of the some participants about this were as follows;

"*In particular, some activities require materials. This is costly. In addition, it is difficult to find well-qualified teachers who lack adequate training on this subject. Since it requires a process, it may not be suitable for the lesson time. Exam-oriented systems may not be appropriate, either*." (P5)

"It is not easy to implement STEM applications in exam-oriented education systems like in Turkey. In a society where socio-economic diversity is high, STEM education increases the inequality among students who do not have equal opportunities." (P1)

"In fact, it's not as difficult as you might think. All it needs is good planning." (P9)

The opinions of the participants about the perception of efficacy are given in Table 9.

Table 9. *Results of analysis regarding the theme of the experts' perception of efficacy*

Categories	Codes	f

I am efficient	Organizing, developing and coordinating the activities	1
	Guiding students and teachers in educational subjects	2
	Doing STEM studies for a long time	2
	Team work	1
I am not efficient	Robotic coding	1
	Application	2
	Art dimension	2
	Need for a roadmap	1
	Being an area open to constant development	2

According to the findings in Table 9, some of the participants found themselves sufficient in STEAM applications. They stated that they had been doing STEAM applications and studies for a long time; that they trained teachers on STEAM education; and that they improved themselves on teamwork STEAM education. In addition, some of the participants stated that they did not consider themselves fully sufficient; that they had deficiencies in adding the application and art dimension to the process; and that STEAM areas were those open to continuous development. The opinions of the participants about this were as follows;

"Actually, it is very difficult to say that I feel adequate about the application of STEM education. I need a roadmap for this. I also need to seek the guidance of an expert working on this subject. I think it is a difficult process to come up with something in the art dimension by integrating many fields." (P5)

"I find myself largely sufficient, though never completely. About 4 years ago, I carried out a series of studies in the field of STEAM and wrote and conducted projects. In this respect, I can say that I can be sufficient in practice to a large extent." (P3)

"I consider myself somewhat competent, but I am not creative enough to do a lot of STEAM activities. Particularly, the aspect of art concerns me the most because what exactly does the word "art" mean? That is, does art have an aesthetic meaning here (for example, the harmony of the leaves falling on the ground); or is it an activity where art is applied (music, cinema, dance, etc." (P4)

The opinions of the participants about the suitability of the available facilities with STEAM applications are given in table 10.

Table 10. *Results of analysis regarding the theme of availability of facilities for STEAM applications*

Categories	Codes	f
Based on the teaching environment	Inappropriate workshops and labs	2
	Lack of tools	5
	Environments not appropriate to STEAM education	5
	High cost	1
	Failure to integrate technology	1
Based on the teacher	Lack of qualification	2
	Creativity being required	2
	Negative attitude	1
	Need for 21st century skills	1
	Adoption of STEAM understanding	1
Student-based	Negative approach	2

Curriculum-based	Higher education course being inappropriate	1
	Deficiencies in the current curriculum	1

According to the findings in Table 10, the participants mostly pointed out the problems related to the teaching environment regarding the suitability of the available facilities with STEAM education. In addition, some participants also emphasized the problems of teachers-students and curriculum. Some of the opinions of the participants in this direction are presented below

"Currently, the present situation in schools and the curriculum content are likely to prevent some studies from being carried out." (P9)

"Not suitable. STEAM applications need flexible learning environments. In other words, instead of traditional classrooms - in which students cannot sit facing the board or interact with each other - they sometimes require a classroom environment that can be transformed in a way to increase the interaction between students, and sometimes, they allow them to work individually and conduct research." (P7)

"STEM education, like all modern approaches, is activity-based and student-centered. Although some educational institutions are lacking in material, STEM education can be done well or badly even with every day and waste materials. It also depends a bit on the individual efforts of our teachers, who are business practitioners." (P2)

The opinions of the participants regarding their suggestions for STEAM applications are presented in table 11.

Table11. *Results of analysis regarding the theme of recommendations for STEAM applications*

Category	Codes	f
Student	Effective team work	4
	Achieving active participation	4
	Applications allowing the development of the 21st century skills	3
	Discovering oneself	2
	Motivating the students	1
Learning environment	Infrastructure and appropriate educational environments	5
	Class level	2
	Class size	2
	Selecting the institutions in line with the purposes where STEAM activities will be applied in common	1
Field knowledge	Goal analysis	6
	Having a holistic view of STEAM	4
	Being knowledgeable about the process and course content	3
		3
	Being knowledgeable about the engineering design processes	2
		2
	Being knowledgeable about constructivist learning and project-based learning	2
		2
	Time management	2
	Effective lesson plans	

According to the findings in Table 11, the experts who participated in the study stated that during STEAM practices, teachers should make students work effectively in teams and act in a way to allow them to discover themselves and that the physical conditions of the learning

environment should be regulated by considering class size, level and existing infrastructure. In addition, it was emphasized that teachers should have a good command of the process and that they should be equipped especially in subjects such as goal analysis, time management, handling STEAM as a whole, and lesson plans. The opinions of the participants regarding this are presented below;

"They should pay attention to the target audience, the content and the lesson plans prepared in this context." (P9)

"Since constructivist learning and project-based learning are the main pillars of STEAM education, first of all, the logic of constructivist learning and project-based learning should be fully understood. Also, in line with whatever is important while giving education based on these approaches, the necessary steps should be applied as they should be." (P2)

"The time must be carefully planned; preparations must be made; and possible disruptions must be considered. Grade level, class size, achievement, infrastructure and opportunity must be taken into consideration." (P10)

The opinions of the participants about their suggestions to teachers who want to take STEAM education are given in table 12.

Table 12. *Results of analysis regarding the theme of suggestions to teachers who want to take STEAM education*

Categories	Codes	f
Things to be done	Following STEM centers	1
	Taking constant education	2
	Being aware of STEAM	4
	Reviewing the literature	4
	Dedication and effort	3
	Taking STEAM education from experts	3
	Adopting modern approaches	2
	Positive attitude	1
	Goal analysis	1
Efficacies	Having 21st century skills	3
	Cognitive, psychomotor and affective efficacy	3

According to the findings in Table 12, a significant part of the experts who participated in the study thought that teachers should adopt and be aware of STEAM education; that they should take STEAM education from people who have proven their expertise in this field; and that they should read the literature on STEAM. In addition, they stated that teachers should have skills such as 21st century skills and that they should be able to create a STEAM lesson plan and take into account the physical conditions of the learning environment. The opinions of the participants in this direction are presented below;

"*Some of our universities have STEM education centers, and trainers are trained in these centers. They can follow these centers and attend trainings or seminars suitable for their own development."* (P2)

"Training alone is not enough. The teacher who starts and adopts this process should embrace continuous improvement. They should receive continuous training and read and repeat the practices regularly. Especially instructors and institutions who have proven their competence in this field should be preferred." (P10)

"Teachers who want to take STEAM education should first adopt the teaching methods which can serve this understanding and which have a positive attitude towards it. Also, they should cognitively read some important resources on this subject and examine some products that came out with STEAM. I also think that they should have the lowest level of emotional and psychomotor competence in applying them." (P5)

4. Discussion

At the end of the study, when the opinions of STEM education experts about the importance of the STEAM approach and its contributions to the students were analyzed, it was revealed that they generally emphasized the 21st century skills, the importance of the design dimension in the STEAM approach, its positive reflections on daily life and science education, and that this type of education contributed to the personal development of the students. In the literature, there are studies emphasizing the importance of STEAM education (Çorlu, 2012; Baran et al., 2016; Siew, Amir, and Chong, 2015). In our changing and competitive age, students also need skills that will enable them to keep up with this change. Among these come the 21st century skills first. The curricula in which STEAM (Science, Technology, engineering, art, mathematics) education is integrated have an important role in the development of students' participation in the process, imagination, innovation, problem solving and other skills (Liao, 2016). In the literature, there are many studies stating that STEAM education has an important role in the development of 21st century skills (Tunç and Bagçeci, 2021; Şahin et al., 2014). It was pointed out that it had positive contributions such as increasing motivation and interest, developing scientific process skills and psychomotor skills, developing creativity and productivity, gaining a positive perspective, enabling them to spend productive/enjoyable time in science classes, allowing them to be successful in other fields and gaining sense of responsibility. Sighn (2021) stated that STEAM education had important effects on the development of critical thinking, creativity, cooperation, and communication skills, which were the 4Cs of the 21st century skills. The author also stated that students would approach daily life problems by using these skills. Biblokaite, Bilbokaitė-Skiauterienė, and Šlekienė (2019), in their study in which they examined the opinions of expert trainers on STEAM education, stated that the cognitive processes of students were activated with STEAM activities and that they were able to establish a connection between real life and school knowledge. The experts participating in the study emphasized that science education would become stronger with STEAM education and that the students would develop in areas such as holistic approach, effective learning, and self-discovery. Biblokaite, et. al, (2019) pointed out that the school knowledge gained through STEAM education is more profound and permanent. Supporting the opinions of the experts in the study, Oh, Lee and Kim (2013) also stated that STEAM activities developed an interdisciplinary perspective in students.

Regarding the importance of art in STEAM education, the experts participating in the study stated that art should be in the STEAM approach for original designs and that visuality, design and presentation were effective. The participants pointed out that art was an integral part of STEAM education; that it was necessary to create different original designs; that it developed creativity and a holistic perspective; that visuality and aesthetics were effective in the presentation of the product in learning environments, as in many other fields. In a study conducted by Kahya and Özdilek (2021), STEM experts stated that art was effective in creating original designs, developing creativity and interdisciplinary thinking and that aesthetic perception was important. Katz-Buonincontro (2018) stated that the integration of art created opportunities for new learning emerging in the applied design and production process with the use of creative thinking and problem solving and that it was an integral part of the development of such cognitive skills as communication, creativity, imagination, observation, perception and thinking, and problem solving and decision making, for both students and teachers (Cited in Kahya and Özdilek, 2021). The experts participating in the study emphasized that art should

be employed more in product and design processes. Some of the participants stated that art could be included in the process at any stage with lesson planning. In literature, Kahya and Özdilek (2021) stated in their study that some experts thought art should be included in the design dimension. However, most of the participants in the same study reported that art could be included in the process at any stage. Art is a phenomenon that exists spontaneously in nature and science. Therefore, STEAM Education emerged on the basis of the need for the concept of art within STEM fields (Özkan and Topsakal, 2017). It is possible to say that art, which is in all areas of nature and life, can be integrated in any process of education. Gess (2007) also stated that, similar to the results of the study, art could be integrated into every stage of learning environments.

In the study, the participating experts stated that the methods and techniques suitable for the constructivist theory, in which the teacher is the guide and the student is at the center, could be used in STEAM education. The participants thought that the STEAM applications were most suitable for project-based learning, inquiry-based learning and the 5E model. The common aspect of these models and methods mentioned is that in all three of them, students conduct research very effectively and that a result or product emerges at the end of the research. When we look at the literature, it is seen that there are many studies showing that these methods and models are frequently used in STEAM education (Rahmania, 2021; Şahin, 2013; Hacıoğlu, 2020). One transdisciplinary teaching approach contributing to learning and collaborative, critical thinking and problem-solving skills, which are all goals of STEAM, is PBL (Herro and Quigley). Topalska (2021) found in her study that teachers mostly used the project-based learning model while conducting STEM activities. Baran et al. (2021) conducted STEM activities according to the project-based learning model and achieved effective results. t was revealed that many STEM studies were planned based on the 5E model (Kaniawati, Kaniawati, and Suwarma, 2017; Eroğlu and Bektaş, 2022).

In the study, a significant majority of the participants stated that STEAM applications could be carried out in all areas. They stated that STEAM was an effective approach for both social and science fields in order to facilitate daily life. When we look at the literature, the word "science" in the first letter of STEM referred to science, and it was used in Turkish as FETEMM. Therefore, it is generally concluded that STEM fields are more suitable for science fields. The experts participating in the study made this distinction clearly. In the literature, it is reported that STEM education does not only cover science but also social areas (Bybee, 2010; Sanders, 2009; cited in Uştu, 2019). In its translation, also known as BILTEMM, the word "science" is translated as "bilim (meaning ‘science’ in Turkish)". It is thought that this translation is more appropriate in terms of covering all areas.

In the study, most of the experts stated that the pre-school age was the most appropriate age to start STEAM education. As a reason for this, they cited the highest level of imagination, creativity and learning capacity at this age. Some participants stated that individuals who had been acquainted with STEAM activities from an early age could become investigative and critical individuals throughout their lives. Many studies were conducted on the age at which STEAM education started. By emphasizing the developmental characteristics of this period, the participants thought that it would be appropriate to give STEAM education at an early age. In all of the studies carried out, this education should start from an early age (Aronin and Floyd, 2013; Başaran, 2018; cited in: Erol and İvrendi, 2021). These are the ages when the sense of curiosity and discovery is at the highest level (Kahraman, Ceylan, and Ülker, 2015). The characteristics of this period are the most basic features sought in students for STEAM activities.

The experts participating in the study stated that they mostly used scientific studies and books related to STEAM as a source to obtain information about STEAM education. They

stated that they used resources such as laboratory materials, lesson plans from the Internet, recycling materials and school curriculum while carrying out the applications. Topalska (2021), in her study, stated that the participants mostly used video materials as a source in STEAM activities, while they used laboratory and STEAM plans similar to the findings in this study. As it is understood from the opinions of some experts who participated in the study, there was no need for very complex and hard-to-access materials to carry out STEAM activities. It is thought that STEAM activities could be designed using simple materials (Baran et al., 2021). While a significant part of the experts participating in the study stated that STEAM applications were difficult, some reported that STEAM applications were not difficult. The experts who found STEAM applications difficult mostly emphasized physical inadequacies, lack of teachers' qualifications and exam-oriented education systems. Physical inadequacy and exam-oriented education systems, which stood out in the findings, are very important negative factors not only for STEM education but also for student-centered applications of the constructivist approach in general (Baran, 2016). Li et al. (2022) mentioned the problems experienced in relation to the STEAM applications, inadequately qualified teachers, discontinuous development and integration of disciplines. Geum and bae (2012) pointed out that teachers carried out very few STEAM activities in the classrooms due to the insufficient STEAM education infrastructure. Even though the teachers were aware of STEAM education, most of them still were not clear on how to do practice (Herro and Quigley, 2016). Teachers may experience self-confidence problems, especially in applied activities such as laboratories (Bayram, 2015). Batty and Reilly (2022) also mentioned lack of self-confidence in practitioners. Some expert participants stated that there would be no difficulties in the execution of STEAM activities with effective planning, adoption of modern approaches and individual efforts of the teacher. One participant stated that STEAM education was already parallel to the curriculum and that it was possible to do STEAM education under any circumstances.

Another result obtained in the study was that although some of the experts considered themselves competent in STEAM applications, they did not find themselves sufficient in terms of application, robotic coding, art dimension and the need for constant updating. However, some participants considered themselves sufficient in coordination and teacher-student education. Others stated that they considered themselves sufficient, saying they had been working on STEAM for many years thanks to their teamwork contributions. Considering the opinions of the experts, it could be stated that they considered continuous development and specialization as basis in certain subjects. This finding was not surprising considering the fact that some of the participants in the study were academicians and some of them were experts working actively in STEM centers. On the other hand, in one study conducted with STEM teachers, Arnado, Pene, Fuentes and Astilla (2022) reported that the participants found themselves to be highly competent in laboratory practices and moderately in science teaching. Most of the experts participating in the study stated that the existing learning environments were not sufficient to carry out STEAM activities. However, emphasizing lack of teachers and negative attitudes of students, the participants reported that STEAM was not included in the higher education curriculum and was not sufficiently included in other levels. In one study with teachers who received STEM education, Eroğlu and Bektaş (2016) stated that the teachers had shortage of materials while conducting STEM activities. For many parts of the world, the problem of lack of learning environment and qualified teachers is thought to be similar. Landicho (2020) considered lack of financial support for STEAM education applications as an important problem. In their study, Biblokaite, Bilbokaitė-Skiauterienė and Šlekienė (2019) found that education specialists did not have laboratory competences to carry out STEAM activities. Ejiwale (2013) emphasized inadequate laboratory environments as one of the important obstacles to STEM education. Similar to the finding in this study, the researcher also

stated that inadequate qualifications of teachers in STEM fields were one of the important obstacles to STEM education. Batty and Reilly (2022) emphasized the need for trained practitioners for effective STEM education. In a study on STEAM, Topalska (2021) interviewed with teachers and reported that they needed training in STEM fields. As a result from these findings, it is thought that the equipment in learning environments is very important for STEM/STEAM education

Most of the experts who participated in the study stated that while doing STEAM activities, students should be cared about and should participate actively in the process and that importance should be given to effective group work. Some of the experts also emphasized that it was very important to have a suitable learning environment, an effective planning, goal analysis, a holistic approach to STEAM education, and mastery of design and content knowledge. However, it was reported that they should pay attention to their competence in mastering the constructivist theory and time management. Similar to this finding, in a study conducted by Tunç and Bagçeci (2021), it was revealed that the teachers emphasized process mastery, time management and material deficiencies during STEAM practices. Similarly, it was seen in the literature that problems such as pedagogical, curriculum, student interest, time and domain dominance are mentioned in STEAM education practices (Bunbury 2018; Hewett et al. 2017; Margot and Kettler, 2019; Li et al., 2022).

In the study, the experts mostly stated that those who wanted to take STEAM education should first review the literature, understand STEAM, adopt the philosophy of lifelong learning, and get STEAM education from experts. However, they stated that they should have the 21st century skills and should carry themselves to a sufficient level in terms of cognitive, affective and psychomotor skills. One of the main purposes of STEAM education is to provide students with 21st century skills. From this point of view, it is expected that teachers who will make STEAM applications in order to gain these skills will also have these skills. However, another result that emerged from the expert opinions was that the teachers should receive training from experts in order to fully understand the concept of STEAM education and to carry out effective and efficient STEAM applications in learning environments. Kahya and Özdilek (2021) stated in their study that the teachers who wanted to practice STEAM should first receive training. In their study, Herro and Quigley (2016) found that the teachers who received STEAM education did effective practices in the classroom.

5.Conclusion

At the end of the study, the experts participating in the study stated that STEAM education was very important for both teacher and student development and that the integration of art into STEM education would add vitality and dynamism to learning environments and learning products. However, they stated that it would be beneficial to start STEAM education at an early age due to its developmental characteristics. It is thought that it would be beneficial to carry out studies in this direction. They also stated that STEAM activities could be done in every field. It is thought that there should be more studies on awareness raising in order to change the perception that STEM activities should be done in science fields. In order for teachers to implement STEAM education, it is important that they should adopt continuous education, make dedication and effort and constantly update themselves and that STEAM education studies should be conducted by the Ministry of National Education. Physical conditions of learning environments are very important for STEAM applications. It is thought that STEAM applications are more difficult due to environmental factors and that STEAM activities will be facilitated by making environmental factors positive. In order to make learning environments suitable for STEAM applications, it is recommended that the necessary support be provided by the Ministry of National Education.

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