TPM Vol. 32, No. S5, 2025
ISSN: 1972-6325
https://www.tpmap.org/

PEDAGOGICAL STRATEGIES IN THE IMPLEMENTATION OF THE STEM/STEAM APPROACH IN PRIMARY AND SECONDARY EDUCATION: A SYSTEMATIC REVIEW

JENIFFER XIMENA VEGA FAJARDO
CORPORACIÓN UNIVERSITARIA ADVENTISTA
EMAIL: jvega@unac.edu.co, ORCID: 0000-0001-6733-891X

WILLIAM F. BERNAL
COMPUBUGA (UDEV): GUADALAJARA DE BUGA, VALLE DEL CAUCA, CO, ORCID: 0009-0000-0453-5641

DIANA M. JARAMILLO
INSTITUTO ADVENTISTA DE CÚCUTA, ORCID: 0009-0008-7793-5767

PAULA ANDREA SAAVEDRA
CORPORACIÓN UNIVERSITARIA ADVENTISTA, ORCID: 0009-0001-3042-3528

Abstract
This article presents a systematic literature review aimed at identifying pedagogical strategies within the STEM/STEAM approach, which integrates Science, Technology, Engineering, Art and Mathematics as a response to the educational challenges of the 21st century. The study focused on experiences implemented at the elementary and secondary education levels, considering both practical and methodological interventions. The search was carried out in electronic databases using Boolean operators, automatic filters and applying inclusion and exclusion criteria. The study made it possible to identify pedagogical strategies implemented in the STEAM approach and the skills promoted in students. Among the most frequent are the use of digital tools and project-based learning. Regarding the skills developed through the STEAM approach, the findings highlight logical thinking and problem solving as key competencies of the 21st century, enhanced through dynamic, contextualized and collaborative learning experiences.
It highlights the need to promote educational policies that ensure technological provision and specific teacher training programs, especially in Colombian educational contexts with economic and technological limitations. It is recommended that greater curricular flexibility and interdisciplinary approaches be promoted.

Keywords: Educational strategies, motivation, primary education, secondary education, school integration, pedagogical innovation.

INTRODUCTION

The STEM/STEAM approach has established itself as an innovative pedagogical alternative aimed at responding to the educational challenges of the 21st century through the integration of Science, Technology, Engineering, Art and Mathematics. Its main purpose is to promote interdisciplinarity, critical thinking, creativity and the solution of real problems, fundamental skills for the integral development of students in a globalized and technologically advanced context.
Various studies have shown that this proposal not only transforms traditional teaching practices, but also strengthens the participation of students in the educational process. (López Rivero, 2023) highlights significant improvements in motivation and academic performance through the use of digital tools such as Scratch and GeoGebra, which allow modeling complex phenomena and promoting computational thinking. Likewise (Bernal Piza & Vargas Sandoval, 2024) highlight the positive impact of Project-Based Learning (PBL) as a strategy that articulates interdisciplinary

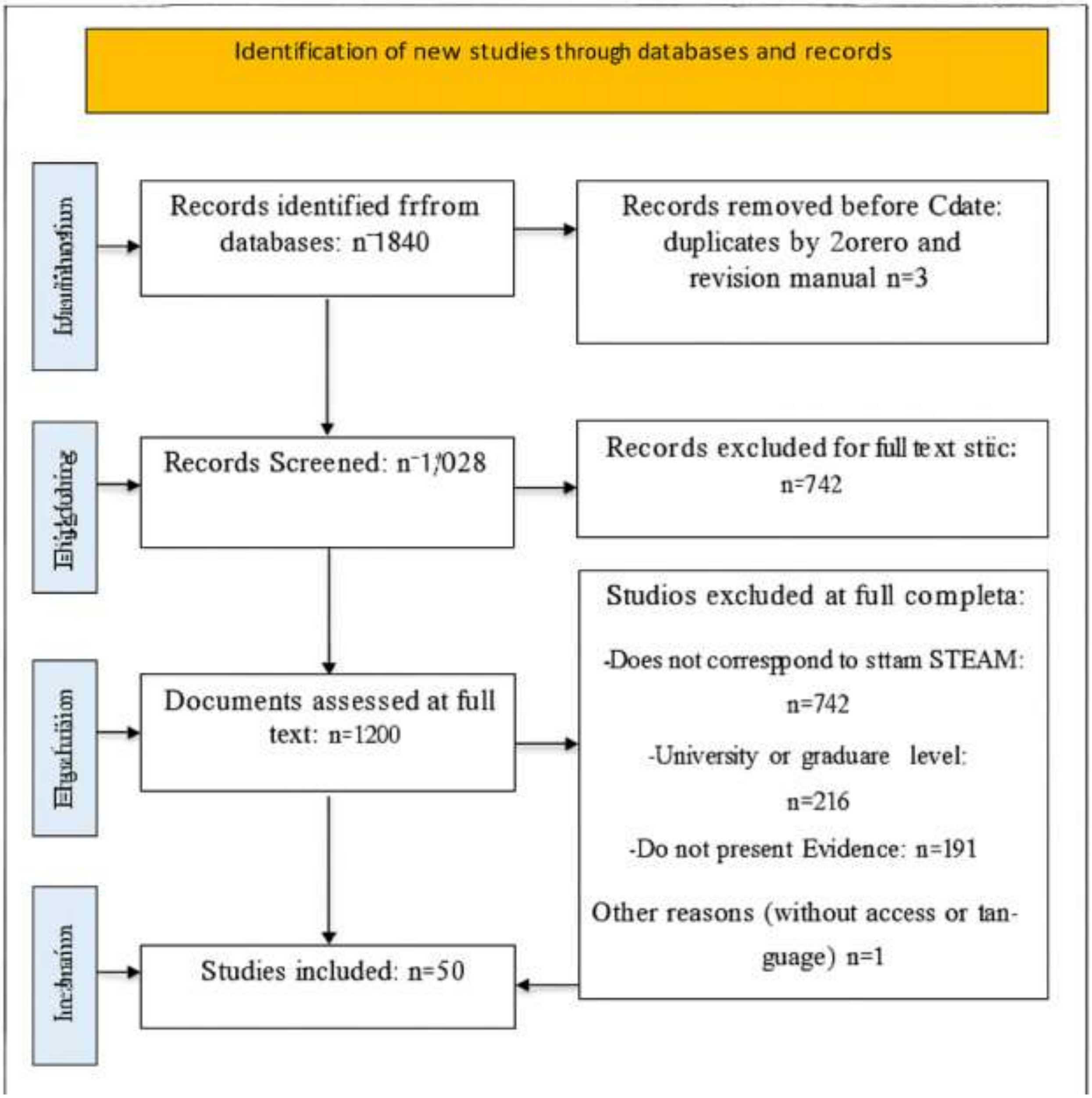
knowledge around authentic challenges, stimulating autonomy, planning and a deep understanding of scientific phenomena.
On the other hand, the inclusion of emerging technologies, such as educational robotics and programming, has proven to be a valuable resource to enhance logical reasoning and motivation, as they point out (Camino Herrera et al., 2024). These tools, together with integrated active methodologies such as the flipped classroom or gamification, make up a dynamic and adaptive didactic ecosystem that responds to the diversity in learning.
In this way, this systematic review aims to identify the pedagogical strategies implemented and the skills that are developed through them in contexts of basic primary and secondary education within the STEAM approach, in order to offer a comprehensive vision of their impact, conditions of application and transformative potential in the school environment.

METHODOLOGY

This study was developed through a systematic literature review, using the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) model, proposed by (Page et al., 2021). This methodological approach allows for standardization and transparent documentation of each phase of the process: from source identification, screening, and eligibility, to the final inclusion of studies. Its application guarantees reproducibility, bias control and scientific validity in the synthesis of results.
The search strategy was designed using Boolean operators "OR", "AND" to identify studies related to the STEAM approach at the primary and secondary education level. The equation formulated was: ("pedagogical strategies" OR "educational methodologies") AND (STEM OR "Science, Technology, Engineering, Mathematics") AND ("secondary education" OR "basic education"). When applying this search equation, the SATO databases yielded a total of 18,400 documents.
After the elimination of duplicates (n = 3,372), a total of 15,028 records were screened, of which 12,993 were excluded by title and abstract, and 1,200 documents were evaluated in full text. Finally, 1,150 studies were discarded for not meeting the established inclusion criteria. Manual screening was carried out in two phases: first, a reading of titles and abstracts to assess thematic relevance; subsequently, a complete review of the selected texts, applying explicit inclusion and exclusion criteria such as: year of publication (2017–2024), language (Spanish, English, Portuguese) and type of document.
Finally, the documents distributed according to their source of access were selected as follows: 24 articles were from Dialnet, 9 come from RedALyC, 2 located in EBSCOhost, and the remaining 15 were extracted from Scielo.
Only those studies that explicitly addressed the STEM or STEAM approach as a central axis were included, including methodologies such as project-based learning (PBL), gamification, computational thinking, educational robotics, among others. In addition, they had to be applied in primary or secondary education (baccalaureate) contexts, evidence practical experiences, interventions or real training programs, and incorporate teacher training processes within the STEAM approach.
Those documents that superficially mention the STEAM approach without applying it as the central axis of the study, those that focused exclusively on university or postgraduate education, or those that did not present methodological application, practical intervention or direct connection with the classroom were excluded. Studies that did not include teachers or students as direct beneficiaries, those that did not show concrete results, findings or impacts, as well as those that were outside the established time range were also discarded. Documents written in languages other than Spanish, English or Portuguese without available translation, duplicate files, extended abstracts or without full access to the content, works focused on a single discipline without interdisciplinary articulation with the STEAM model, and texts of general dissemination, opinions without academic support or publications without formal scientific review were also excluded.
The 50 articles that met the established requirements were systematically classified and analyzed to answer the research question: What are the most used pedagogical strategies in the STEAM approach and what skills do they develop in the students?
The data analysis was carried out using an extraction matrix, where variables such as year of publication, country of study, educational level, pedagogical strategy used, type of evidence reported, skills developed and macro competencies were recorded in a structured way. The process was carried out by a lead reviewer with cross-checking by the co-authors, ensuring the consistency of the recorded data. All the articles included were managed using the Zotero software, which allowed the sources to be organized.

For the synthesis of results, a qualitative approach based on thematic categorization and frequency analysis was used. The included articles were coded according to the STEAM pedagogical strategies applied and the skills developed in the students to facilitate their analysis.
The process flow is represented in Figure 1, corresponding to the PRISMA 2020 diagram, which visualizes the number of records processed in each phase of the document analysis.

Figure 1. Adapted PRISMA diagram.

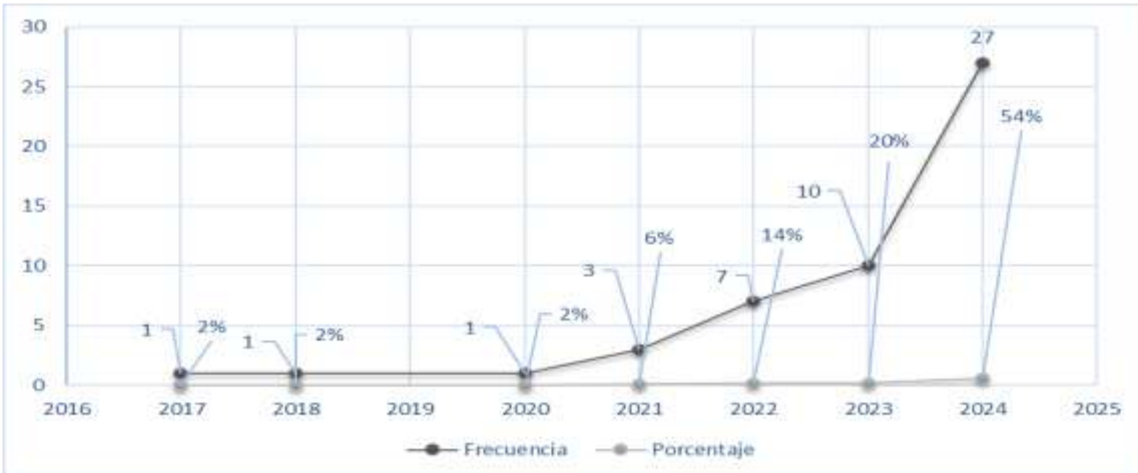


Own elaboration based on (Page et al. 2021).

RESULTS AND DISCUSSION

Publications on STEAM in primary and secondary education have increased markedly in the last three years, reflecting increased academic interest. According to the distribution presented in graph 1, the years 2022, 2023 and 2024 account for 88% of the total number of articles analyzed, with a peak in 2024 (n = 27). The above may indicate the research interest in this field of knowledge.

Figure 1 Frequency and annual percentage of STEAM studies in basic education (primary and secondary)



Note. Prepared by the author based on the 50 articles included in the systematic review. In original Spanish language

Recent studies such as those of (Espinosa Cevallos, 2024) and (Flores, 2024), show that the application of the STEAM approach constitutes both a pedagogical innovation and a validated mechanism for the leveling of competencies after the pandemic educational crisis. Both works highlight the use of emerging technologies, which combine face-to-face and virtual and practical methods that help students catch up in science, technology and mathematics.

This shift towards more practical educational methods, adapted to the reality of students, is a great opportunity to renew traditional teaching. The pedagogical practices linked to the STEAM approach develop the ability to analyze complex situations, solve practical problems and connect knowledge from different areas from early stages, which prepares students to face the challenges of the contemporary world.

Table 1 presents the most commonly used pedagogical strategies in the STEAM approach, indicating the exact number of articles that mention each of them

Table 1 STEAM pedagogical strategies

Strategy	Conceptualization	Frequency	Authors per article
Project-Based Learning (PBL)	It is developed through projects that articulate scientific, technological, artistic or social knowledge.	13	Queiruga-Dios et. al (2021); Gaitán Hernández and de la Cruz Hernández (2024); Armijos Romero and Dután Duque (2022); López Rivero (2023); Bernal Piza and Vargas Sandoval (2024); Pelejero de Juan (2018); Borda Martínez (2021); Agudelo Rodríguez and Gonzáles-Reyes (2024); Flores Zaragoza et al. (2024); Chía Fuentes (2023); Turriate and Castillo (2022); Bucio-Gutiérrez et al. (2024); Espinosa Cevallos (2024)
Gamification or educational game	Transform the learning environment	1	Gaitán Hernández and de la Cruz Hernández (2024)

	through game-specific dynamics.		
Digital tools	Use of programming software and artificial intelligence in educational applications, simulators and platforms.	18	González Díaz (2024); Espinosa Cevallos (2024); López Rivero (2023); Camino Herrera et al. (2024); Dellepiane (2023); García Mejía and García Vera (2020); Turriate and Castillo (2022); Bucio-Gutiérrez et al. (2024); Gaitán Hernández and de la Cruz Hernández (2024); Chía Fuentes (2023); González Díaz (2024); Espinosa Cevallos (2024); Dellepiane (2023); López Rivero (2023); Camino Herrera et al., (2024); García Mejía and García Vera (2020); Bucio-Gutiérrez et al. (2024); Chacón González and Hernández Pérez (2023)
Integrated active methodologies	Integration of strategies that promote collaborative learning, critical thinking, and creativity.	10	Gaitán Hernández and de la Cruz Hernández (2024); Flores Zaragoza et al. (2024); Espinosa Cevallos (2024); Dellepiane (2023); Chía Fuentes (2023); Borda Martínez (2021); Turriate and Casillo (2022); Bucio-Gutiérrez et al. (2024); López Rivero (2023); Agudelo Rodríguez & Gonzáles-Reyes (2024)
Problem solving/logical thinking	It is based on modeling, simulation and tools that favor abstraction and analysis based on complex problems.	3	De la Hoz Ruiz and Hijón Neira (2022); Arias-De la Cruz and Vergara-Ibarra (2024); Chía Fuentes (2023)
Educational robotics / programming	It is based on the design, simulation and control of artifacts.	5	Masaquiza Pinto (2025); Becerra Avendaño et al. (2024); Chía Fuentes (2023); Dellepiane (2023); Bucio-Gutiérrez et al. (2024)

The findings reveal a notorious preeminence of the use of digital tools (n = 18), confirming the role of platforms such as Scratch, simulators and interactive kits to articulate the interdisciplinary learning pursued by the STEAM approach. Research such as that of (López Rivero, 2023), confirm that the use of technological resources not only facilitates the understanding of complex theoretical concepts, but also improves student participation and autonomy in the educational process, (Camino Herrera et al., 2024) For their part, they emphasize that these resources promote the development of logical thinking, problem solving and intrinsic motivation of students, as well as (Espinosa Cevallos, 2024) argues that the incorporation of interactive technologies in STEAM educational environments favors the transfer of knowledge to real and collaborative contexts, which together show that these resources transfer theoretical concepts to applied scenarios, strengthening logical thinking and student motivation.
Project-Based Learning (PBL) occupies the second position (n = 13) and is a strategy that is related to the foundations of this approach, since it encourages students to address real problems and actively participate in contexts with practical meaning. Research such as that of (Queiruga-Dios et al., 2021) conclude that PBL, by focusing on authentic and contextualized tasks, favors student involvement and improves their performance in STEM subjects. The authors

stress that project work provides an ideal environment for developing both cognitive and socio-emotional skills, for its part. (Gaitán Hernández & De la Cruz Hernández, 2024) argue that the implementation of PBL in secondary classrooms not only encourages student participation, but also stimulates critical thinking and decision-making in collaborative environments. Their analysis shows an increase in academic commitment and a sustained improvement in performance, in addition to the work of (Armijos Romero & Dután Duque, 2022), present a pedagogical experience where PBL made it possible to integrate curricular content with the sociocultural reality of the environment, promoting significant learning. Similarly, (García-Mejía & García-Vera, 2020) document that the implementation of the STEAM approach with PBL during the pandemic strengthened the understanding of mathematics and stimulated motivation in high school students. The authors show that this didactic strategy enhances the student's autonomy, since it requires planning, research and decision-making throughout the process. Together, these studies support the value of PBL as a transformative pedagogical strategy, especially in secondary education, where active, cooperative and student-centered learning is essential for comprehensive education.

In this order of ideas, integrated active methodologies were identified in ten studies (n = 10), confirming the inclination to merge gamification, flipped classroom and cooperative learning in contemporary educational contexts. According to (Flores Zaragoza et al., 2024) These interactive methodologies generate a dynamic environment that increases student participation, stimulates critical thinking and reinforces the collective construction of knowledge. The authors highlight that gamification, by introducing playful and motivational elements, improves the attitude towards learning, while the flipped classroom allows a more efficient use of class time for discussion and problem solving, in the same way (Espinosa Cevallos, 2024), stresses that these combined methodologies generate more inclusive and participatory environments, favouring both autonomous and collaborative learning. Her research shows improvements in academic performance and a greater willingness of the student to face complex challenges through teamwork and self-regulation of learning. These combinations raise students' motivation and critical thinking. It has also been documented that the combination of PBL, gamification and flipped classroom improves participation and understanding of content (Guanotuña Balladares et al., 2024); (Herrera-Barzallo et al., 2024); (Michuy Gaibor et al., 2023); (Arias Villalba et al., 2024). Together, the strategies reinforce the relevance of adopting integrated didactic approaches to foster motivating and meaningful learning within the framework of educational transformation driven by the STEAM approach.

It is worth noting that educational robotics and programming are also strategies that stimulate logical thinking and creativity, evidenced in five of the studies analyzed (n = 5), marking a growing trend within the STEAM approach, research such as that of (Masaquiza Pinto, 2025); (Blázquez Álvarez, 2022)presents an experience in which basic education students applied programming knowledge through the use of platforms such as Tinkercad and Arduino, managing to consolidate interdisciplinary learning by facing real challenges of basic engineering, the results showed a substantial improvement in the ability to design functional solutions and argue their technical decisions. Supporting the above, (Becerra Avendaño et al., 2024) show that robotic kits are powerful tools to promote creativity, autonomy and decision-making in secondary school students. The implementation of activities based on the programming of sensors, motors and robotic structures allowed participants not only to understand abstract concepts of electronics and computational logic, but also to work collaboratively in active learning environments, these studies support the effectiveness of educational robotics as it enhances both technical learning and the development of higher cognitive skills, fully aligning with the goals of the STEAM approach (Diego Salomón et al., 2023) ; (Moronta Diaz, 2024) ; (Barzola Quintero & Barrera Barrera, 2022); (Urquizo, 2023)

Other strategies that emerge from this analysis are problem solving and logical thinking, which are identified in three articles (n = 3), and are presented as strategies linked to the teaching of mathematics, particularly at school levels where it is necessary to strengthen conceptual understanding and the practical application of the contents. highlighting the role of tools such as Scratch and mathematical modeling activities, which allow students to be actively involved in processes of abstraction, analysis and creation of solutions, in this sense, (Hoz Ruiz & Hijón Neira, 2022) and (Castillo Estrella & Cajas Monago, 2024) show how the implementation of Scratch in the classroom contributes to improving logical thinking skills in primary and secondary school students. The authors argue that visual programming not only improves motivation, but also facilitates the understanding of sequential, conditional, and algorithmic structures, fundamental in mathematical reasoning. As can be seen, (Arias-De La Cruz & Vergara-Ibarra, 2024); (Tomalá-Vera, 2024) They highlight that mathematical modeling activities allow students to face real or contextualized problems, which promotes the functional use of mathematical knowledge. This strategy not only improves the interpretation and representation of phenomena, but also develops argumentation, data analysis, and critical thinking skills, essential aspects for meaningful mathematical learning. Research agrees that the integration of educational programming and modeling environments allows abstract concepts to be connected with concrete situations. (Gutiérrez, 2023)

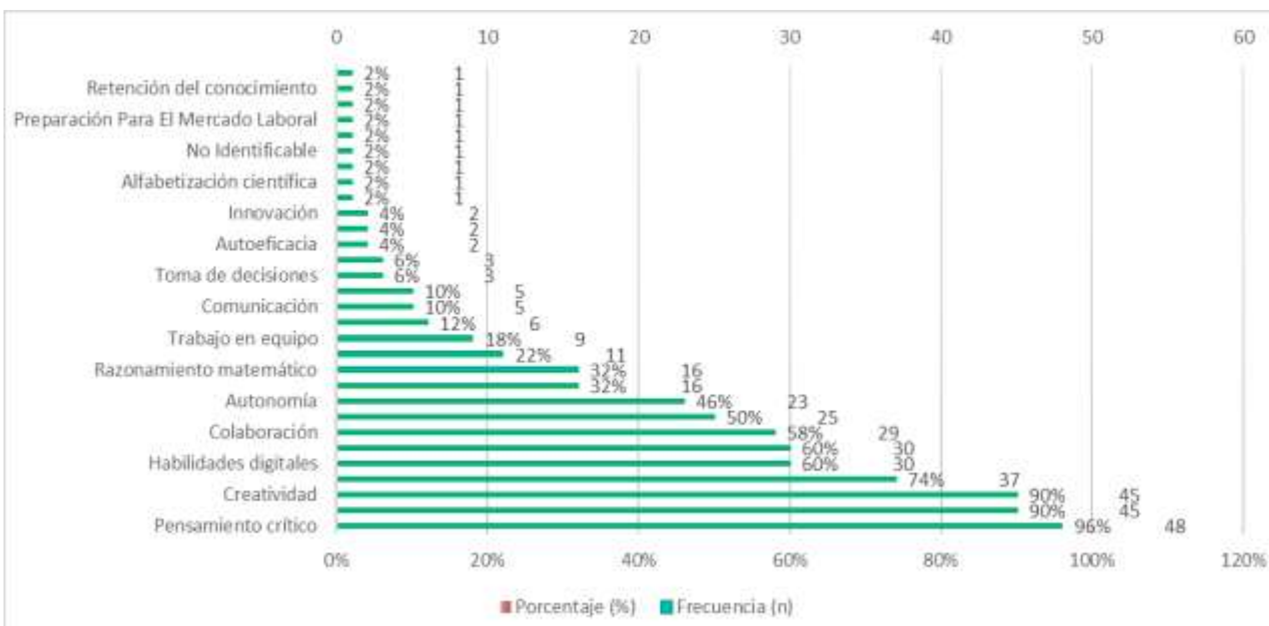
The least frequent strategy after the analysis of the documents is gamification or educational games, presented by the authors (Gaitán Hernández & De la Cruz Hernández, 2024) Those who offer evidence on how gamification, understood as the incorporation of structured playful dynamics in pedagogical processes, enhances meaningful learning by transforming the classroom into a participatory environment, highlight that the use of scoring systems, symbolic rewards, challenges and immediate feedback generates a more immersive learning experience, where students feel emotionally engaged and cognitively stimulated.

This pattern indicates that the most applicable pedagogical strategies in basic secondary education not only combine digital elements with active methodologies, but also prioritize approaches focused on design, creativity and addressing complex problems from the classroom, especially digital tools and PBL that enhance creativity, critical thinking and the practical application of knowledge in STEAM contexts (Agudelo Rodríguez & González-Reyes, 2024).

The versatility of integrated STEAM strategies: combining virtual labs, robotics and digital arts to pose open challenges in which students design solutions to real problems (Queiruga-Dios et al., 2021); (Romero & Ponce, n.d.) and (González Díaz, 2024), show that structuring long-range projects increases motivation and fosters creativity by positioning students as active managers of their own learning (López Rivero, 2023); (Masaquiza Pinto, 2025). Integrated active methodologies are characterized by combining gamification, cooperative work, and challenge-based learning to enhance problem-solving and critical thinking (Chía Fuentes, 2023). The predominance of integrated STEAM strategies suggests that teachers opt for flexible frameworks capable of simultaneously activating several key competencies.

Active methodologies such as PBL, gamification, flipped classroom, and augmented reality promote a consistent set of cognitive, digital, and socio-emotional skills in students, including computational thinking, logical reasoning, creativity, problem-solving, autonomy, digital literacy, emotional regulation, collaboration, and initiative. thus strengthening their intrinsic motivation and their ability to apply knowledge in real contexts, this is evidenced in Figure 2 where the percentages of skills developed by STEAM strategies in educational contexts can be observed, according to the analysis of the documents included in the systematic review.

Figure 2 Skills developed by STEAM strategies. In original Spanish language



Regarding the competencies promoted by the STEAM approach, critical thinking emerges as the skill with the greatest presence, followed by problem-solving and creativity, which may indicate that they are priority skills in educational contexts. Other notable attributes are academic motivation, the strengthening of digital skills, collaboration and autonomy, which aim to value transversal skills. (Prado Romero, 2023) showed how gender composition in the classroom influences academic performance and the decision to opt for STEM careers, especially among female students. This suggests a shift in focus in educational research, fostering skills that allow students to adapt to the environment, solve problems, and collaborate effectively

Research has allowed students to move from a passive role to an active one as creators of technological solutions, enhancing both their computational thinking and their ability to devise, analyze and propose interdisciplinary improvements in real situations (Chía Fuentes, 2023); (Borda Martínez, 2021); (Dellepiane, 2023) This shows that these strategies promote empathy, ideation and the ability to formulate innovative solutions contributing to a more comprehensive and critical training, promoting scientific and technological skills that prepare students to understand and transform their environment with a vision of the future.

Regarding the use of digital tools, it is reported that platforms such as Scratch, MakeCode, Micro:bit, GeoGebra and virtual laboratory simulators offer experiences that help students better understand abstract concepts. These tools allow you to receive immediate feedback, explore without physical risks and work in immersive environments (López Rivero, 2023); (Satrústegui Moreno et al., 2024); (Chía Fuentes, 2023); (Ramírez & Cubillos, 2021). and (Espinosa Cevallos, 2024). Therefore, it is necessary to have an infrastructure and trained teachers who can promote the development of more complex mental processes by promoting technical, social and citizenship skills.

Allowing students to formulate, manage and evaluate their own proposals favors the development of autonomy, creativity and can maintain constant motivation due to the challenges that give them purpose and meaning when carrying out STEAM activities (López Rivero, 2023); (Flores Zaragoza et al., 2024); (Gaitán Hernández & De la Cruz Hernández, 2024); (Esteban Ríos, 2023) they also integrate different disciplines adapting to real contexts, developing decision-making and adaptation skills (Landero Olán, 2024), which leads to the development of a greater variety of competencies and skills ideal for facing the challenges of the twenty-first century.

Based on the above considerations, the 50 articles have been reviewed, finding competencies that can be grouped from the skills that are developed through the STEAM approach, as already mentioned, the findings confirm that the more interdisciplinary the approach, the greater the variety of skills that students will develop. Table 2 shows the relationship found between the macro-competencies of the twenty-first century – consistent with international frameworks such as (Binkley et al., 2012) – and the skills that compose them found in the reviewed literature. This structure facilitates the understanding of the impact of the STEAM approach on the integral development of students.

Table 2 Macro competencies grouped based on specific skills (N = 50)

Macro competition	**Skills**	**Authors**
Cognitive	Critical thinking, problem solving, hypothesising, analytical skills, informed decisions	Chía (2023) and Borda Martínez (2021)
Creative and innovative	Original ideas, problem solving, openness, exploration	López Rivero (2023), Flores Zaragoza et al. (2024), Agudelo Rodríguez & González-Reyes, 2024
Emotional	Collaborative work, communication, empathy, leadership, group cohesion and sense of relevance, capacity for dialogue, social sensitivity and collective responsibility.	Agudelo Rodríguez & González-Reyes, 2024
Digital and interdisciplinary	Digital literacy, understanding of technological concepts, integration of knowledge	Pulido Varela, 2024, Bernal Párraga et al., 2024
Metacognitive	Reflection, self-regulation, planning, monitoring, self-evaluation	Arias-De la Cruz & Vergara-Ibarra (2023)

When grouping the specific skills into five macro competencies, a clear pattern of predominance of cognitive and creative processes is observed. (Banguera Zamora et al., 2024); (Bucio Gutierrez et al., 2024)evidenced, through quantitative analysis, that the STEAM approach strengthens technical and cognitive skills in technical high school students. The STEAM programs analyzed privilege cognitive competencies demonstrating improvements in critical thinking or problem solving. Research such as that of (Chía Fuentes, 2023) and (Borda Martínez, 2021) They describe how robotics and design thinking sequences lead students to formulate hypotheses and test them through prototypes, strengthening the ability to analyse and make informed decisions.

Creativity and innovation feature prominently among the skills promoted by STEAM strategies, (López Rivero, 2023) shows how Project-Based Learning (PBL) motivates students to develop original ideas to solve problems close to their reality. Similarly, (Flores Zaragoza et al., 2024) They document how creative and unexpected proposals are generated when working on biology projects that integrate art and science. This type of challenge encourages not only the production of new ideas, but also an attitude of openness and exploration in the face of knowledge (Agudelo Rodríguez & González-Reyes, 2024); (Montalvo-Ruíz et al., 2024). These experiences highlight that creativity does not arise only from talent, but from methodologies that allow students to experiment, make mistakes and try again. (Rodríguez Espinoza & Calderón Aguirre, 2023) illustrate this approach through a system of STEAM projects in Physics, which encouraged inquiry, collaborative work and a sustained improvement of learning in high school.

Socio-emotional competencies are also strengthened, especially when teamwork is promoted in collaborative contexts as demonstrated by (Buitrago et al., 2022) . Research such as that of (Agudelo Rodríguez & González-Reyes, 2024) they show improvements in skills such as communication, empathy and leadership, within the framework of open and flexible STEM projects, they also add how by addressing real problems in the community, students develop greater group cohesion and a sense of belonging. These experiences show that STEAM environments not only have an impact on academics, but also on the comprehensive training of citizens with the capacity for dialogue, social sensitivity and collective responsibility. (Joya Sandoval et al., 2024); (Martín Pérez, 2023) showed that STEAM projects in secondary school promoted school transformations and strengthened the scientific vocations of students.

Similarly, digital and interdisciplinary skills, studies highlight the role of technologies as a means to connect knowledge from different areas, (Pulido Varela, 2024) He highlights that, by programming microcontrollers, students improve their digital literacy and better understand technological concepts. For its part, (Bernal Párraga et al., 2024); (Turriate Guzman & Castillo Perez, 2022) They report that the use of simulation software facilitates the transfer of knowledge between subjects such as physics, mathematics and technology. Thus, the STEAM approach is consolidated as an effective way to overcome the fragmentation of school knowledge and promote learning applicable to real life.

Although it is rare in similar reviews, metacognitive competencies are also reflected in several studies. For example (Arias-De La Cruz & Vergara-Ibarra, 2024) ; (Valdés et al., 2022) They point out that when students manage their own projects, they tend to plan better, monitor their progress, and evaluate results critically. These types of skills are key to achieving more lasting and transferable learning, although they still need to be incorporated more intentionally in STEAM proposals. From a pedagogical perspective, the review shows that this approach is not limited to improving grades or specific performances, but also trains autonomous, critical and creative learners. However, it is also clear that it is necessary to continue strengthening strategies that make visible the processes of reflection and self-regulation in the classroom (Ramos Salcedo, 2024).

The analysis of the articles demonstrates a convergence between emerging technologies, active methodologies and contexts of meaningful learning. Along these lines, (Quiceno Arias, 2017) and (Pelejero-de-Juan, 2018) they point out that physical and methodological limitations in official institutions hinder the consolidation of sustainable STEM environments. However, this review allows us to evidence structural tensions that limit its effective implementation in real scenarios, especially in contexts such as Colombia, since most of the studies reviewed were developed in contexts with greater access to technologies and digital environments, which does not reflect the reality of many public and rural schools where connectivity gaps, infrastructure and teacher training are significant. (Masaquiza Pinto, 2025) and (Arias-De La Cruz & Vergara-Ibarra, 2024).

CONCLUSIONS

Overall, the results obtained throughout the analysis allow us to clearly answer the first part of the research question. Thanks to the systematization carried out, it was possible to identify precisely which are the most common STEAM pedagogical strategies and how they are combined in the different studies reviewed. In addition, when observing how these strategies are articulated in diverse contexts, it is confirmed that methodologies such as PBL, robotics, gamification and the use of digital tools are the most used due to their ability to adapt to real educational needs. This thematic identification not only allows for the recognition of trends, but also for the guidance of future evidence-based teaching practices.

On the other hand, by classifying and analysing the skills developed in each intervention, grouping them into macro-competences (cognitive, creative, digital, social and metacognitive), the second part of the research question is answered. This highlights the positive impact these strategies have on students' critical thinking, creativity, collaboration, and digital literacy. The body of findings was consolidated into a solid and organized evidence base.

Based on this study, it is recommended to foster greater curricular flexibility and promote interdisciplinary approaches that facilitate the effective implementation of the STEAM approach, allowing students and teachers to fully experience its benefits.

Finally, future research should focus on less advantaged educational contexts and on evaluating the long-term impact of STEAM strategies. It is also necessary to deepen specific teacher training in active methodologies, to guarantee effective and sustainable integration in various educational scenarios.

REFERENCES

1. Agudelo Rodríguez, C. M., & González-Reyes, R. A. (2024). 4. Design of a Teacher Training Program in Education with a STEM approach for intermediary cities. Redipe Newsletter Magazine, 13(11), 100-123. https://doi.org/10.36260/xs0abz60
2. Arias Villalba, W. O., Mejía Carrillo, M. D. J., Universidad Pedagógica de Durango, Durango, México, Carranza Basantes, S. F., Universidad de Especialidades Turísticas UDET. Quito Ecuador, Alvarado Jaya, H. G., & Universidad Regional Amazónica IKIAM. Tena. Ecuador. (2024). 48.STEAM (Science, Technology, Engineering, Arts and Mathematics) Education in Basic Education: Curricular Integration and Effectiveness, a Review from the Literature. Polo del Conocimiento, 9(2), 2026-2045. https://doi.org/10.23857/pc.v9i2.6651
3. Arias-De la Cruz. , I. A., & Vergara-Ibarra, J. L. (2024). 9. STEM methodology to improve the learning of mathematics in Higher Basic Education. MQRInvestigar, 8(4), 5845-5867. https://doi.org/10.56048/MQR20225.8.4.2024.5845-5867
4. Armijos Romero, O. E., & Dután Duque, M. J. (2022). 25. STEAM methodology to contribute to motivation and academic performance in Biology for the third year of Baccalaureate, "Herlinda Toral" Educational Unit. http://repositorio.unae.edu.ec/handle/56000/2348
5. Banguera Zamora, L. P., Tapia Navia, L. A., Anzules Ballesteros, J. E., & Maliza Cruz, W. I. (2024). 20. Evaluation of skills in the STEM methodology for technical high school students of the Alfonso Quiñonez George Educational Unit. ConcienciaDigital, 7(3), 46-65. https://doi.org/10.33262/concienciadigital.v7i3.3077
6. Barzola Quintero, E. R., & Barrera Barrera, M. F. (2022). 37.STEAM education as a methodology for the teaching-learning process of physics in the first year of high school, UE "César Dávila Andrade. http://repositorio.unae.edu.ec/handle/56000/2808
7. Becerra Avendaño, C. M., Calderón Díaz, F. J., & Jiménez Serna, E. T. (2024). 42.Reflection on the implementation of technology education with a STEM approach based on educational robotics and gamification in elementary school. http://repository.pedagogica.edu.co/handle/20.500.12209/19953
8. Bernal Párraga, A. P., García, M. D. J., Consuelo Sánchez, B., Guaman Santillán, R. Y., Nivela Cedeño, A. N., Cruz Roca, A. B., & Ruiz Medina, J. M. (2024). 8. Integration of STEM Education in Basic General Education: Strategies, Impact and Challenges in the Current Educational Context. Ciencia Latina Revista Científica Multidisciplinar, 8(4), 8927-8949. https://doi.org/10.37811/cl_rcm.v8i4.13037
9. Bernal Piza, B. N., & Vargas Sandoval, B. E. (2024). 17. PROJECT-BASED LEARNING TO PROMOTE THE DEVELOPMENT OF COMPETENCIES IN BASIC EDUCATION. OER: Revista Científica Especializada en Educación y Ambiente, 3(1), 65-83. https://doi.org/10.48204/rea.v3n1.5103
10. Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining Twenty-First Century Skills. En P. Griffin, B. McGaw, & E. Care (Eds.), Assessment and Teaching of 21st Century Skills (pp. 17-66). Springer Netherlands. https://doi.org/10.1007/978-94-007-2324-5_2
11. Blázquez Álvarez, M. (2022). 50. STEM-ABP Project: Automated irrigation with photovoltaic solar energy. https://hdl.handle.net/10953.1/18201
12. Borda Martínez, A. A. (2021). 3. The development of competencies of the STEM education system with students in basic secondary education. A case study. https://repositorio.ucm.edu.co/handle/10839/3456
13. Bucio Gutierrez, D., Barrios del Ángel, A. X., Alvillo-Villicaña, M. E. C., Cerda-Luque, P. A., & Reyna-Castillo, M. (2024). 44. Is STEAM inclusion possible in special education? Pedagogical approaches in the voice of experts. https://doi.org/10.46377/dilemas.v11i3.4118
14. Buitrago, L. M., Laverde, G. M., Amaya, L. Y., & Hernández, S. I. (2022). 7. Computational thinking and STEM education: Reflections for inclusive education from pedagogical practices. Panorama, 16(30), 12.
15. Camino Herrera, C. A., Andrade Muñoz, J., Rivera Cano, K. Y., & Sánchez Valtierra, J. A. (2024). 10. Implementation of Effective Pedagogical Strategies to Develop Technical Skills in the Context of the STEM Methodology in Mathematics in Students of the Julio Jaramillo Educational Unit. Revista Social Fronteriza, 4(2), e42246. https://doi.org/10.59814/resofro.2024.4(2)246

16. Castillo Estrella, S. Y., & Cajas Monago, E. A. (2024). 18. Machine Learning For Kids and its influence on the STEM educational approach in students of the 3rd. Bachelor's degree in secondary education from the Laboratory of Research and Pedagogical Innovation "El Amauta" UNDAC, Pasco Region. Daniel Alcides Carrión National University. http://repositorio.undac.edu.pe/handle/undac/4676
17. Chía Fuentes, Y. (2023). 01. Methodological strategies for the implementation of the STEM approach, through the development of computational and design thinking. Journal of Innovation in Science Education, 7(2), 37-61. https://doi.org/10.5027/reinnec.V7.I2.186
18. Dellepiane, P. (2023). 43. Technologies and pedagogy for STEM teaching. Ibero-American Journal of Technology in Education and Education in Technology, 34, Article 34. https://doi.org/10.24215/18509959.34.e16
19. Diego Salomón, N. R., Vargas Barros, V. H., Vásquez Barrera, F. J., Andrade Zambrano, W. D. J., & Espinoza Valarezo, F. L. (2023). 35.STEM Education: A Review of Interdisciplinary Approaches and Best Practices to Foster Skills in Science, Technology, Engineering, and Mathematics. Ciencia Latina Revista Científica Multidisciplinar, 7(2), 2023-2045. https://doi.org/10.37811/cl_rcm.v7i2.5453
20. Espinosa Cevallos, P. A. (2024). 46. Integration of the STEAM approach in basic general education: Impact on the development of critical thinking and creativity. Revista Tecnopedagogía e Innovación, 3(1), 53-69. https://doi.org/10.62465/rti.v3n1.2024.70
21. Esteban Ríos, B. (2023). 49.Female models in strategies for the promotion of STEM vocations: analysis of the situation and proposal for action in Secondary Education. https://uvadoc.uva.es/handle/10324/63060
22. Flores, E. P. Y. (2024). 32. STRATEGIES WITH STEAM METHODOLOGY FOR THE DEVELOPMENT OF CLOTHING SKILLS OF STUDENTS OF THE TECHNICAL BACCALAUREATE OF THE CLOTHING INDUSTRY. https://repositorio.uti.edu.ec/handle/123456789/6894
23. Flores Zaragoza, M., González Martínez, L. B., & Vences Esparza, A. (2024). 5.La STEM Education and Active Methodologies: A Systematic Review. Contemporary Dilemmas: Education, Politics and Values, 12, 1-19.
24. Gaitán Hernández, M. A., & De la Cruz Hernández, R. (2024). 12. Impact of active methodologies on the motivation and academic performance of students in secondary education. Pedagogical Constellations, 3(1), 127-146. https://doi.org/10.69821/constellations.v3i1.32
25. García-Mejía, R. O., & García-Vera, C. E. (2020). 26. STEAM methodology and its use in Mathematics for high school students in times of the Covid-19 pandemic. https://www.dominiodelasciencias.com/ojs/index.php/es/article/view/1212
26. González Díaz, G. J. (2024). 24. Implementation of an instructional design methodology incorporating a virtual digital fabrication laboratory and simulators for STEM subject practices in high school in virtual mode. https://ri-ng.uaq.mx/handle/123456789/11424
27. Guanotuña Balladares, G. E., Pujos Basantes, A. A., Oñate Pazmiño, M. F., Ponce Jiménez, M. A., Carrillo Llumitaxi, E. P., Delgado Yar, N. P., Vásconez Maza, E. C., & Calvopiña Trujillo, M. C. (2024). 39.Adaptation of the STEM-STEAM Methodology in Post-Pandemic Education: A Comprehensive Approach to Academic Recovery. https://zenodo.org/records/10694156
28. Gutiérrez, M. M. B. (2023). 40. Challenges and barriers to the successful implementation of the STEM method in the teaching of mathematics in primary education in the new Mexican school. Strategic Training, 7(1), 216-234.
29. Herrera-Barzallo, J. G., Hernández-Dávila, C. A., Montes de Oca-Sánchez, I. V., Triviño-Sanchez, J. J., & Vargas-Marín, H. J. (2024). 11. STEM Teaching Strategies: An Analysis of Active Methods in the Classroom. Multidisciplinary Latin American Journal (MLAJ), 2(3), 17-33. https://doi.org/10.62131/MLAJ-V2-N3-002
30. Hoz Ruiz, A. de la, & Hijón Neira, R. (2022). 23. Teaching Mathematics through the Use of Scratch (STEM Transversality). IE Comunicaciones: Revista Iberoamericana de Informática Educativa, 36 (July-December), 14-34.
31. Joya Sandoval, A. S., Álvarez Pulido, G., Panche Martínez, D., González Valcárcel, A. P., Fernández Romero, F., González Reyes, H. M., & Salazar Garzón, F. A. (2024). 41. STEM + Teacher Network Transforms: A Strategy That Drives Education for the 21st Century. Pedagogical Praxis, 24(37), 93-121. https://doi.org/10.26620/uniminuto.praxis.24.37.2024.93-121
32. Landero Olán, S. (2024). 21. RELATIONSHIP BETWEEN MANAGERIAL SUPPORT, TEACHING SUPPORT, MATHEMATICAL SELF-CONCEPT, AND INTEREST IN STEM DISCIPLINES OF TECHNOLOGICAL HIGH SCHOOL STUDENTS IN TABASCO. https://ri.ujat.mx/handle/200.500.12107/5235
33. López Rivero, A. F. (2023, July 17). 2. Didactic strategy based on the STEM approach to strengthen computational thinking skills in elementary school students. https://repositorio.unicordoba.edu.co/handle/ucordoba/7499
34. Martín Pérez, L. (2023). 29.Impact of the STEAM projects of the Junta de Andalucía. Ethnography of an educational center [University of Granada]. https://doi.org/10.30827/Digibug.83971

35. Masaquiza Pinto, W. D. (2025). 14.La STEM educational robotics and the learning of mathematical logical thinking in third-year high school students of the Luis Alfredo Martínez Educational Unit. https://repositorio.uta.edu.ec/handle/123456789/43285
36. Michuy Gaibor, M. F., Molina Verdugo, A. L., Peña, P. M., & Vistin Vistin, J. M. (2023). 28.The STEAM approach for the improvement of knowledge and motivation from interdisciplinary learning in primary school students. Prometheus Scientific Knowledge, 3(2), e51. https://doi.org/10.55204/pcc.v3i2.e51
37. Montalvo-—Ruíz, R. A., Remache-Oyaque, F. A., & Chiquito-Chilán, R. R. (2024). 36.The STEAM approach as a didactic strategy in the second year of Technical Baccalaureate, Professional Figure, Marketing and Sales. MQRInvestigar, 8(4), 6699-6721. https://doi.org/10.56048/MQR20225.8.4.2024.6699-6721
38. Moronta Díaz, S. (2024). 31. Impact of the use of science laboratory and robotics on student motivation towards STEAM areas Dominican Republic. Ciencia Latina Revista Científica Multidisciplinar, 8(5), 8385-8410. https://doi.org/10.37811/cl_rcm.v8i5.14248
39. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, n71. https://doi.org/10.1136/bmj.n71
40. Pelejero-de-Juan, M. (2018). 16.STEM Education, PBL and Cooperative Learning in Technology in 2nd ESO [masterThesis]. https://reunir.unir.net/handle/123456789/6838
41. Prado Romero, V. J. (2023). 22.Effects of gender on the choice of STEM careers and academic achievement [masterThesis, Quito, Ecuador : Flacso Ecuador]. http://repositorio.flacsoandes.edu.ec/handle/10469/19176
42. Pulido Varela, J. A. (2024). 6. The E for engineering in the STEM approach. Academia y Virtualidad, 17(2), 137-147. https://doi.org/10.18359/ravi.7283
43. Queiruga-Dios, M.-Á., López-Iñesta, E., Diez-Ojeda, M., Sáiz-Manzanares, M.-C., & Vázquez-Dorrío, J.-B. (2021). 13.Implementation of a STEAM project in compulsory secondary education that creates connections with the environment (Implementation of a STEAM project in Secondary Education generating connections with the environment . Journal for the Study of Education and Development, 44(4), 871-908. https://doi.org/10.1080/02103702.2021.1925475
44. Quiceno Arias, J. F. (2017). 15. Conditions for the implementation of STEM learning environments in official institutions of the city of Medellín, Case of I.E. Monsignor Gerardo Valencia Cano. http://hdl.handle.net/10784/11869
45. Ramírez, C. A. C., & Cubillos, L. D. S. (2021). 45. Pedagogical innovation through the STEM model to improve mathematical reasoning in patients who are students in hospital classrooms by implementing the multiplatform Cloud Labs. 2021. https://hdl.handle.net/20.500.12494/35769
46. Ramos Salcedo, V. (2024). 47. STEM Education in Latin American Perspective. A documentary review. http://repository.pedagogica.edu.co/handle/20.500.12209/20160
47. Rodríguez Espinoza, P. V., & Calderón Aguirre, A. J. (2023). 27. STEAM project system for the Physics EAP in 1st year of baccalaureate A, in the EU Manuel J. Calle. http://repositorio.unae.edu.ec/handle/56000/3181
48. Romero, V. J. P., & Ponce, J. (n.d.). Thesis to obtain the master's degree in Research in Development Economics.
49. Satrústegui Moreno, A., Quílez-Robres, A., Mateo González, E., & Cortés-Pascual, A. (2024). 19. Learning strategies and academic performance in STEM subjects in Secondary Education. Revista Fuentes, 1(26), 36-47. https://doi.org/10.12795/revistafuentes.2024.23324
50. Tomalá-Vera, V. V. (2024). 34.La STEAM methodology and its contribution to mathematical learning. EPISTEME KOINONIA, 7(13), 203-220. https://doi.org/10.35381/e.k.v7i13.3215
51. Turriate Guzmán, A. M., & Castillo Pérez, V. M. (2022). 33.Contributions of STEAM in the curricular aspect and didactics of secondary education. http://hdl.handle.net/20.500.12404/22205
52. Urquizo, A. J. N. (2023). 38.STEAM METHODOLOGY AS A DIDACTIC STRATEGY FOR TEACHING GENERAL ELECTRONICS IN STUDENTS OF 1ST YEAR OF TECHNICAL BACCALAUREATE OF THE U.E. "CARLOS CISNEROS", PERIOD 2021-2022. [National University of Chimborazo, Riobamba, Ecuador]. http://dspace.unach.edu.ec/handle/51000/11525
53. Valdés, J. N., Ruiz, A. E. V., & Ruiz, R. A. V. R. V. (2022). 30. How would the authors explain STEM/STEAM Education to Secondary and Baccalaureate students? UNIÓN - REVISTA IBEROAMERICANA DE EDUCACIÓN MATEMÁTICA, 18(66), Article 66. https://www.revistaunion.org/index.php/UNION/article/view/1173