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ANALYSIS OF MATHEMATICS EDUCATION FROM A STEAM APPROACH AT SECONDARY AND PRE-UNIVERSITARY EDUCATIONAL LEVELS: A SYSTEMATIC REVIEW

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Abstract

Society is in an incessant process of reflection, but the educational system is not following the same path, creating an urgent need for a quality educational renovation in which new methodologies, approaches and educational resources are developed based on creation, collaboration and learning by doing. In this sense, the integrated education of science, technology, engineering, art, and mathematics (STEAM) is postulated as an educational approach through which to transform the teaching-learning processes into processes that contribute to the development of critical, creative, and scientific thinking. Proof of this is the continuous increase in publications in this line of research. This article presents a systematic review with a total of 19 studies published in high-impact journals with the aim of making a critical reflection and evaluating the real scope of incorporating STEAM projects in education to improve the students' mathematical skills. In particular, five areas of interest have been evaluated: active learning in the teaching of STEAM subjects, the development of technological resources, the design and implementation of educational proposals, the evaluation of STEAM education and teacher training in STEAM education. Considering the results, we emphasize the need to continue working on the theoretical foundation and educational practice of this approach to allow teachers to implement it effectively.

Keywords – STEAM education, STEAM approach, Mathematics education, Teaching-learning process, Mathematics learning, Educational research, Systematic review.

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1. Introduction

Teaching methods have changed a lot over the years due to the different trends in educational innovation that are more frequently being implemented in classrooms. This is why both education and its professionals must be engaged in an exhaustive search for methodologies that fit each of the educational levels. It is necessary to provide students with meaningful learning which promotes their mathematical skills and helps them to think (National Council of Teachers of Mathematics [NCTM], 2014) from a balance between mathematical reasoning, computational thinking, and problem-solving processes (Organisation for Economic Cooperation and Development [OECD], 2023).

However, achieving this objective is not easy since, for many years in mathematics education, the memorization of concepts and properties tends to be predominant, which, in most cases, is not readily understood by students (Barrantes-López, Fernández-Leno & Balletbo-Fernández, 2013). Fortunately, this change in the teaching-learning trends of mathematics is becoming more profound. Currently, more importance is given to the transmission of mathematical thought processes than to the transfer of content since mathematics must be treated as a science in which the procedure is predominant (de Guzmán, 2007). Mathematics is definitely a fundamental part of education. It is considered an essential element in the development of student preparedness since it helps them to reason in an orderly manner, to use logic and to have a mind prepared for thought, criticism, and abstraction (Jaramillo & Puga, 2016).

According to Callejo (1994), there are two types of meaning in the concept of mathematics education: the attitudes towards mathematics and mathematical attitudes. On the one hand, attitudes towards mathematics refer to the interest in the subject and its learning, paying more attention to the affective-emotional part than to the cognitive one, as well as expressing a higher degree of satisfaction and curiosity. On the other hand, mathematical attitudes are mainly focused on the cognitive aspect and how to use mathematical abilities in a more thorough, deductive, objective, and abstract way (NCTM, 2014; Hidalgo et al., 2004). In order to give students an opportunity to get these two attitudes, it is necessary to use or implement methodological strategies enabling the students' full potential to be engaged and also allow them to achieve that mathematical rigor so necessary at secondary and pre-university educational levels.

Thanks to progress achieved in technology, the 21st Century is being a challenging time for education. For this reason, it is important to provide students with the competencies and knowledge required to reason, investigate, argue, ad reflect on the behavior of phenomena that occur in the social context and thus, be able to face the demands of today's society (Ge, Ifenthaler & Spector, 2015; OECD, 2023). In such circumstances it is clearly necessary to promote a shift in the traditional educational model of mathematics teaching and seek a more innovative one where meaningful learning, critical thinking, and mathematical flexibility in problem-solving are encouraged (Salmon, 2019). The formulation of a problem, the alternative solutions and the strategies used to solve it are situations typical of professional life for which the student must be prepared. In this sense, it is worth highlighting the interest in the use of interdisciplinarity amongst mathematics education practitioners.

According to Lehrer (2021), interdisciplinary proposals promote the transfer of knowledge between mathematics and other disciplines and, in this way, build a structured knowledge system that facilitates the resolution of certain problems. However, Tytler, Mulligan, Prain, White, Xu, Kirk et al. (2021) pointed out the need to maintain the integrity and characteristics of each discipline involved to generate knowledge. Using methodologies in which mathematics is used as an interdisciplinary subject in other fields of knowledge can make students stop seeing it as unattainable and appreciate its true value and usefulness. Among the different interdisciplinary proposals that involve mathematics, we focus in this paper on the development of STEAM projects based on the integrated work of Science, Technology, Engineering, Art, and Mathematics that involve training whose purpose is the comprehensive competency development of the students for their action in society and that are, in many cases, also linked to citizen participation or sustainability (Ortiz-Revilla, Sanz-Camarero & Greca, 2021).

STEAM education was born in 2008 with the aim of turning the teaching-learning process into a transversal and creative education (Yakman, 2008). In recent years, it has become an educational methodology that allows for the development of scientific, artistic, logical-deductive, and mathematical thinking, while improving creativity, innovation, problem-solving and decision-taking skills and increasing students' engagement and motivation (Quigley & Herro, 2016; Liao, 2016; Greca, 2018). This methodology not only presents the contents of complex areas in a more attractive way (Contradty, Sotiriou & Bogner, 2020) but it also generates in the students new ways of knowing and the ability to solve problems in a society that is in constant change (Perignat & Katz-Buonincontro, 2019; Gates, 2017).

In this regard, with the implementation of STEAM activities in mathematics programme, students can achieve scientific competence, especially focused on experimental activity (Gallego & Márquez, 2018), as well as a technological education adapted to the present that promotes computational thinking (Ruiz, Zapatera, Montes & Rosillo, 2019). An education in engineering and mathematics allows students to develop skills related to the development and creation of solutions to solve real-world problems (Yakman & Lee, 2012), while art, also referring to design from an open perspective, helps them to develop creative and innovative thinking (Liao, 2016; Anderson & Meier, 2016). At the same time, they are enabled to understand not only scientific and technological behaviors but also social and human behaviors (Wing, 2006); all of this applied is in a collaborative work environment in which the students are actively involved (Greca, 2018) through participation in their own learning (Hsiao & Su, 2021).

This educational model makes it possible to face certain challenges within the current scientific and technological education such as the gender gap, lack of interest or inadequate teaching of STEAM subjects. Thinking that success or failure in experimental sciences, mathematics or technology depends on cognitive abilities that cannot be developed through practice directly affects students (Wang & Degol, 2017). Therefore, it is necessary to bet on the development in the classroom of projects that facilitate scientific popularization and gender inclusion (Sánchez-Rodríguez, Colomo, Sánchez-Rivas & Ruiz-Palmero, 2020).

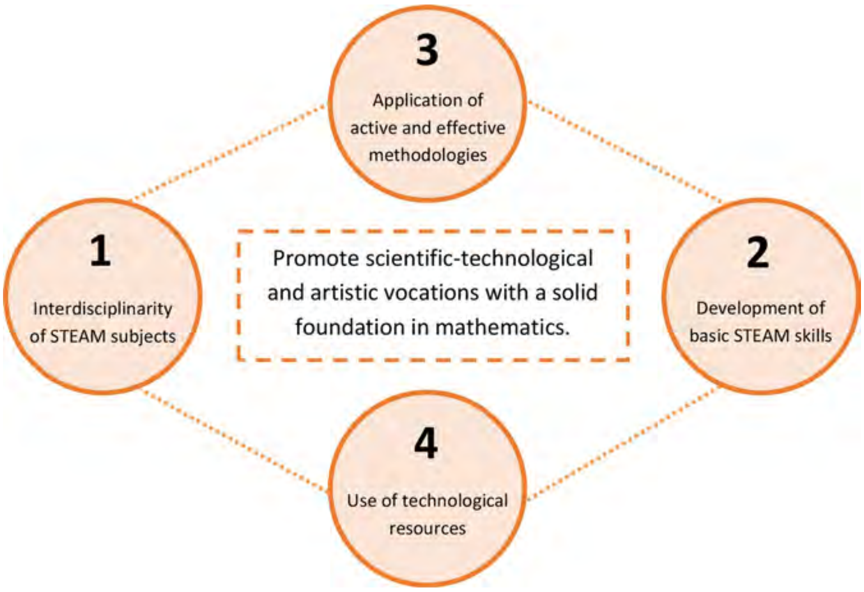

Figure 1. Action lines of STEAM education

While it is true that this pedagogical approach has already been studied in most of the literature reviews published in recent years on STEAM education, none of them consider mathematics as the basis that supports the rest of STEAM disciplines. For instance, you can carry out a physics project without having artistic knowledge or make a sketch of a sculpture without knowing about experimental science, but in each of them it is essential to know mathematics. That is, a scientific, technological, engineering, or artistic project cannot be applied without using mathematics at some point in its development Perignat and Katz-Buonincontro (2019) examine articles published on STEAM education with the aim of describing the general purpose of this methodology.

This review contains a great number of definitions of the STEAM concept in a generalized manner and provides recommendations to advance the research and implementation of STEAM education. However, they set their focus on creativity and the elements of artistic education as learning outcomes. As for Bases-García and García-Sánchez (2021) present a systematic review on the impact of STEAM approaches on academic results with the purpose of evaluating the self-efficacy of students and checking whether there is a significant increase in learning outcomes. Other authors such as Ortiz-Revilla et al. (2021) make a critical reflection on the implementation of an integrated education in STEAM disciplines and evaluate the real scope of this approach from an epistemological, psychological, and didactic perspective.

In this connection, Santamaria, Povis, Colca and Urcia (2022) carry out a bibliometric and documentary analysis with the aim of analysing scientific competences and describing the transdisciplinary approach and the main characteristics of the STEAM methodology and García-Fuentes, Raposo-Rivas and Martínez-Figueira (2022) show how effective the implementation of STEAM activities in classrooms is and focus on giving a general evaluation of STEAM education without considering other important factors such as the most appropriate type of active methodology or the criteria that should be followed to design and implement STEAM activities. Other authors such as Leavy, Dick, Meletiou-Mavrotheris, Paparistodemou and Stylianou (2023) are committed to identifying the application and prevalence of emerging technologies in the field of STEAM education, giving more emphasis to new technologies and artistic skills.

A more complete review is provided by Kwang and Wong (2021) who study the characteristics that involve the empirical practices of a STEAM education. This study shows that: (a) arts, science and technology are the most covered areas in the STEAM methodology, with mathematics being relegated to a lower priority, (b) the effectiveness of STEAM learning must be improved, expanding the diversity of STEAM education and addressing teacher support and (c) project-based learning, real-life problem solving, and extensive use of educational technology are the most common methodologies in STEAM education.

As can be seen, none of the reviews mentioned above highlight the role of mathematics as the main core in the STEAM methodology. All of them provide relevant information on the evaluation and effectiveness of implementing STEAM projects in classrooms but, in general, very little is said about which active methodologies should be applied or which may be, in this sense, the most attractive proposals for students. Nor are previous experiences on teacher training shown. Although the implementation of STEAM initiatives is increasing, existing theoretical frameworks are nor developed with sufficient specificity for teachers to apply them in the preparation of their classes (Yakman, 2008). This limits opportunities for teachers to design STEAM proposals with broader educational objectives.

Awareness of this problem, this scoping review provides an overview of the state of research knowledge on the current situation of STEAM education from a mathematical perspective. To respond to this objective, the following research questions were posed:

1. What elements should be considered to implement STEAM activities or projects in the teaching-learning of mathematics? What criteria should be followed to develop them?

2. What are the benefits of applying STEAM activities or projects in the teaching-learning of mathematics? Do the practices of the STEAM methodology have a positive impact on students and their learning?

3. Are there STEAM learning programs for mathematics teachers? How does the teacher training program affect the teachers' ability to plan STEAM activities or projects?

STEAM education is proposed from a perspective of curricular integration, but there are very diverse approaches on how to bring it to the classrooms. In all of them, the role of mathematics is the most committed. Yakman (2008) claims that the study of mathematics has direct links with all fields of study, especially when we face the formulation, analysis, and resolution of all types of problems. This point is very interesting for STEAM education, since the basis of communication is the language of mathematics and, to understand anything, you must know and understand the basic concepts of mathematics. To define a broader view of this integrative mathematics-based education and adequately answer research questions raised above, we are going to analyse in this review the following five study groups:

1. *Active methodologies used in teaching-learning of mathematics with a STEAM approach.*

   The use of active methodologies such as problem-based learning, project-based learning, gamification, flipped classroom, the use of information and communication technologies (ICT) or the use of WebQuest, among others, improve the academic performance, increase student participation and motivation, encourage class attendance, and reduce school absenteeism, as many research studies have confirmed. Likewise, it strengthens comprehensive training and the transfer of knowledge while awakening the ingenuity and creativity of students in problem solving. The final objective is to transform traditional teaching into an active, participatory, and interdisciplinary teaching. For this reason, we think it is important to know what the most appropriate active methodologies may be to implement STEAM project or activities in mathematics classes.

2. *Development of technological resources to teach mathematics with a STEAM methodology.*

   The use of technological resources in classrooms has been highlighted as one of the key factors that make teaching is of quality. With the advent of ICT to secondary schools has been a revolution for the world of learning. This forces the construction of a new cultural context and the global adaptation of the school itself, but mostly from the teachers. Therefore, knowing the technological resources most used is beneficial when designing any STEAM project.

3. *Design and implementation of STEAM proposals in the mathematics programme.*

   Designing STEAM activities is not easy since many factors must be considered for the experience to be positive, such as applying the correct methodology, choosing the appropiriate technological resources, organising work times appropriately or establishing specific evaluation criteria. So, another objective of this review is to analyse some of the STEAM projects that have already been applied and in which mathematical content prevails.

4. *Training in STEAM education for teachers who teach artistic and scientific subjects.*

   One of the challenges of STEAM education is the teachers' training to implement integrated lessons (Herro, Quigley & Cian, 2018). Teachers are responsible for guiding the discussions, providing feedback on progress during the program and its activities. It is necessary that they previously acquire all the knowledge the intend to teach and master skills specific to their teaching work, such as the ability to adapt to the different disciplinary requirements of STEAM, staying up to date with the latest advances in science and technology. Teachers with STEAM training are required to promote integrated management of mathematics learning from a holistic and interdisciplinary perspective (Conradty & Bogner, 2020) and in this way, increase students' ability to analyse and evaluate the consistency of mathematical concepts and reasoning studied in class and know how to formulate, apply and interpret them in real-life situations, recognizing the role that mathematics plays in the world (OECD, 2023). Therefore, we see it would be advisable to evaluate whether there are STEAM training programs for teachers who are not experts in mathematics.

5. *General evaluation of STEAM education.*

   Finally, we consider it necessary to give an overview of the evaluation of STEAM education in terms of motivation, attitude, limitations, learning processes and strategies, etc. It is essential to reflect on the theoretical issues related to this approach, the psychological and didactic foundations that support its application and its benefits.

In conclusion, it is important to know which are the active methodologies and technological tools that are most frequently used in STEAM projects, what is the design and implementation phase of these projects in the classrooms and what is the current situation of teacher training in STEAM education. This article offers a critical view of these perceptions seeking to promote reflection on the role that mathematics should have in this STEAM framework. To do this, different contributions that have been made in recent years on STEAM education in the pre-university stage have been studied and analyzed. This will allow us to know, in a synthesized way, what has been investigated regarding this subject, what its current status is and how much importance is usually given to mathematics.

2. Methodology

To answer the aforementioned research questions, a systematic review of qualitative studies on the implementation of STEAM education in the curriculum of pre-university education was performed. The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) Statement, updated in 2020, was used as the base document for the analysis which "includes reporting guidance that reflects advances in methods to identify, select, appraise, and synthesise studies" (Page, McKenzie, Bossuyt, Boutron, Hoffmann, Mulrow et al. (2021: page 1).

First of all, from 21 November 2023 to 28 November 2023, an exhaustive search of information was carried out using the following databases: Web of Science, Scopus, Dialnet, Springer and Eric. There were no limitations regarding the search range by years since it was not about analyzing current or newer studies but rather evaluating the contributions of other authors on STEAM education in the classroom over the years. As a secondary search complement, Research Gate (a social network and collaborative tool aimed at scientists of all disciplines) was used in order to locate researchers whose motivation was related to the object of study and thus to request the full texts in the event that they would not be available in the primary sources of reference.

The search equations used were the same in the different databases mentioned above (Table 1). The first group of search equations in Spanish was performed in which the keywords were taken as a whole, excluding documents that included the words university, primary or school, since our subject of study was far from primary or higher studies. Subsequently, the same process was carried out with a second group but this time with the keywords in English. In both groups, the search for keywords was divided into subsections following the sequence: << object, technique, basis, course, exclusion >>. That is, the search was focused on the object of study (STEAM education), the technique to be applied (methodological proposal), the basis or what it is to be used for (teaching-learning and/or education), the course on which the review focuses (secondary and pre-university education), and the exclusions that were not the reason for the search (primary or elementary education and university degrees).

After an initial search, a total of 1286 documents were found to study, of which only 246 were open access. Of the 246 documents, those whose titles do not focus attention on the object of study were discarded, leaving 118 documents. Subsequently, and before making the first selection of articles, duplicates, degree theses, literature reviews and documents in presentation format or in a language other than Spanish or English were eliminated. After this qualifying process, 86 documents were selected for study.

After reading and reviewing the abstracts, a total of 48 studies were discarded. Among the reasons for exclusion were the methodology used, the type of research (only statistical texts without relevance to our review), document type (conferences or reviews), and the target audience (primary or university courses). A first reading of the remaining 38 documents was made, of which 15 were discarded without reading the complete text, since it was enough to read only a few pages to realize that they did not fit the object of study or were not research papers. After further reading, it was decided to exclude another 4 documents from the review because the approach of the documents was too theoretical and generalized. Table 2 specifies the inclusion and exclusion criteria for this review.

A second reading was carried out with the remaining 19 documents and it was decided not to discard any of them since they were all considered important to include in the systematic review. The diagram provided by the PRISMA 2020 statement was used to complete the flow of documents (Figure 2). Using the systematic review approach, an attempt will be made to identify, select, synthesize, and evaluate the selected studies in order to answer the question under study, specifically including STEAM education as a methodological proposal in the teaching-learning of mathematics in secondary and pre-university education to improve the students' mathematical attitudes and skills.

Date bases	Search Strategy	Search Results
Web of Science	"steam education" or "steam project" teaching learning mathematics (All Fields) AND steam education (Title) OR steam project (Title) NOT primary stem university school (All Fields)	All fields (216) Limited to Educational Research (47) Open Access (**47**)
Scopus	(TITLE-ABS-KEY("steam education" OR "steam project") AND NOT TITLE-ABS-KEY(stem AND school AND university AND primary) AND TITLE-ABS-KEY(teaching AND learning)) AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "MATH")) AND (LIMIT-TO(DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Spanish")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO(PUBSTAGE, "final")) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (EXACTKEYWORD, "STEAM") OR LIMIT-TO (EXACTKEYWORD, "STEAM Education"))	Title-Abs-Key (861) Limited to Social Sciences, and Mathematics (136) Open Access (**112**)
Dialnet	"educación steam" OR "metodología steam" OR "proyecto steam" NOT "primaria" NOT "infantil" NOT "universidad"	Full Text - Open Access (**34**)
Springer	"steam education" AND (methodology OR project OR teaching OR learning) AND NOT (stem AND primary AND school AND university)	Mathematics Education (22) Open Access (**4**)
Eric	"steam education" AND (methodology OR project OR teaching OR learning) AND NOT (stem AND primary AND school AND university)	All fields (151) Peer reviewed/Full text (49) Education level (**16**)

Table 1. Search equations and search results

Eligibility criteria: Inclusion and exclusion criteria		
Descriptor	**Inclusion**	**Exclusion**
Type of research	Qualitative research	Quantitative research
Document type	Articles Book chapters and e-books	Conferences Reviews
Source type	Journal Reports	Presentations at conferences Documents in presentation format Final Degree-master's projects Doctoral theses
Publication stage	Final	Article in the press
Language	Publications in English and Spanish	Publications in other languages
Interest area	STEAM education	STEM Education
Subject area	Social Sciences, Science Education and Mathematics Education	Other areas
Education level	Secondary and pre-university education	Primary or university education

Table 2. Inclusion and exclusion criteria of documents

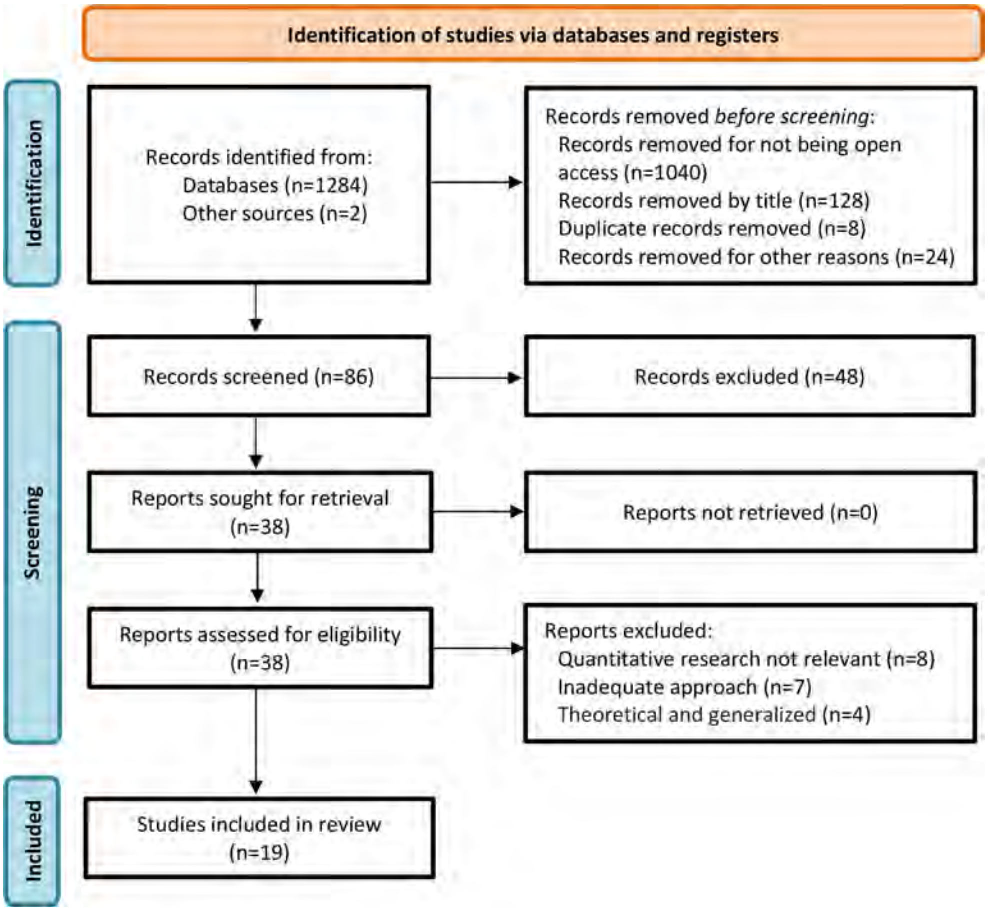

Figure 2. Flow diagram (PRISMA, 2020)

3. Results and Discussion

First of all, with the aim of grouping all documentation, Table 3 is a summary in which a general description of the 19 documents submitted is made, indicating the content and research purposes of each one of them. It is worth mentioning that the papers are ordered by publication date, from most to least current.

<table>
<tr><th colspan="5">Synthesis methods</th></tr>
<tr><th colspan="3">Paper</th><th colspan="2">Investigation dimension</th></tr>
<tr><th>N.</th><th>Year</th><th>Author(s)</th><th>Purpose</th><th>Interest area</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">2023</td><td rowspan="3">Delgado-Rodríguez, Carrascal & García-Fandino</td><td rowspan="2">To design and validate an educational methodological model based on the use of augmented reality to improve learning processes in science subjects</td><td>Design and implementation of educational proposals</td></tr>
<tr><td>Development of technological resources</td></tr>
<tr><td>To show that teachers need training in immersive technological resources</td><td>Teacher training on STEAM education</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">2023</td><td rowspan="3">Wiegand & Borromeo</td><td>To detail a theoretical reflection on the connections between STEAM education and sustainability</td><td>STEAM education assessment</td></tr>
<tr><td>To present mathematical modelling as a possible instrument in STEAM education and education for sustainable development (ESD)</td><td rowspan="2">Teacher training on STEAM education</td></tr>
<tr><td>To create an ESD-modelling seminar for mathematics teachers</td></tr>
</table>

Synthesis methods				
Paper			Investigation dimension	
N.	Year	Author(s)	Purpose	Interest area
3	2022	Zhan, Yao & Li	To explore the effects of association interventions on students' creative problem-solving ability	STEAM education assessment
4	2022	Tsekhmister, Kotyk, Matviienko, Rudenko & Ilchuk	To identify the impact of the use of augmented reality technologies in STEAM education	Development of technological resources
5	2022	Malagrida, Klaassen, Ruiz-Mallén & Broerse	To facilitate the implementation of Responsible Research and Innovation (RRI) within science education	RRI and teacher training in STEAM education
6	2022	Körtesi, Simonka, Szabo, Guncaga & Neag	To analyse the utility of ICT tools as a method of active learning To apply innovative teaching methodologies related to a STEAM education program	Active learning for the teaching of STEAM subjects
				Development of technological resources
				Design and implementation of educational proposals
7	2022	Roldán-Zafra & Perea	To design a scientific workshop for learning mathematics with a focus on cryptography To create activities adapted to the STEAM model	Active learning for the teaching of STEAM subjects
				Design and implementation of educational proposals
8	2022	Hsiao, Chen, Chen, Zeng & Chung	To show the implications of using teaching approaches for a STEAM activity through project-based learning (PBL) and a cognitive-affective interaction model (CAIM)	Active learning for the teaching of STEAM subjects
				Design and implementation of educational proposals
				STEAM education assessment
9	2022	Lavicza & Tejera	To integrate technological and pedagogical innovations in the classroom	Development of technological resources
10	2022	García-Cuéllar & Martínez-Miraval	To develop activities based on STEAM education under the mediation of GeoGebra	Design and implementation of educational proposals
				Development of technological resources
11	2022	Rodrigues-Silva & Alsina	To analyse the effects of a practical teacher-training program on the teachers' abilities related to planning activities using the STEAM approach	Teacher training on STEAM education
12	2022	Wu, Liu & Huang	To evaluate the cognitive load to explain the continuous learning intention of STEAM education	STEAM education assessment
13	2021	Hsiao & Su	To combine the concept of STEAM education with interdisciplinary teaching-learning. To integrate virtual reality to support STEAM education	Active learning for the teaching of STEAM subjects.
				Development of technological resources
14	2021	Soroko, Soroko, Mukasheva, Ariza-Montes & Tkachenko	To analyse the use of virtual reality to support STEAM education in a general secondary school	Active learning for the teaching of STEAM subjects
				Development of technological resources
15	2021	Lee, Peng & Klemm	To include the Makerspaces movement within STEAM education	Active learning for the teaching of STEAM subjects.
16	2021	Diego-Mantecon, Prodromou,	To analyse project-based learning based on the STEAM education model implementation in	Active learning for the teaching of STEAM subjects.

Synthesis methods				
Paper			Investigation dimension	
N.	Year	Author(s)	Purpose	Interest area
		Lavicza, Blanco & Ortiz-Laso	school mathematics (STEAM-PBL)	Teacher training on STEAM education
				STEAM education assessment
17	2020	Jesionkowska, Wild & Deval	To evaluate the applicability of the STEAM education with a qualitative approach applying augmented reality	Development of technological resources
				Design and implementation of educational proposals
				Development of technological resources
18	2019	Rizzo, del Río, Manceñido, Lavicza & Houghton	To offer different ways of mathematics learning through providing contexts for exploration and the students' creation of their own content through collaborative learning and creative thinking	Active learning for the teaching of STEAM subjects
				Development of technological resources
				Design and implementation of educational proposals
19	2018	Gülhan & Shain	To implement an activity based on the 5E model for STEAM education	Active learning for the teaching of STEAM subjects
				Design and implementation of educational proposals

Table 3. Synthesis methods of documents

The 19 papers were divided into five study groups that were already specified in the introduction of this document: (A) active methodologies, (B) technological resources, (C) didactic proposals, (D) training for teachers, and (E) evaluation of STEAM education. Within the first group were papers that focus on the application of active learning methodologies. So, then the students may be able to have better knowledge and essential skills to function adequately in the social and professional field, it is necessary move from teacher-centred to student-centred teaching, that is, using methodologies that put the student at the centre of the process where teaching does not revolve around the teacher and the content. Rather, the focus is on the students and activities carried out to achieve learning (Silva & Maturana, 2017).

In this sense, Körtesi et al. (2022) were committed to an education focused on implementing active and innovative teaching methodologies related to sustainable STEAM education using resources that allow students to deepen their understanding of mathematical notions and solving tasks in STEAM subjects and real-life applications. On the other hand, Hsiao et al. (2022), Diego-Mantecon et al. (2021) and Soroko et al. (2021) reflected the importance of considering project-based learning (PBL) as a way of integrating STEAM subjects in the classroom. Hsiao et al. (2022) considered that the teaching content should be designed based on the PBL strategy together with a cognitive-affective interaction model (CAIM) in order to implement the hands-on STEAM activity and, in that way, achieve quality education.

Other authors such as Roldán-Zafra and Perea (2022) speak of informal environments as motivating spaces for the development of STEAM activities. In mathematics teaching, diverse teaching strategies are employed to facilitate the students' learning process and carrying out STEAM activities outside the classroom is one of them. In this context, Lee et al. (2021) argued that makerspaces (any space that promotes active participation, the exchange of knowledge and collaboration through exploration and the creative use of tools and technology) have the potential to improve the learning outcomes of students since they support STEAM activities, as well as promote natural creativity among students who present with difficulties understanding mathematics and science in general. Introducing the concept of makerspaces in STEAM subjects encourages students to promote their critical thinking skills as they progress in their studies (Lee et al., 2021; Vuorikari, Ferrari & Punie, 2019).

Likewise, Rizzo et al. (2019) and Gülhan and Shain (2018) as well as Roldán-Zafra and Perea (2022), and Lee et al. (2021) also opted for a methodology based on collaborative work and creative thinking in order to improve mathematical learning and the students' enthusiasm towards the subject. In particular, Gülhan and Shain (2018) applied the 5E model (engage, explore, explain, elaborate and evaluate) in their research, that is, "a teaching sequence based on the constructivism" (Bastida-Bastida, 2019: page 75). Designing STEAM activities in which this type of methodology is applied is a good strategy for the students to use to achieve meaningful learning.

In the second group were the papers that develop and incorporate technological resources for the teaching-learning of STEAM disciplines. ICT consists of increasingly accessible and adaptable tools that high schools can incorporate for the purpose of making pedagogical changes when teaching traditionally in order to move towards a more constructive learning environment (Castro, Guzmán & Casado, 2007). There are many authors included in this review who studied the use of technological resources to carry out STEAM activities. Among the most used resources were GeoGebra (García-Cuellar & Martínez-Miraval, 2022; Jesionkowska et al., 2020; Körtesi et al., 2022; Rizzo et al., 2019; Lavicza & Tejera, 2022), augmented reality (Delgado-Rodríguez et al., 2023; Tsekhmister et al., 2022; Jesionkowska et al., 2020) and virtual reality (Soroko et al., 2021; Hsiao & Su, 2021). As Tsekhmister et al. (2022) pointed out, the use of augmented reality technologies significantly improves students' performance, increasing the understanding of complex systems and mechanism promoting collaboration among them, developing spatial abilities, and improving performance on physical tasks (Jesionkowska et al., 2020). In mathematics, this can be beneficial to work with geometric elements in the plane and in space. Likewise, Körtesi et al. (2022) pointed out, it is very important that students have a broad knowledge of mathematical theory since it is an essential asset to guarantee the effective use of mathematical software.

In this regard, Jesionkowska et al. (2020) said that activities must be designed to improve not only the technical and artistic skills such as coding, computational thinking, art or geometry but also the communication, problem solving and project management skills. The results obtained after applying this methodology showed that the combination of STEAM education with ICT tools could help to improve the learning satisfaction and outcomes of the students and increase their motivation for technology and mathematics. Other authors such as Hsiao and Su (2021) said that it was necessary to implement learning proposals based on technology integrating the sustainability concept into virtual reality system-aided STEAM education in an effort to further provide the students with integrated interdisciplinary education. For example, this can include the design of an application of an experiential gaming model and virtual reality in education.

The third group was dedicated to documents that focused on the design and implementation of didactic proposals with a STEAM approach. In mathematics teaching, different strategies must be employed to promote and facilitate the students' learning process. Some authors such as Roldán-Zafra and Perea (2022) based their research on the design of a didactic proposal focused on mathematics learning in a science museum with a STEAM strategy in place making didactic use of cryptography, while others such as Gülhan and Shain (2018), Hsiao et al. (2022), and Lavicza and Tejera (2022) were committed to the use of art and structural modeling to develop STEAM activities that make use of materials that the students can identify and provide easily.

According to García-Cuéllar and Martínez-Miraval (2022: page 14), "art allows teachers to carry out creative, collaborative, and supportive learning environments, as well as to develop interconnections between disciplines from a creative, motivating perspective, and where technology is integrated into pedagogical practice". A good example of the application of art in learning mathematics is the activity that Rizzo et al. (2019) proposed in their research. The approach consisted of a contest in which students had to catch a mathematical concept in the form of a picture and insert it in GeoGebra software, make up a problem that could be solved using that picture and analyse it using the software's tools to solve the problem.

Apart from Rizzo et al. (2019), there are other authors such as Körtesis et al. (2022), García-Cuéllar and Martínez-Miraval (2022) who have used mathematical software to develop STEAM activities. Körtesi et al. (2022) pointed out that the constant use of educational software is a requirement for sustainable STEAM and mathematics education. For this reason, it is necessary to design didactical projects where computer algebra systems or dynamic geometry systems are implemented in the classroom. In this connection, Jesionkowska et al. (2020) used the concept of augmented reality and codification in their activities since it was of a good quality in order to provide a direct link between the physical reality and virtual information about that reality. In particular, the activities consisted of developing a certain concept and creating a working application prototype through the use of a pseudo-code. Other authors such as Delgado-Rodríguez et al. (2023), showed, through a quantitative study, that there is significant empirical evidence that validates the methodological model developed to explain key concepts and improve the level of motivation and acceptance of augmented reality technology by students. STEAM evaluation projects where augmented reality is used are more fun and enjoyable for the students. In fact, this technology has the potential to increase student participation in class (Jesionkowska et al., 2020) and may induce improvements in educational processes (Delgado-Rodríguez et al., 2023).

Of course, all activities cannot be applied if the teachers who teach STEAM subjects are not adequately prepared for this methodology. According to Tsekhmister et al. (2022) the formation of a group of experts in the disciplines involved in STEAM education is the most important procedure, as it largely determines the quality and success of any STEAM activity. Therefore, in the fourth study group, it was considered convenient to evaluate the training of teachers of STEAM disciplines. Rodrigues-Silva and Alsina (2022) analyzed the effects of a practical teacher-training program on the teachers' ability to plan STEAM projects. For that, they designed a preparation course for the teachers of STEAM subjects which consisted of evaluating the implementation of STEAM activities through different educational approaches. In particular, they evaluated the dimensions of knowledge, usage, willing to use and appropriateness to STEAM projects.

Wiegand and Borromeo (2023) present a detailed theoretical reflection on the connections between STEAM education and the sustainability from the perspective of mathematical modelling. They point out that "mathematical modelling can be a possible instrument for promoting pre-service teachers' professionalism in STEAM education and education for sustainable development (ESD)" (Wiegand and Borromeo, 2023: page 1269). In this sense, they created a STEAM-ESD modeling seminar for pre-service teachers in which three teaching profiles for handling ESD within mathematical modeling were developed: (a) students learn to deal with mathematical models by performing socially relevant sustainability-oriented problems, (b) teachers use ESD topics to promote mathematical concepts, and (c) teachers use mathematical models as an instrument for achieving ESD goals in the classroom. After training, the participants claim to promote STEAM-ESD modeling in their future teaching lives.

On the other hand, Diego-Mantecon et al. (2021: page 1137) pointed out that "mathematics is recognized as the fundamental basis of other disciplines; however, many students still perceive it as a difficult subject and abandon it". As we have already mentioned, to avoid this, they propose in their study to implement a STEAM methodology based on project-based learning. To analyze this methodology, they examined classroom experiences from some secondary education teachers who participated in a STEAM training program for several academic courses. The results showed that mathematics teachers avoided interdisciplinary projects in which mathematics is difficult to address, while out-of-field mathematics teachers ignored mathematics of the projects. For this reason, Diego-Mantecon et al. (2021) was unsure about whether interdisciplinary projects are suitable for emphasizing mathematics in an effective way. However, they suggest combining traditional teaching with integrated content approaches since students should be able to apply mathematics in context.

Other authors such as Delgado-Rodríguez et al. (2023) and Tsekhmister et al. (2022), through a qualitative study of teachers who used augmented reality as a technological resource, showed that teachers require specific training regarding the creation and appropriate use of educational resources and digital evaluation systems. In this regard, Tsekhmister et al. (2022), added that "the widespread introduction of innovative technologies in the educational process at all levels has led to the need to create a model for monitoring the quality of teaching and learning, considering new factors influencing the assimilation of new educational resources" (Tsekhmister et al. (2022: page 253).

Finally, the fifth study group is dedicated to the articles that try to give an overview of the evaluation of STEAM education. Malagrida et al. (2022) focused their research on Responsible Research and Innovation (RRI) and more specifically on how its implementation is facilitated within secondary STEAM education. In particular, the main objective was to evaluate STEAM education through an exhaustive study carried out focused on the different teachers of STEAM subjects. This research was comprised of two phases: (1) developing a comprehensive framework of RRI competences in STEAM education and (2) analyzing the perspectives of STEAM teachers on the implementation of RRI competences and their learning methods.

The items that were evaluated in this article were, among others, identifying and defining problems, research questions, and the methods used in STEAM education, as well as identifying the evidence needed and judging its reliability or analyzing the best methodology to be applied. The methods and actions that the teachers suggested to address the RRI competences were:

1. Designing activities aimed at identifying problems, research questions and scientific methods in which the students search for information before performing virtual or real experiments.
2. Facilitating spaces for students to interact with each other or creating e-learning platforms where students from different schools can work on the same STEAM project.
3. Reflecting on the social impact of the activities, their risks, and consequences.

The results show that the comprehensive framework of RRI competences helps the teachers reflect on how to innovate in STEAM education.

On the other hand, Wiegand and Borromeo (2023) are committed to STEAM education linked to sustainability. They point out that applying sustainability concepts in STEAM education could stimulate critical discussions in the educational and social domain, transforming education into an innovative environment for sustainable development. Mathematical models in the context of STEAM-ESD present two main approaches: contextual and realistic. The objective of contextual modeling is to offer students incentives for processing and argumentative discussion while realistic modeling consists of applying interdisciplinary STEAM training based on the resolution of real problems applied to sustainability and other artistic and/or scientific-technological disciplines.

Other authors, such as Wu et al. (2022), propose a learning cycle and comprehensive research framework that integrates Bloom's taxonomy (Figure 3), that is knowledge and learning (cognitive domain), attitude and motivation (affective domain), and the implementation of STEAM activities (psychomotor domain) to explore the relationship between the learning domains and learning intention. According to these authors, to explain the continuous learning intention of STEAM activities, several factors must be taken into account: usefulness, ease of use, enjoyment, and the relevance and mental effort, among others. The findings of this research reveal that critical factors affect the students' learning attitudes and intentions regarding STEAM education.

After analysing and evaluating the five study groups based on the papers included in the review, we have everything necessary to answer the questions that are the focus of our research. Table 4 indicates those articles that have been used to answer each of these research questions.

What elements should be considered to implement STEAM activities or projects in the teaching-learning of mathematics? What criteria should be followed to develop them?

After evaluating the different theoretical frameworks and methodologies used in the articles included in this review, we realize that it is important that the work of teachers and the rest of the educational community is oriented around the development of the STEAM field. Clear and concrete objectives must be set to achieve the greatest possible involvement of students. However, these objectives cannot be excessive, but must be adapted to real needs and implicitly linked to a strategy in order to facilitate its subsequent review and evaluation. Before designing and implementing any STEAM project, it is advisable to ask yourself to what extent each activity marked in the project will help achieve the objectives, define the actions (work calendar, human and material resources, organizational measures, and monitoring and evaluation), specify its approach, and choose the methodology that will be applied.

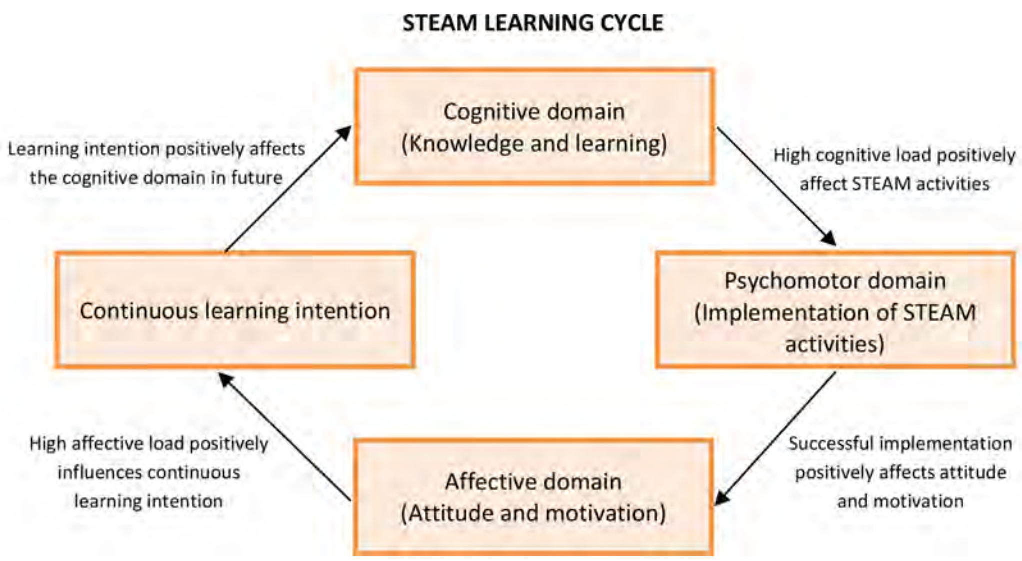

Figure 3. STEAM learning cycle (Wu et al., 2022: page 3)

The STEAM projects proposed in the reviewed articles are developed using active methodologies contrasted with scientific and technological evidence and, at the same time, based on challenges or problems that promote the development of integration in the teaching of digital technologies. The objective that is intended to be achieved with this is to develop meaningful learning in students in which critical, analytical, and abstract thinking predominates. It should be emphasized that the active methodologies do not mean discarding traditional instructional structures and tools such as direct instruction when necessary and contextualized, since it is very possible that in the development of the activity the teacher will have to intervene to explain a new concept to the students.

Most authors agree on highlighting the use of interdisciplinarity in projects with this approach. They emphasize that it is important to cover all possible STEAM disciplines, focusing on the artistic and creative part, since it is the one that differs from the STEM approach, without "A". Regarding the most used active methodologies, collaborative work, project/problem-based learning and learning and education through design and manipulation of materials stand out.

Figure 4. How to make a STEAM plan

What are the benefits of applying STEAM activities or projects in the teaching-learning of mathematics? Do the practices of the STEAM methodology in mathematics have a positive impact on students and their learning?

Studies reveal that applying STEAM activities encourages students to improve their critical thinking skills and create or solve problems at an even deeper level as they progress in their studies. In addition, it will allow them to work collaboratively, using their imagination to solve or find a creative solution to real-life problems (Lee et al., 2021). This helps improve students' social and communication skills, as well as their ability to work effectively as a team. Likewise, this approach facilitates learning with digital resources and the use of ICT tools, promotes practical and proactive learning and concept retention, and improves students' creative capacity. The STEAM methodology involves practical projects where students can experiment how mathematical principles are applied in real life. In this way, the understanding of theoretical concepts is promoted, students' interest in mathematics and other sciences is increased, and experimentation and research work is also stimulated.

In all the articles analyzed in which the attitude of the students is evaluated, it is concluded that in general terms, they enjoyed the work carried out and pointed out that the activities proposed created expectation and curiosity and helped them to better understand the key concepts explained by the teacher. They tend to react with a lot of enthusiasm, especially those who disengage in more traditional classroom environments (Lee et al., 2021). The use of technological resources, such as augmented reality and education through design, generates a positive impact on students' academic performance and understanding (Delgado-Rodríguez et al., 2023). In most cases, at the end of activity, students challenge themselves with new questions and strategies to answer them and, in general, were less afraid of making mistakes (Rizzo et al., 2019).

Are there STEAM learning programs for mathematics teachers? How does the teacher training program affect the teachers' ability to plan STEAM activities or projects?

After the search carried out in the different databases, only 5 articles of those that were selected evaluate teacher training in STEAM education in recent years. This indicates the lack of training for teachers who teach STEAM disciplines and the urgent need to implement training programs that promote this type of methodology among future teachers.

Teachers who were evaluated, indicated openness to change and continuous learning as a required ability for teachers who teach STEAM subjects. Consequently, they suggest teacher training programs in this field, which allow them to explore active learning teaching methods and guide them in the progress of planning their activities. Some of the questions asked of the teachers who participated in the Rodriges-Silva and Alsina's (2022) preparation course, referred to the main advantages and disadvantages found in the preparation and development of the activities as well as what kind of skills they thought the teachers may need to apply to the teaching-learning process of STEAM subjects. The results showed that using different areas of knowledge in an interdisciplinary way seemed to be the most difficult part. Added to this is the time that it takes to prepare activities using this format, the lack of experience of the teacher in some areas of knowledge and the risk of working on the content superficially. However, most teachers highlighted the importance of addressing this type of project since it is a way for them to learn about other disciplines and develop a good planning capacity.

Other authors such as Diego-Mantecon et al. (2021) showed that teacher in STEAM areas tended to avoid activities with a lot of mathematical content because it is the subject that causes the most rejection among students. For that, they suggest combining traditional teaching with an integrated education in which mathematics is applied as an interdisciplinary subject and problem-based learning as a notable methodology. On the other hand, Delgado-Rodríguez et al. (2023) and Tsekhmister et al. (2022) point out that teachers need training in immersive technological resources since they consider it important that teachers know how to adapt to changes in technological and educational innovation. Malagrida et al. (2022) analyzed the implementation of Responible Research and Innovation within STEAM education and the results showed that this integrated framework helps the teachers think on how to innovate in their classes.

Research question	Main results	Papers
What elements should be considered to implement STEAM activities or projects in the teaching-learning of mathematics? What criteria should be followed to develop them?	• To define concrete objectives. • To choose the methodology according to the objectives. • To use of interdisciplinarity, technological resources and collaborative work. • To evaluate if set objectives have been achieved.	Delgado-Rodríguez et al. (2023), Wiegand & Borromeo (2023), Tsekhmister et al. (2022), Malagrida et al. (2022), Körtesi et al. (2022), Roldán-Zafra & Perea (2022), Hsiao et al. (2022), Lavicza & Tejera (2022), García-Cuéllar & Martínez- Miraval (2022), Hsiao & Su (2021), Soroko et al. (2021), Lee et al. (2021), Diego-Mantecon et al. (2021), Jesionkowska et al. (2020), Rizzo et al. (2019), Gülhan & Shain (2018).
What are the benefits of applying STEAM activities or projects in the teaching-learning of mathematics? Do the practices of the STEAM methodology have a positive impact on students and their learning?	• Development of basic STEAM competencies. • Improved students' critical thinking and their social and communication skills. • Increased students' creative capacity in problem solving. • Increased students' attitude and motivation.	Delgado-Rodríguez et al. (2023), Wiegand & Borromeo (2023), Zhan et al. (2022), Malagrida et al. (2022), Körtesi et al. (2022), Roldán-Zafra & Perea (2022), Hsiao et al. (2022), García-Cuellar & Martínez-Miraval (2022), Wu et al. (2022), Diego-Mantecon et al. (2021), Jesionkowska et al. (2020), Lee et al. (2021), Rizzo et al. (2019), Gülhan & Shain (2018)
Are there STEAM learning programs for mathematics teachers? How does the teacher training program affect the teachers' ability to plan STEAM activities or projects?	• Few teacher training programs in STEAM methodologies. • Need to implement training in technological resources and STEAM education in general. • Exploration of active learning teaching methods with a solid basis in mathematics. • Creation of e-learning platforms for STEAM projects.	Delgado-Rodríguez et al. (2023), Tsekhmister et al. (2022), Rodrigues-Silva & Alsina (2022), Malagrida et al. (2022), Diego-Mantecon et al. (2021).

Table 4. Summary of the main results obtained from the research questions

4. Conclusion

For adequate development in the mathematics subject supported by the STEAM methodology, the teacher is required to study multiple knowledge in depth and make appropriate use of teaching-learning strategies to achieve the success of the subject, as this makes that the pedagogical practice impacts on students, generating significant learning outcomes. From the bibliographical review that has been carried out, it was determined that using the STEAM concept in the teaching-learning of mathematics as an approach applied to education can be a good methodology to develop in the students the necessary skills to stimulate growth both academic as well as personal and scientific, mathematical, technological, and artistic. But, to evaluate the real scope of STEAM, it is essential to reflect explicitly on the theoretical issues and the didactic and epistemological foundations that support its implantation in classrooms. Only in this way can its educational potential be harnessed.

It is very common to talk about comprehensiveness, contextualization, interdisciplinarity and dynamism in the learning generated by the STEAM methodology, which seeks to train autonomous students, capable of working collaboratively and developing investigative skills that help them respond to new social and technological challenges by applying their learning in the different areas of STEAM knowledge. In this connection, it is considered convenient to use this methodology to develop interdisciplinary activities and strengthen multiple knowledge taught from the same approach. To do this, a student is required to assume leadership roles and responsibilities, know how to work as a team and collaboratively, make use of ICT resources and be creative and innovative.

To carry out STEAM activities, it is necessary to apply a methodology in which the students actively build their own learning (Sánchez, 2019, leaving the teacher in the background to serve as a guide and counselor during the activities. The teacher, in addition to knowing the intellectual and affective needs of his students, must also master previously and by himself all knowledge and skills of his teaching work, such as the ability to adapt to the different disciplinary requirements of STEAM education (Zamorano, García & Reyes-González, 2019) and, if necessary, to receive adequate training to be able to guide the discussions, provide feedback on progress and support the solutions that are built during the process. In addition, it is important that the teacher maintain communicative links and collaborate with other members of the educational community to carry out high-quality projects (Yakman & Lee, 2012).

Regarding the methodology to be used, it is suggested to implement the teaching-learning of mathematics through design, creativity, project/problem-based learning, integrative/integrated learning, and the use of technological resources that will help in the development of activities through collaborative work. It should be fully organized that promotes cohesion and social interaction. The articles whose research has been based on the implementation of STEAM educational practices reflect an increase in the attitude of students towards mathematics and other STEAM disciplines, especially the artistic ones, since the manipulation of materials is usually a motivating resource for them (Gülhan & Shain, 2018; Hsiao et al., 2022; Lavicza & Tejera, 2022). However, in most of articles analysed, mathematics is not considered as the main integrating element, and this may become a long-term problem for students, since they tend to pay more attention to manipulative work or the use of technologies than to mathematical concepts behind it.

In conclusion, for STEAM education to evolve as an effective assessment project, prior research is needed to understand the implications of this practical and methodological approach. Such research should focus on the learning outcomes related to thinking skills such as problem solving, critical thinking, decision-making processes, abstraction skills, and/or creativity.

There is no significant evidence that develops a high mathematical content in the STEAM activities proposed in the review articles. Among the methodologies used, the use of technological resources and the manipulation of materials without a mathematical background prevails. Only in activities in which calculation and design computer programs are used does the role of mathematics stand out. Regarding the STEAM proposals analyzed, the research works of García-Cuellar and Martínez-Miraval (2022), Lavicza and Tejera (2022) and Rizzo et al. (2019) deserve to be highlighted as they focus their research on the teaching-learning of mathematics with a STEAM approach. According to them, with computer calculation tools such as GeoGebra, it is possible to apply those mathematical notions related with the field of functions and geometry that can be linked to art and engineering through mathematical modeling, adjusting a model to a specific situation and making additional calculations. In fact, the use of educational software is a prerequisite for a STEAM education based on mathematical concepts, since "it helps to comprehend the limits and possible contradictions of applying these concepts in theoretical and real-world practical problems" (Körtesi et al., 2022: page 19).

STEAM training programs and qualitative studies are carried out between current teachers and future teachers to implement quality STEAM projects. The most relevant, and worrying, results were obtained from the research study by Diego-Mantecon who, after a qualitative evaluation of different teachers in STEAM areas, concluded that mathematics teachers usually avoid incorporating STEAM activities with a lot of mathematical content to prevent students from becoming discouraged, while non mathematics teachers directly eliminated any mathematical content in their activities. This is undoubtedly a problem because as Boon (2019) says, the integration of mathematics allows it to be considered central elements in scientific and technological work, always present in real life. For this reason, activities should be designed in which mathematical reasoning prevails in problem solving, and in this way, promote reflection on the role that mathematics should have in the STEAM framework.

Overall, for STEAM education to evolve as an effective assessment project, prior research is needed to understand the implications of this practical and methodological approach. Such research should focus on the learning outcomes related to scientific-technological and artistic thinking skills with a solid mathematical basis, such as real-world problem solving, critical thinking, decision-making processes, abstraction skills, and/or creativity.

5. Limitations and Future Lines of Research

After this review process, we can affirm that, although there are still certain weaknesses regarding the contribution of mathematics in STEAM education that must be addressed, there is a lot of work done in this sense with different well-founded points of view. In the preparation of this article there have been certain limitations that have made the review process difficult.

Firstly, the search had to be generalized since no specific results were returned where mathematics skills were the central discipline among the STEAM areas. In most articles, more importance was given to art as it is the las discipline to be incorporated and the one that poses the most challenges when designing STEAM projects.

Secondly, existing theoretical frameworks on STEAM education are, in some cases, too open and unspecific. We consider it extremely important that the theoretical models are clearly descriptive, explicitly including the assumptions on which they are based. Otherwise, its application will be reduced only to specific contexts, contributing to very few teachers decide to implement this methodology in their classes.

On the other hand, it should be noted that although technological, information and communication advances are developing rapidly, gender differences still persist in STEAM subjects. None of the articles reviewed mention this and, without a doubt, it is important because the motivation to undertake activities with a STEAM approach not only influences the knowledge but also the psychological processes, beliefs, and principles of each one. For this reason, it is necessary to promote the development of STEAM vocations equally among all students, regardless of sex, as this would reinforce the impact of this methodological approach in the present and for the future.

Finally, we already know from the review that the most prevalent methodology in STEAM education is problem/project-based learning and that the most used resources are augmented reality, the use of computer programs or the manipulation of materials. However, we believe that it would be convenient to provide something new and propose STEAM activities or projects where other types of methodologies are used, such as math trails. Math trails are activities to discover "in situ" the mathematical properties of the places visited. What is truly important about this type of activities, in terms of learning, is the mathematical modeling process that is carried out. The aim is to transform the real situation posed into an abstract problem that can be addressed mathematically. This links directly to the STEAM approach, in which the contextualization of the problems raised is very important.

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