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STEAM education approach: Application examples in Turkey and the world*

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Abstract

STEAM education is an innovative educational approach that combines the disciplines of science, technology, engineering, art, and mathematics. This new educational approach, which evolved from STEM education (science, technology, engineering, and mathematics) in the 1990s by adding art in 2006, has filled gaps in creativity and innovation within the model. The importance of proficiency in STEAM disciplines, integrated thinking, and innovation is increasing day by day for individuals and society. The fact that STEAM is an interdisciplinary educational approach adaptable to the needs of the current century has ensured its widespread adoption worldwide. Among the many studies in the literature on the STEAM educational approach, analyses comparing application examples are pretty limited. Therefore, this research aims to bring together successful application examples from Turkey and around the world, compare them, and fill a gap in the literature. The practical importance of the research is that it presents case studies to field experts and educators who adopt the STEAM education approach and provides guidance for new research. The research is a qualitative, interpretive study grounded in a literature review and document analysis. The data for the research findings were obtained from application forms from schools that were considered good examples of schools adopting the STEAM approach in Finland, the United States, Singapore, and Turkey. The findings emphasize the sustainable, problem-solving, and holistic development dimensions of STEAM applications and prove that it is a practical educational approach in this century. However, it also shows that, to ensure practice efficiency, the STEAM education model should be adopted and incorporated into the school's learning culture rather than integrated into existing courses, and that it brings significant gains, particularly in student motivation and interest levels.
Keywords: STEM model, STEAM education approach, innovative education approach, interdisciplinary education models

Extended Abstract

STEAM education is an innovative learning approach that brings together five different disciplines -science, technology, engineering, art, and mathematics- within a holistic framework. Based on the STEM model developed in the 1990s, this approach evolved into a broad educational paradigm in 2006 with the addition of the art discipline, supporting students' higher-level skills such as creativity, design-oriented thinking, aesthetic awareness, and innovative problem-solving. The inclusion of art has not only increased the model's inclusiveness but also enabled students to concretize abstract scientific concepts, produce original products, and ground their learning processes in more meaningful foundations. For this reason, STEAM is recognized as one of the most suitable interdisciplinary learning models for today's rapidly changing cognitive, technological, and social needs.

A review of the literature reveals numerous descriptive, theoretical, and model-development studies related to STEAM. However, in contrast to theoretical discussions, studies comparing STEAM models implemented across different countries are limited. Research that provides in-depth analyses of how application examples are structured across different socio-cultural contexts, how pedagogical approaches vary, and what results they yield in learner outcomes is notably lacking. In this context, this study aims to bring together successful STEAM applications from both Turkey and around the world (Finland, America, Singapore) to make an interdisciplinary comparison and fill an important gap in the international literature.

The research is based on literature review and document analysis methods within the scope of a qualitative research approach. The data used in the study were obtained from the application forms of educational institutions implementing the STEAM model in selected countries deemed "good examples." The documents were systematically analyzed within the following themes: instructional design, learner outcomes, level of interdisciplinary integration, problem-solving approach, technology use, project-based learning applications, and assessment methods. This interpretive framework enabled an understanding of how each application is positioned within its own pedagogical context and the establishment of comparable dimensions across countries.

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The research findings show that although STEAM models are implemented with different pedagogical approaches across countries, they converge on three standard features. First, all applications focus on inquiry-based and production-oriented learning processes that develop students' problem-solving skills. The Finnish examples show a high level of interdisciplinary integration, with students producing work based on real-life problems; in Singapore's STEAM approach, technology-supported learning and creativity are at the forefront. In the US example, design-thinking processes were observed to play a decisive role in students' project development stages. Applications in Turkey are noteworthy, particularly in strengthening a production-oriented learning culture, demonstrating that incorporating STEAM into school culture significantly increases student motivation. Secondly, the findings reveal that the STEAM approach strongly supports the development of 21st-century skills, such as critical thinking, collaboration, creativity, and cognitive flexibility, in students. In all implementation examples, students took responsibility in both individual and team work, structuring their learning by experiencing the problem-solving stages throughout the project. This shows that STEAM is not only a teaching method but also an ecosystem of student-centered learning. Thirdly, the analyses show that for STEAM to be effective, the model must be implemented not merely as an activity added to existing courses, but as part of the institution's fundamental learning culture. The sustainability of the models, teachers' pedagogical competencies, the school's technological infrastructure, and institutional structures that support interdisciplinary collaboration are decisive factors in this process. The examples examined show that when STEAM is implemented holistically, it has a meaningful impact on students' motivation, interest levels, and academic achievement.

In conclusion, this study fills an important gap in the literature by providing a comparative framework for STEAM applications from around the world and Turkey. The findings show that STEAM makes substantial contributions to today's educational understanding through its sustainable, creative, and problem-solving-oriented structure; however, they also show that achieving effective results requires a holistic, institutional transformation of the approach. The study offers a comparative perspective that is both instructive and foundational for new research for researchers, policymakers, and educators working in the field of STEAM.

Introduction

In a rapidly changing world, countries are updating their education systems to meet pedagogical and political needs. Accordingly, contemporary education strategies and approaches are being developed and integrated into curricula. Although steps toward making STEM education a national education policy in the United States began in the 1990s, its roots date back to the 1950s (Bybee, 2013).

The integrated STEAM (science, technology, engineering, arts, and mathematics) education approach, one of the 21st-century's innovative education models, offers a flexible curriculum that can be applied from preschool through higher education. It enables the restructuring of education systems to meet the needs of the era and shapes them in line with local and universal problems, in line with the opportunities of the city and school where they are located. According to the findings in the literature, when theoretical studies conducted on the STEAM approach are examined (Erol, 2023; Gülhan, 2022; Kahya and Özdilek, 2021; Helvacı and Yılmaz, 2020; Erdoğan, 2020; Güneş, 2019), it is seen that more studies include application examples compared to theoretical studies. The main objective of this research is to systematically examine and mutually analyze the applications of the STEAM approach in different countries. According to the literature, theoretical studies on the STEAM approach outnumber those with application examples. In this context, the research is important for bringing together strong examples of STEAM applications, demonstrating their practical applicability, and for filling a theoretical gap in the existing literature. The examination of STEAM application examples enables the comparison of the learning process, prior planning, and subsequent evaluations. This comparison not only helps teachers enrich their course content but also supports them in making a positive contribution to students' in-class learning outcomes by enhancing their professional development. In this regard, the secondary objective of the research is to contribute to the development of STEAM practitioners' pedagogical competencies. To this end, the research first presents the theoretical framework of the STEAM approach, then examines case studies from Turkey, Finland, the USA, and

Singapore, comparing the basic objectives, teacher role, learning environment, social participation, and sustainability dimensions. Subsequently, the findings were evaluated, and recommendations were developed for practitioners and researchers.

Methodology

This research was conducted within the scope of a qualitative research approach, using literature review and document analysis methods. Although theoretical discussions on the STEAM approach occupy a prominent place in the field, the limited number of studies comparing application examples across countries guided this research. In this regard, the study aims to fill the existing gap by examining “good example” STEAM applications selected from both Turkey and around the world. Data were obtained from accessible application forms and official documents of educational institutions working with the STEAM model. As a Turkish example, a STEAM application implemented at a public secondary school in the Western Mediterranean Region was examined; as global examples, one application each from Finland, the United States, and Singapore was evaluated. The documents were systematically analyzed within the following themes: instructional design, learner outcomes, level of interdisciplinary integration, problem-solving approaches, technology integration, project-based learning applications, and assessment processes. This interpretive analysis enabled an understanding of how each application was structured within its own pedagogical context and the development of comparable dimensions across countries.

Theoretical Framework

Innovative STEM/STEAM education model

The origins of STEM education can be traced back to the space race between the Soviet Union and the United States in the 1950s. The launch of Sputnik 1, the world’s first artificial satellite, in 1958 not only initiated the space race between the two superpowers that would continue throughout the Cold War years, but also, particularly in the US, the need for qualified human resources led to the development of many new integrative programs in science, technology, engineering, and mathematics education during the same years (Bybee, 2013). In the United States, STEM was designed by the National Science Foundation (NSF) in the 1990s and initially emerged as an acronym for four separate disciplines (science, mathematics, engineering, and technology), known as SMET. It is known that following negative feedback during the ongoing process, the abbreviation was changed to STEM (Sanders, 2009). According to the explanations by Bybee (2013) and Sanders (2009), STEM education emerged in line with the era’s needs and was renewed based on feedback. In this context, a historical look at recent developments shows that STEM is not only an innovative educational model but also a strategic plan for countries. The need for technology in the 1950s led to the emergence of a new learning-teaching approach tailored to the era’s needs in education. In the ongoing process, it is known that Georgette Yakman, after completing her master’s degree at the Virginia Polytechnic Institute and State University, argued that art and aesthetics should not be neglected in innovative educational approaches and, in this direction, developed the STEAM education model in 2006 (Çepni, 2023). In this context, it is understood that the STEM/STEAM model is not a temporary educational trend but a practical educational approach that produces solutions to problems, demonstrating that STEAM education remains relevant in education. The innovative aspect of STEAM is the skills that become visible with the discipline of art, such as creativity, innovation, aesthetic sensitivity, and emotional intelligence. The addition of the creativity dimension to the STEAM education model has made it a more holistic educational approach.

The STEAM approach encourages individuals to use both their analytical and emotional intelligence together, thereby aiming to increase the permanence of learning. According to Baek (2011), the STEAM approach arose from the goal of educating individuals who can help solve the problems of the era in the field of education and from the need to increase the connections between STEM disciplines (Baek et al., 2011; Yakman, 2008; Yakman & Lee, 2012). Therefore, as Yakman & Lee (2012) also emphasize, the STEAM approach is among the educational models designed to meet today's knowledge, skills, and needs and to adopt an education and training approach connected to life. However, it is also possible to define the field of art as arising from the need to strengthen interdisciplinary connections in STEAM. One characteristic of creative thinking is establishing connections between different fields and materials. In this context, while the five disciplines in the STEAM approach offer a broader creative perspective, the field of art facilitates the concretization of abstract ideas and a more conscious design of the product's aesthetic dimension.

Regarding the purpose of STEAM education, Wellington and colleagues (2020) emphasized that, in the innovative interdisciplinary STEAM education model, the teaching-learning process occurs through students' direct experience of nature and technology. Thus, students access knowledge as a result of their own experiences, and learning occurs through inquiry. According to Bush and Cook (2019), the foundation of the STEAM approach is the principle of equal educational opportunities. Furthermore, STEAM education's flexibility to adapt to different conditions enables diverse school and classroom applications. The STEAM approach aims to have every student engage in collaboration, problem-solving, risk-taking, adaptation to society, exploration, and in-depth learning. In this way, students develop solutions to contemporary life problems through trial and error and by establishing empathy. Thus, students both solve their own problems and facilitate a more holistic experience by deeply analyzing the problems and needs of others (Edelen et al., 2023). Therefore, it is understood that this model is not just a teaching method but an innovative educational philosophy that aims to enhance individual development holistically and to facilitate students becoming more sensitive individuals who are aware of the problems of the society they live in and who contribute to it (Bush & Cook, 2019).

The global prevalence and need for STEAM education

According to Google Trends data from 2025, STEAM education has seen a steady rise worldwide from 2004 to the present. In this context, interdisciplinary thinking, innovation, and digitalization are increasingly gaining ground in education. When examining the STEAM world map, it can be seen that STEAM education is widespread worldwide today, except in Africa, and that the STEAM education approach is widely applied, especially in the Americas and Europe (see Figure 1). The lack of a balanced distribution worldwide is also an important finding regarding educational inequalities. According to data from the literature, the top 10 countries among the 60 countries with the most prevalent innovative STEAM approach in education are, in order: Hong Kong/China, Jamaica, Nepal, Sri Lanka, Lebanon, New Zealand, Ghana, Uzbekistan, Cambodia, and Singapore. Turkey ranks 58th, and this data shows that the STEAM approach has limited impact and application potential in our country.

Figure 1. Distribution of countries offering STEAM education worldwide (Source: Google Trends)

According to Çapar (2024, p. 37), digital transformation in education is currently considered "a process developed to provide students with a more effective, participatory, and learning-promoting environment." In this regard, digital transformation in education can be defined as a comprehensive change process comprising infrastructure and technological equipment as its core components. However, it is important to remember that digital transformation in education is not only about using technological tools but also about making the educational process more student-centered. Technology serves as a tool that makes learning more participatory and practical. In the digitalizing world, the importance of designing educational environments that are student-centered, motivating, and equipped with technological infrastructure is increasing. In this context, it is clear that the STEAM approach stands out today as a contemporary educational approach that equips students with the knowledge and skills needed for the demands of the age.

The World Economic Forum's 2025 report, "The Future of Jobs," outlines five macro trends affecting the labor market: technological change, green transformation, geo-economic fragmentation, economic uncertainty, and demographic changes. It noted that technological change is expected to transform the job market the most. It also projected that 170 million jobs would be created and 92 million jobs would be displaced by 2030. Considering the findings of this report, it becomes clearer why STEAM education is necessary. As a technological transformation, the most important factor in transforming the labor market is the emergence of new professions; it becomes inevitable for individuals to gain interdisciplinary perspectives and develop creative thinking, learning-to-learn, problem-solving, and technological literacy skills. This element directly aligns with the goal of STEAM education, which is not only to provide academic knowledge but also to enable experiential learning by connecting it to real life. In this regard, STEAM education has proven to be a practical approach that builds a foundation in students, both by increasing their technological literacy and by equipping them with the skills required by the era.

Figure 2. OECD configuration compass

The launch of the “Education and Skills for the Future 2030” project conducted by the Organization for Economic Cooperation and Development (OECD) in 2015 and its joint implementation by policymakers, researchers, school leaders, teachers, and students from around the world can be considered one of the important developments in this regard. The “Learning Compass,” part of the “Learning and Teaching for 2030” working group within this project, aims to provide students with a roadmap for the future of education grounded in a globally informed yet locally adaptable vision. The Learning Compass incorporates knowledge, skills, attitudes, and values within cycles of foresight-action-reflection. Surrounding these elements are cycles of creativity, transformative competencies, common sense, accountability, and collaboration. All these competencies develop in classroom environments where students are active. In this context, educators must create an appropriate learning environment and adopt teaching approaches that enable students to acquire these competencies. The STEAM approach aims to develop the 21st-century competencies outlined in the “Learning Compass,” targets holistic student development, and is structured to build skills such as learning by doing, interdisciplinary thinking, taking responsibility, critical thinking, learning to learn, and creative thinking. The student-centered and process-oriented nature of the STEAM approach enables 21st-century skills to be learned through doing and experiencing.

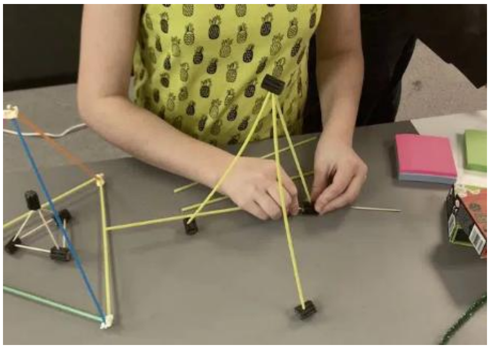
Examples of STEAM Education Implementation Around the World

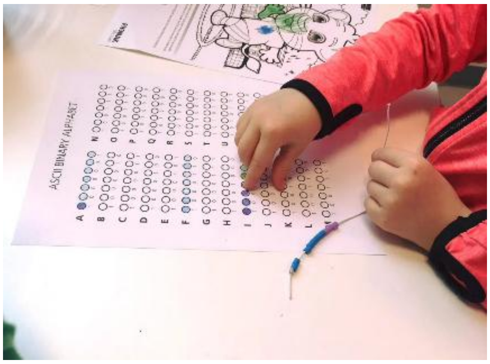
The STEAM approach and structure in Finland

Finland is known to have the most comprehensive national plan for STEM education. The national plan published in 2014 by the *Finnish National Agency for Education (EDUFI) [National Curriculum Framework]* aims to increase children’s and young people’s interest and aptitude for STEM education and careers. In line with this, working groups consisting of education and culture leaders were established, and institutes, universities, and other organizations developed their own STEM strategies (MEB, STEM Report, 2016).

The Yli-Ii Comprehensive School in Oulu, Finland, is recognized as one of the exemplary schools that successfully implements the STEAM approach. Within the scope of STEAM education, the *STEAMario learning environment*, created in their schools to produce solutions to real-life problems, is seen to support significantly classroom application activities and the school's learning culture. Jukka Miettunen, the school principal, stated that the Finnish education system implements a curriculum that promotes transversal competencies and interdisciplinary themes that support collaboration across disciplines. He also emphasized that collaboration is a skill that every Finnish educator must learn and apply in their own teaching practice. In addition, institution officials emphasized that schools need innovative initiatives and strong leadership to ensure they move in the right direction in a changing world. In this context, they stated that the STEAM approach offers an important opportunity to bring together different disciplines and teachers within a common framework (Miettunen, 2025).

The "learning" environment called STEAMario (Värkkäämö in Finnish), which helps teachers collaborate on STEAM topics and supports professional development in a changing world, has created a strong "culture of doing" in the school and is a modern and encouraging STEAM learning environment equipped with the necessary technologies such as coding, robotics, electrical work, laser cutting, engraving, and vinyl printing. A STEAM team was established, comprising teachers who wanted to acquire new skills to support the development phase, and all educators received STEAM training before implementation (Miettunen, 2025). Ensuring that educators experience learning before teaching it actually forms the basis for creating the aforementioned STEAM environment in Finland and its impact on learning outcomes, given the challenges in the widespread adoption of STEAM environments and in achieving effective outcomes in our country.





Figures 3-4-5. STEAMario learning environment

Almost all the projects carried out and prototypes produced within the scope of the *STEAM Learning Environment* serve to find solutions to real-world problems, and these experiences are fundamental requirements for a potential learning environment. For example, the Arduino-controlled automatic irrigation system, which "measures soil moisture levels through sensors and activates the water pump when necessary," was developed by students who were concerned that the seeds they planted in biology class would dry out during the week-long mid-term break. This problem-solving-based STEAM project encompasses a process that integrates science, engineering, and technology disciplines, including planning, trial-and-error, and redesign stages, and plays an important role in developing students' responsibility, collaboration, creative thinking, and problem-solving skills (Miettunen, 2025).

This case study demonstrates that the Finnish education system has a contemporary pedagogical philosophy and that teachers are positioned as lifelong learners. In this context, the success of the teaching process depends on the school and the teacher implementing innovative strategies aligned with students' needs. This example is also important for highlighting schools' freedom to innovate in line with local communities' needs and students' expectations through a school-based leadership approach. Therefore, STEAM education should be seen not only as a combination of five disciplines but also as a contemporary educational approach that facilitates interdisciplinary thinking. In other words, STEAM is a transformative force in Finland's learning culture that supports the fundamental goals of the education system. Miettunen's (2025) emphasis on the "environment of discovery and the culture of the maker" clearly demonstrates that STEAMario can be considered a Maker Space. The establishment of a STEAM team within the school demonstrates that innovation is a culture of collaboration, and the tools used lay the groundwork for experiential learning in technological literacy. Another important point here is that the productions were realized through problem-based learning scenarios. The inclusion of real-life scenarios in STEAM education has enabled students to transfer knowledge, equipping them to solve problems they may encounter in daily life before they even arise, and making it easier for them to take precautions. In this sense, scenarios involving real-life problems within the scope of STEAMario have contributed to the permanent development of students' knowledge and skills.

The STEAM approach in the United States

The STEM education approach is a pedagogical and political national strategy in the United States education system. STEM education aims to create a society with advanced 21st-century skills and to sustain this accumulation. In line with this, numerous STEM centers have been established at many universities and schools across the country. These centers offer project-based learning, inquiry-based learning, Maker and robotics applications, design and innovation activities, creativity and creative drama, and STEM lesson plan development workshops (STEM Academy, 2013, cited in MEB STEM Report, 2016).

Taylor School is among the schools in the United States that successfully implement STEAM education. Roos (2025), the exemplary project coordinator at Taylor School in Washington, D.C., which has adopted the STEAM education approach as its school culture, stated that STEAM education has been provided at their school since 2012 and that all students attend STEAM classes once a week (Roos, 2025, cited in Taylor Elementary School, 2025). It is understood that the STEAM education approach is not merely a teaching method or technique but an integral part of the school curriculum. In STEAM classes, students have the opportunity to develop their problem-solving skills through design-oriented thinking, productive struggle, and the 4Cs (collaboration, communication, critical thinking, and creativity). The systematic use of STEAM classrooms across the school has fostered a learning culture in which students are active producers, ensuring they participate regularly in STEAM education from pre-kindergarten onward (Roos, 2025, cited in Taylor Elementary School, 2025). In this regard, the existence of a productive learning culture demonstrates that contemporary pedagogical education and training are effectively implemented at this school. As shown in *Table 1*, the grade-level activities carried out in the STEAM workshop at Taylor School are planned to impart specific basic skills at each age level, to integrate different disciplines, and to create a structure that progresses from basic to more complex achievements.

Table 1. Scope of Taylor School STEAM education activities

Grade Level	Topic	4C Skills	Learning Outcomes
Pre-K	Code-a-pillars (direction coding with simple robotic toys)	Collaboration, communication, creativity	Takes the first step toward algorithmic thinking.
Kindergarten	Problem-solving and the 4Cs through children's literature	Critical thinking, creativity	Produces solutions through children's literature; empathy and creative thinking develop.
1st Grade	Using Hess trucks and building roller coaster mazes, experiments on motion and force.	Collaboration, experimentation, problem solving	Explores basic machines and force concepts using concrete materials.
2nd Grade	Creating one's own invention under the theme "Inventors and Their Inventions."	Creativity, experimentation, problem solving	Learns the cycles of the creative process; develops maker-oriented thinking by designing an invention.
5th Grade	Creating Ninja Jr. courses using AI and Tinkercad	Technological literacy, critical thinking, creativity	Develops digital fabrication skills through artificial intelligence.

According to Ross (2025), what distinguishes STEAM from regular science and art classes is that it incorporates a process-oriented, interdisciplinary, problem-solving-focused thinking and learning culture. Furthermore, because the process-oriented STEAM approach has an open structure that is always open to development, it can never be completed; in turn, it is always open to continuous development, and one side of it can never be taught. Thus, the student's product is a prototype that needs to be continuously developed and reproduced through experience. On the other hand, it is known that the activities carried out at the institution in question are not limited to the workshop environment but are also transferred to out-of-school learning environments, and that gains in skills such as collaboration, communication, critical thinking, and creativity are put into practice across different contexts. Similarly, the STEAM Days events, which take place three or four times a year, provide an interactive learning experience in which projects are shared with the entire school outside the classroom. These experiences are seen to play an important role in increasing professional competence by facilitating opportunities for teachers to observe process-based "STEAM Days" and integrate them into their own lessons (Roos, 2025, cited in Taylor Elementary School, 2025).

In these activities, projects were developed in different categories and through collaboration between different disciplines, ranging from students from different grade levels using different waste materials to design a functional arcade game, to developing protective devices that prevent an egg from breaking when dropped from a high distance-starting with stairs and playground equipment and ending with a drill created by the fire department using student creations. Additionally, classes have presented solutions to real-world problems within the school community using the Shark Tank theme, -ranging from building a ukulele from a mini golf hole to producing solutions for other structural problems- have resulted in activities such as the selection of these proposals by a teacher panel and their placement around the school as prototypes, which are the result of both collective effort and interdisciplinary forms of thinking and attempts to find answers to current problems.

Figure 6-7. Taylor School, STEAM application classroom, Washington, DC, USA

Table 2. Scope of “STEAM Diaries” studies

Topic	**4C Skills**	**STEAM Disciplines**
Cardboard Arcade Challenge	Design, collaboration, hand–eye coordination, creativity	Science, Engineering, Technology
Egg Drop Challenge	Problem solving, collaboration, testing, and resilience	Science, Engineering, Technology
Shark Tank (Idea Pitching)	Entrepreneurship, creativity, collaboration, communication	Technology, Mathematics, Art
Interdisciplinary Mini Projects	Teamwork, creativity, collaboration	All STEAM Fields
Career Day	Real-world connections, career awareness	All STEAM Fields

According to Roos (2025), the school’s proximity to numerous business and technology resources in the Washington, D.C. metro area -such as NASA, Amazon, Hess, the Air and Space Museum, and the US Air Force- gives the institution a unique advantage. Visits by some of these organizations to the school have had a positive impact on students. For example, as part of the “Future Engineers Program,” Amazon visited the school to share experiences in space and AI (artificial intelligence), interact with students, and discuss the work produced in the STEAM classroom. Furthermore, the STEAM culture formed at school has spread beyond the school, with students developing and producing STEAM projects with their families. This continuity proves that students' multidimensional and creative thinking skills have become part of their lives and that sustainable curiosity, learning, and production have been established.

The STEAM education approach in Singapore

It is known that the Singapore education system, like those of the other countries examined, supports students' potential through a student-centered approach. The goal is for students to become lifelong learners by enabling their holistic development, not just academic development. In this regard, the focus is on developing the fundamental skills that will enable them to be successful in the 21st century (Ministry of Education, Singapore, 2025). Singapore University of Technology and Design (SUTD) introduces students to liberal arts, humanities, and social sciences by expanding its STEM applied curriculum. In the first three semesters of work under the STEAM approach, the development of students' 4C skills was targeted in courses delivered in a "cohort-based class" format (Singapore Ministry of Education, 2025).

Table 3. Scope of STEAM education work

Topic	4C Skills	STEAM Disciplines	Learning Outcomes
Building Bridges to Foster Friendships	Creativity, collaboration, critical thinking, sharing and presenting, problem solving	All STEAM disciplines	Abstract knowledge is transformed into concrete experience. Empathy and a sense of social solidarity are developed.
Chromatography and the Learning Process through Composition	Creativity, collaboration, sharing, and presenting	Science, Art, Engineering	Students experience an interdisciplinary learning process by integrating scientific concepts with artistic principles.
Reimagining Classroom Walls through 3D Design	Problem solving, creativity, sharing and presenting, collaboration	All STEAM disciplines	Students apply iterative 3D design methods in project-based work, producing modular and visually compelling solutions.

Located in Tampines, Pasir Ris Secondary School is among the schools in Singapore that successfully implement the STEAM educational approach. Viewing STEAM not only as a teaching method or technique but as part of the school culture, Pasir Ris Secondary School (2025) states that it is important to incorporate innovative STEM/STEAM educational approaches into the teaching and learning process in the information age, saying, "Our children must be equipped with a variety of skill sets that will open doors for them in the modern economy. In a world driven by new technologies and science, we will need to strengthen STEM learning in our schools," highlighting the pedagogical and national strategic importance of STEAM education. Furthermore, it has been observed that integrating the STEAM approach into other subjects at schools such as Pasir Ris facilitates an interdisciplinary perspective in the learning process (Pasir Ris Middle School, 2025). Rather than viewing STEAM as a separate subject, students adopt a holistic approach that enables them to see the connections between different fields and understand how knowledge is constructed. Therefore, regardless of the field in which STEAM is integrated, interdisciplinarity is at the forefront of the learning process, and learning by doing takes place. The STEAM festivals held at Pasir Ris foster a STEAM culture and enable students to learn while having fun. It is known that teachers also increase their professional competence by observing the products exhibited at these festivals. To ensure the sustainability of STEAM, the school aims to support students in positioning STEAM as an active part of their own lives, rather than viewing it solely as a school project (Pasir Ris Secondary School, 2025). Basic information on some of the applications carried out within the scope of STEAM education at Pasir Ris Secondary School is presented in Table 3.

An example of the application of the STEAM education model in Turkey

In Turkey, the first studies on STEM/STEAM approaches began in 2016 with the publication of the STEM Report by the Ministry of National Education. In 2021, a report identifying the needs of teachers in STEAM education in Turkey and Europe was prepared as part of the “Fostering STEAM Education in Schools- EDUSIMSTEAM project” coordinated by the *General Directorate of Innovation and Educational Technologies of the Ministry of National Education* (MEB YEĞİTEK, 2021). In addition, projects aimed at providing teachers and academics with innovative approaches, strategies, methods, and techniques were carried out through the 4005 program, developed by the Scientific and Technological Research Council of Turkey (TÜBİTAK). The “EDUSIMSTEAM Project” carried out within this scope is among the important projects that demonstrate that STEAM education is structured and supported in accordance with international standards. The STEM/STEAM approach is included in Turkey’s education policies, but its full integration into practice has not yet been fully established. The reasons for this include the lack of comprehensive guidelines on STEAM, the lack of detailed educator training, the failure to present concrete evidence of the outcomes of reports prepared for the public, and the fact that learning environments are not fully equipped for interdisciplinary applications such as STEAM in practice.

The Turkish sample of the research consists of STEAM applications integrated into art education courses at a public middle school in the Western Mediterranean Region. STEAM activities were carried out in the school's workshop and classrooms, and the resulting work was exhibited in common areas to increase interaction. These exhibitions facilitated observation by other teachers at the school and contributed positively to their professional development.

Figure 8. The implementation process of STEAM activities integrated into the visual arts course

The STEAM applications and achievements carried out throughout the semester within the scope of the visual arts course are presented in *Table 4*. In this context, the common goal of the STEAM application examples is primarily to develop creativity, one of the course’s basic objectives, and to achieve other benefits of the STEAM approach. At the same time, it is intended to contribute to the formation of a STEAM culture among students and throughout the school through exhibitions, and to ensure that STEAM plays an important role not only in students’ schoolwork but also in their personal lives. The learning environment was organized by the educator in a way that was free, flexible, and allowed students to show their potential, without limiting their thoughts. Thus, the goal is to create a learning environment that minimizes barriers to creative thinking. The educator prepared lesson plans aligned with the class's pedagogical needs, and the teaching process was conducted in branch classrooms because there was no STEAM laboratory at the school. Since the classrooms were shared spaces for all lessons, conducting STEAM education there posed some limitations. For example, elements such as the tools and equipment provided in the workshop environment and the seating arrangement could not be created in the classroom. In addition, the material requirements for the application were met with support from teachers, students, and local tradespeople. During the learning process, students were encouraged to produce their work using the STEM/STEAM learning cycle (ask a question, design a product, test the product, draw conclusions, evaluate, share, rethink) (see Figure 9).

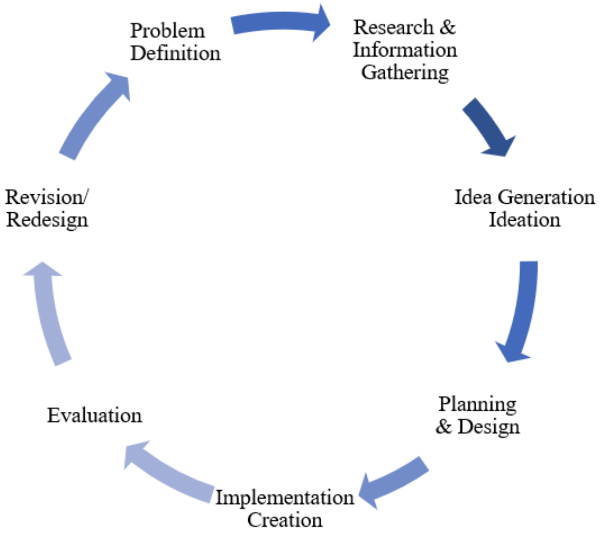


Figure 9. The learning cycle of the STEM education model

The development of creative skills in visual arts classes depends on the selection of appropriate teaching methods and techniques. In other words, teaching methods, techniques, and strategies are critical to achieving the goals set in the field of education. Interdisciplinary thinking connects independent fields and ideas around a common theme, thereby fostering both interdisciplinary and creative thinking in a coordinated manner. In this context, adopting the STEAM approach in the art education process contributes to the development of creativity skills, a fundamental objective of the course. The quantitative results of the research, which aim to develop students' creativity levels and to reveal the positive contribution of the STEAM approach to creativity compared to the traditional learning approach, provide evidence for this possibility through estimates.

In line with this goal, the education plan developed by the educator and structured in a process-oriented manner for the development and sustainability of 21st-century skills (see Table 4) ultimately facilitated the development of a learning culture beyond the main objectives of the course; it was observed that it facilitated the sustainability of skills such as creativity, interdisciplinary thinking, lifelong learning, problem solving, and scientific and technological literacy.

Table 4. Scope of STEAM education activities

Grade Level	Topic	4C Skills	STEAM Disciplines	Learning Outcomes
6th Grade	Transforming post-consumer waste into a three-dimensional artwork	Creativity, problem solving, collaboration, design, sharing, and presenting	Science, Technology, Engineering, Art	Learns and applies recycled art; develops environmental awareness and sensitivity.
6th Grade	Transforming natural materials into a three-dimensional artwork	Design, creativity, problem solving, collaboration, sharing, and presenting	Science, Technology, Engineering, Art	Learns and applies ecological art; enhances sensitivity toward nature and living beings.
6th Grade	Using technological tools and materials in an art project	Design, creativity, problem solving, sharing, and presenting	Technology, Engineering, Art	Learns that technological tools can function as art materials and creates an original artwork.
6th Grade	Using geometry in art-making	Design, creativity, problem solving, sharing, and presenting	Technology, Engineering, Mathematics, Art	Recognizes that geometric knowledge can be integrated into visual art practices.
6th Grade	Understanding the differences between pigment colors and light colors	Sharing and presenting, design, creativity, problem solving	Science, Technology, Engineering, Art	Understands how art makes scientific knowledge visible; creates a contemporary artwork aligned with the theme.
6th Grade	Creating an artwork inspired by the solar system	Design, creativity, collaboration, problem solving, sharing, and presenting	Science, Technology, Engineering, Art	Learns to create an artwork inspired by scientific knowledge and produces an original piece.

Figure 10. STEAM application examples 10a. Artistic recycling of waste materials, 10b. Ecological recycling, 10c. Transformation of waste material into light sculptures

The recycling application, which encompasses almost all of the skills of creativity, problem solving, collaboration, design, sharing, and presentation -including the transformation of waste materials that have reached the end of their useful life into three-dimensional artworks- aims to raise students' awareness of the reusability of waste materials and to transform environmental waste into creative designs from the perspective of different disciplines (Figure 10a). In another STEAM application, an extension of this lesson, the goal was to develop awareness of ecological issues through the transformation of natural materials into three-dimensional artworks. Students had the opportunity to discuss and interpret the interaction between natural and artificial materials by bringing them together, focusing on the reconciliation between humans and natural life (Figure 10b). In the third activity, drawing on collaboration among the technology, engineering, and art disciplines, students were encouraged to produce their own three-dimensional designs using waste materials, electronic devices, batteries, and cables, embracing the concept of recycling while transforming their designs into functioning illuminated sculpture prototypes.

STEAM Application Examples Comparison: Finland, the United States, Singapore, and Turkey

In this section of the study, the STEAM application examples from the four countries sampled are examined and compared in terms of the fundamental purpose of education, the role of teachers, the learning environment, social participation, and sustainability dimensions.

The fundamental purpose of STEAM education

In the Finnish example, it is seen that STEAM is more than just a subject; it is part of the contemporary pedagogical education philosophy. It is also understood that STEAM learning aims to produce solutions to real-life problems. In the US, as in the Finnish example, STEAM is accepted not only as a subject but also as a fundamental requirement of educational design. In Singapore, STEAM education is embedded in school culture. As in other countries, STEAM applications are carried out not only in the school environment but also in out-of-school environments, and through studies appropriate to real-life problems, students' problem-solving skills and collaborative learning are facilitated. In this regard, the sustainability of the gains is ensured, functionality is made permanent, and multidimensional and interdisciplinary thinking skills are developed. In the STEAM applications carried out in the Turkish sample, an interdisciplinary perspective is integrated into art education; the applications focus heavily on material transformation and sustainability; and, due to limitations arising from classroom use, the resulting products are structured as simple prototypes. They cannot be transformed into applications for comprehensive problems.

However, it should not be forgotten that the fundamental goal of the STEAM approach in the Turkish sample is to develop creativity levels, achieve other STEAM gains, and increase sustainability. Here, instead of comprehensive lesson plans developed in collaboration across disciplines, program content aligned with the objectives of the visual arts course is included. On the other hand, it has been determined that in almost all of the applications carried out in the United States, Finland, Singapore, and Turkey, interdisciplinarity and a culture of sustainable learning form the basis of the education and training process.

The role of teachers in STEAM education

It was found that in all four countries sampled, students actively participated in the STEAM implementation process. At the same time, teachers served as guides and facilitators, supporting students' potential and going beyond simply providing information and guidance. In Finland, teachers established STEAM teams through collaborative planning in their schools and carried out interdisciplinary STEAM projects in the STEAMario learning environment, thereby enhancing their professional competencies. In the American example, it was analyzed that teachers made a positive contribution to their professional competence through observation in “STEAM Days” events. In the Singapore and Turkey examples, it was found that teachers gained knowledge, skills, and professional development related to the education and training model through interactions at STEAM festivals and exhibitions held at schools.

STEAM learning environment size

While the teaching process in the United States takes place in STEAM classrooms, in Finland it occurs in the STEAMario learning environment, which includes technological tools such as robotic coding, laser cutting, and vinyl printing. The presence of STEAM classrooms in countries such as the United States and Finland significantly contributes to the development of a STEAM culture in schools. In Singapore, STEAM studies are integrated into other subjects. Similarly, in the Turkish sample, STEAM education was integrated into visual arts classes and, due to the lack of STEAM classrooms at the school, the teaching process was conducted in branch classrooms. It should not be forgotten that the lack of a comprehensive STEAM laboratory, workshop/classroom leads to significant limitations on implementation, both for implementers and students.

Social participation dimension

In the United States, while NASA, Amazon, and the Air and Space Museum collaborate to improve STEAM education, students' families also support the learning process. In the Singapore and Turkey examples, social participation occurs only through STEAM exhibitions and festivals, in a shared environment among students, teachers, and parents. Again, the lack of sectoral support and technological participation, both in terms of tools and knowledge, can be identified as a leading factor in the inability to meet specific requirements at the implementation stage and, consequently, in limited student gains.

Sustainability dimension

In almost all examples from Finland, the United States, Singapore, and Turkey, it is possible to define STEAM education as having a dimension that supports a culture of learning not only in school but also outside of school.

Conclusion

This study examined and comparatively evaluated four schools implementing the STEAM approach in Finland, the United States, Singapore, and Turkey. The findings reveal that STEAM applications show significant differences between countries. These differences were found to stem primarily from two factors: (1) the resources and physical/institutional conditions available to schools, and (2) variations in the strategies developed to make STEAM sustainable. However, the data show that all school examples implemented STEAM as a globally accepted educational model. When comparing country examples, Finland is seen to have adopted a holistic, sustainable, and production-oriented STEAM approach that supports innovative teacher leadership. In the US, a STEAM approach focused on real-world problems and the development of 21st-century skills has been identified. The presence of STEAM classrooms in both Finland and the US examples has ensured that the approach is embedded in the school culture. In Singapore, STEAM education is implemented by being directly integrated into the curriculum; it is emphasized that this approach, supported by school management and teachers, is practical for problem-solving, developing 21st-century skills, and strengthening holistic learning. In the state school in Turkey sampled, STEAM was implemented alongside visual arts classes. This example shows that STEAM offers a sustainable and holistic learning approach that develops students' 4C skills. In all four schools, STEAM education is seen as a functional model that meets the needs of the age. The schools stated that creating a STEAM culture throughout the school is necessary for STEAM to become a permanent learning culture. It was determined that differences between schools can be attributed to the opportunities offered by STEAM's flexible structure and that these differences stem from local context (institutional goals, learning environments, teacher training, school facilities).

This study contributes to the limited number of comparative studies on STEAM education in the literature. The findings provide an important reference for researchers, school leaders, policymakers, and teachers to conduct comparative analyses and improve their professional practices. The study is expected to lay the groundwork for future research and contribute to the sustainability of STEAM education. It is recommended that future studies focus on improving the quality of stakeholders involved in planning and implementing STEAM applications, the quality of learning environments, and teacher competencies. Comparing STEAM applications across schools within the same country can enable a more comprehensive analysis of differences in learning environments, lesson plans, and educator approaches. Such comparisons are important in revealing how these differences affect the success of STEAM applications. Furthermore, evaluating STEAM applications from the learner's perspective may enable a more in-depth analysis of changes in students' attitudes, interests, and motivation levels.

However, for STEAM to become sustainable within the school culture, it is recommended that all teachers receive STEAM training and that teachers form STEAM working groups in schools. Planning regular STEAM days to increase teachers' and students' interest and motivation will contribute to its sustainability by increasing the visibility of the approach. Rather than integrating STEAM into only particular subjects, it should be placed at the center of the school's holistic learning culture. On the other hand, for a successful STEAM implementation, it is necessary to collaborate with local civil society organizations and enrich learning processes with environmental, social, and cultural dimensions. Furthermore, process-oriented STEAM education must be supported not only within the school but also by families. Therefore, strengthening the teacher-student-parent collaboration will increase the effectiveness of the STEAM approach.

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Figure 1. *Distribution of countries offering STEAM education worldwide* [Photograph]. Retrieved from https://trends.google.com/trends/explore?date=all&q=steam%20 education&hl=en-US (Access date: August 10, 2025).

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Figure 10. STEAM application examples/ 10a. Artistic recycling of waste materials, 10b. Ecological recycling, 10c. Transformation of waste material into light sculptures. STEAM education work product [Photograph]. Retrieved from the researcher's own archive.

Table References

Table 1. *Scope of Taylor School STEAM education activities*. Retrieved from https://taylor.apsva.us/post/steam-education-at-taylor/ (Access date: September 12, 2025).

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Ethics committee declaration

The application permits for this research were approved by the Non-Interventional Clinical Research Ethics Committee of Burdur Mehmet Akif Ersoy University on January 8, 2025, with permit number 2025/1 and decision number GO 2025/872. Additionally, the Ministry of National Education, to which the state school where the application took place is affiliated, approved the research application permit on March 10, 2025.

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