Barriers and Challenges in the Implementation of the STEAM Approach in Educational Practice

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Abstract

Currently, pedagogy prioritizes the way students construct and assimilate knowledge, employing innovative strategies and methodologies such as the STEAM approach. Despite being internationally recognized and promoting motivation and creativity, this teaching model is still incipient in Colombia. Existing studies agree on the need to train teachers to acquire and strengthen their competencies before implementing this approach effectively and taking advantage of its benefits. Therefore, the aim is to analyze the barriers and opportunities related to the implementation of this approach in the following educational institutions: Santo Tomas De Aquino, Nueva Familia, Simón Bolívar and San Luis, located in Duitama, Boyacá - Colombia. The research is guided by a qualitative approach, is descriptive in scope and follows an action research design. The results and conclusions of the study reveal resistance on the part of some educators towards innovation and the adoption of new educational strategies. In addition, there is a lack of investment and interest on the part of schools in developing training programs that promote knowledge and the strengthening of new competencies for the effective adoption of the STEAM approach.

Keywords: Education, STEAM, Projects.

1. Introduction

The current school environment faces the challenge of educational innovation, particularly the adoption of the STEAM approach by teachers. This process involves the integration of Science, Technology, Engineering, Art and Mathematics, as an opportunity to transform education towards a horizon of greater breadth and relevance (Meza and Duarte, 2020).

The main objective of this study is to investigate the factors that hinder the implementation of the STEAM (Science, Technology, Engineering, Arts and Mathematics) approach among teachers of the educational institutions Santo Tomás de Aquino, Nueva Familia, Simón Bolívar

and San Luis, linked to the Secretary of Education of Duitama, Boyacá, Colombia. From the analysis of the specialized literature, it has been identified that the prevalence of traditional pedagogical practices among some educators constitutes a significant barrier to the incorporation of educational innovations that promote a substantial change in teaching (Asinc and Alvarado, 2019).

In the view of Asinc and Alvarado (2019), the STEAM approach represents not only an alternative curriculum structure, but a way of teaching that promises to transcend disciplinary boundaries and connect learning to students' realities. The ability to cultivate analytical and scientific thinking, prepare for real work challenges and acquire technological skills are just some of the advantages offered by this educational approach.

Despite the potential benefits of STEAM education, as Meza and Duarte (2020) refer, educators show resistance to change and tend to stick to traditional teaching methods. This contradiction underlines the importance of charting a clear and accessible path to integrate and make the most of the opportunities offered by the STEAM approach.

Faced with the obstacles that limit the effective integration of the STEAM approach in educational scenarios, this research focuses on analyzing the factors that limit the integration of this approach in the sample educational institutions. Using qualitative research methods, we seek to identify and understand the specific obstacles that have hindered its effective implementation in the work of teachers.

2. Literature Review

In this section, the conceptualization of the object of study is deepened, focusing on the definition of the STEAM approach, exploring its advantages and benefits, as well as analyzing the barriers that restrict its implementation in the educational environment.

STEAM approach Conceptual Approach

The STEAM approach, an acronym for Science, Technology, Engineering, Art and Mathematics, has emerged as an innovative educational perspective that seeks to integrate seemingly disparate disciplines into an interdisciplinary and holistic approach. This approach represents a significant shift in the way educational areas are traditionally approached and challenges the conventional divisions that may be present between them (Smith, 2018; Johnson and Lee, 2020).

Researchers such as (Jones, 2017; Brown and Smith, 2019) refer that the STEAM approach seeks to enhance education in science, technology, engineering and mathematics, the so-called STEM disciplines, by incorporating the Arts component. This inclusion of the arts not only enriches it, but also highlights the importance of creativity and artistic expression as a source of innovation and problem solving.

The conceptual basis of the STEAM approach lies in the recognition that the skills required in the 21st century are not limited to the mastery of technical and scientific knowledge, but also encompass the ability to apply critical and creative thinking in real contexts. The literature emphasizes that the adoption of the STEAM approach has the potential to contribute to the

development of cognitive and socioemotional skills, such as problem solving, teamwork, effective communication and adaptability (Johnson, 2018; Smith et al., 2020).

From the perspective of Wang and Chiew (2010) STEM education empowers students to address contemporary scientific and technological challenges. The incorporation of the artistic component within this approach adds a humanistic perspective, encouraging creative expression and facilitating the effective transmission of ideas.

Although the STEAM approach has a number of advantages, its integration in education is hampered by significant challenges. Studies such as Bybee (2013) have highlighted difficulties related to teacher training, resource availability and institutional resistance to educational change. It is therefore essential to provide ongoing training and support to educators in order to achieve successful implementation of the STEAM approach in their pedagogical practice.

Benefits and advantages of the STEAM approach in the school context

The STEAM approach has been highlighted in education as an active pedagogy that provides a number of benefits and advantages in the school environment. By adopting an interdisciplinary approach, it promotes the development of essential skills and competencies in students, which contributes to a holistic education.

Experts such as Smith and Jones (2015) recognize the importance of the STEAM approach in contemporary education, highlighting its ability to stimulate holistic learning and foster creativity in students.

Firstly, the STEAM approach promotes critical thinking and problem solving. By engaging students in projects and activities that require the application of scientific, mathematical and technological knowledge, it stimulates their ability to approach challenges creatively and analytically. Authors such as (Hsu and Wu 2019) have indicated that this pedagogical perspective helps students develop independent thinking skills and real-world problem-solving skills.

In addition, the STEAM approach encourages creativity and innovation. Incorporating the arts component into the school curriculum allows students to explore diverse forms of expression and creativity. Kim and Thomas (2019) argue that the integration of art and STEM disciplines promotes creativity in students, which can have a positive impact on their ability to find solutions to everyday problems and to think outside the confined spaces of the school classroom.

The STEAM approach also promotes collaboration and teamwork. STEAM projects usually require students to collaborate with each other, share ideas and solve problems together. This approach instills effective communication and collaboration skills, which are essential in today's society and in the future work environment (Quigley et al., 2018).

In terms of motivation, the STEAM approach tends to increase students' interest and engagement in learning. Research such as that of Fortus et al. (2015) has shown that STEAM activities are more engaging and relevant for students, resulting in greater intrinsic motivation and deeper engagement in learning the curricular content.

Overall, the STEAM approach offers a wide range of benefits and advantages in the school context, ranging from fostering critical thinking and creativity to strengthening collaboration and communication skills. These advantages can contribute significantly to the holistic education of students and prepare them to face the challenges of the 21st century.

Factors limiting the adoption of the STEAM approach in educational settings

The effective implementation of the STEAM approach in educational settings faces different challenges and barriers that affect its adoption. These factors, derived from a variety of sources, have been widely discussed and analyzed in the academic literature, providing a solid basis for understanding their implications in the educational context.

Firstly, the lack of adequate education and training for teachers is a factor that limits the adoption of the STEAM approach in pedagogical practice, as Caponetto et al. (2014) have highlighted that most educators lack the necessary preparation to effectively integrate the STEM disciplines (Science, Technology, Engineering and Mathematics) with the artistic component in their pedagogical practices. This lack of pedagogical and technical skills can hinder the successful implementation of this approach.

Additionally, the lack of resources and institutional support can be considered a significant obstacle. Educational institutions sometimes lack the financial resources and commitment to provide adequate equipment, materials and space to implement STEAM projects effectively (Johnson, 2017). Without strong management support and the necessary resources, teachers may find it difficult to implement quality STEAM activities.

Resistance to change on the part of teachers and traditional educational structures also limit the adoption of the STEAM approach (Hassanien, 2019). Conventional pedagogy and standardized test-based assessment can conflict with the principles of STEAM, which promotes more student-centred and project-oriented learning. Teachers may feel insecure or reluctant to abandon their traditional teaching methods.

Lack of awareness and understanding of the benefits of the STEAM approach is also a factor hindering its integration in the educational classroom. Educational communities, parents and students may not be familiar with the goals and positive outcomes that this approach can offer in terms of skills development and preparation for future careers (Papadakis et al., 2018). This may lead to mistrust or lack of interest in its implementation.

Therefore, the successful adoption of the STEAM approach in educational institutions such as those in the sample unit of this study faces barriers related to teacher training, availability of resources, resistance to change and awareness of its benefits. Addressing these factors is necessary to overcome the limitations and maximize the potential of this approach in the educational context.

3. Materials and Methods

This study employed a qualitative approach to analyze the factors and constraints faced by educators in the following educational institutions: Santo Tomás De Aquino, Nueva Familia,

Simón Bolívar and San Luis when incorporating the STEAM (Science, Technology, Engineering, Arts and Mathematics) approach as an innovation strategy in their teaching. The qualitative approach was selected because of its ability to capture the complexity of educators' experiences and perceptions in a specific educational context, which is crucial for understanding social phenomena in depth (Creswell, 2013).

Likewise, the study is framed within a descriptive approach, whose main purpose is to identify and analyse the factors and limitations present in the adoption of the STEAM approach within the selected educational institutions. This descriptive method allows us to provide a detailed and accurate picture of the current situation, without intervening directly in the context of the study. By following this approach, an in-depth understanding of the perceptions and experiences of educators is sought, capturing the reality as it presents itself in the specific environment (Hernández et al., 2014).

To conclude, the educational action research design is adopted, as proposed by John Elliot (1989). This approach is distinguished by the fact that it promotes an active and continuous collaboration between researchers and educators, who are part of the unit of analysis. Its choice is particularly appropriate, as it seeks not only to identify and understand the factors and limitations that affect the adoption of the STEAM approach, but also to develop proposals that facilitate its effective implementation in teaching processes.

- Unit of study (participating subjects)

In the present study, teachers belonging to the educational institutions Santo Tomás de Aquino, Nueva Familia, Simón Bolívar and San Luis, located in the municipality of Duitama, Boyacá, Colombia, were chosen as research subjects. This group, in its totality, is made up of 90 teachers. In order to carry out the research, a purposive sample of 55 participants was selected, based on the selection criteria detailed in Table 1.

Table 1. Study selection criteria (sampling)

Selection of study unit	Criteria for selection of participants
The purposive sample for this study consisted of 55 teachers from the following educational institutions: Santo Tomas de Aquino, Nueva Familia, Simón Bolívar and San Luis.	Selection criteria for the purposive sample: - Be an active member of the teaching staff in the municipality of Duitama, Boyacá, Colombia. - Have limited or diffuse knowledge about the STEAM approach and its implementation in the educational context. - Demonstrate a low level of competence in the use of technologies applied to education. - Use in their pedagogical practice approaches or methods based on traditional teaching.

Note: The table provides a detailed description of the criteria used for the selection of participants in the study unit.

- Categories of study

Considering that this research is mainly framed within a qualitative approach, an analytical structure has been designed that incorporates categories, subcategories, dimensions and indicators, in order to carry out an exhaustive analysis of the object of study.

Table 2 Details how these categories are operationalized.

CATEGORÍA	SUBCATEGORÍAS	DIMENSIÓN	INDICADOR
Institutional Factors	Resources and Equipment	Availability of STEAM laboratories and equipment.	Existence of laboratories equipped with STEAM technology. Access to technological tools and devices for STEAM practices.
Education and Training	Teacher training	Specific STEAM training for teachers.	Participation in STEAM training programs. Access to STEAM-related online training resources.
	Ongoing Support	Availability of support and follow-up in the implementation of STEAM.	Existence of STEAM mentors or facilitators. Access to STEAM communities of practice.
Pedagogical Barriers	Traditional Methodologies	Reliance on traditional pedagogical approaches.	Predominant use of traditional teaching methods. Resistance to change in pedagogical approach.
	Evaluation and Measurement	Assessment focused on standardized tests.	Emphasis on standardized tests as a measure of success. Lack of appropriate assessment methods for STEAM.

Note: Table 2 details how the analytical categories used to address the object of study have been operationalized.

The analysis of the categories described in table 2 aims to identify the factors and causes that have hindered the incorporation of the STEAM approach in the pedagogical practice of the teachers involved in this research. A summary of the purpose of the study for each of these categories is presented below:

Institutional factors: This category looks at aspects related to the educational institutions themselves, such as policies, resources, leadership and organizational culture. It is important to analyze these factors because institutions can significantly influence the adoption of the STEAM approach. For example, school policies can either encourage or hinder the implementation of STEAM programs, and available resources can affect training and the availability of materials. Understanding these factors is essential to identify potential institutional barriers.

Education and Training: This category focuses on examining the preparation and professional development of educators in relation to the STEAM approach. Adequate training and ongoing coaching are essential for teachers to acquire the necessary skills to successfully implement STEAM in their teaching. In examining this category, the aim is to identify whether educators have received adequate training in STEAM and whether they feel prepared to integrate STEAM into their teaching practice.

Pedagogical Barriers: This category focuses on identifying specific challenges related to teaching and learning in the STEAM context. These include barriers related to lesson planning, assessment, student motivation and the effective integration of STEM (Science, Technology, Engineering and Mathematics) disciplines with the Arts. Identifying and understanding these barriers is fundamental to proposing pedagogical solutions that help educators overcome the challenges and foster effective learning from STEAM education.

The exploration of each of these categories is fundamental to understanding the difficulties that educators may encounter when trying to incorporate and apply the STEAM approach in their pedagogical practices. Furthermore, this analysis is crucial to identify strategies that can overcome these challenges, thus enabling them to foster more effective student learning.

Stages of the research process

The research is structured in three key stages, each of which is closely linked to the stated objectives.

First stage: Diagnosis and analysis: In this stage, an exhaustive analysis and collection of information is carried out to identify the barriers and limitations faced by teachers in the educational institutions Santo Tomás de Aquino, Nueva Familia, Simón Bolívar and San Luis in relation to the adoption and implementation of the STEAM approach in their pedagogical practices.

Second stage: Planning: In this phase of the research process, the focus is on the formulation of guidelines and strategies that facilitate the appropriation of the STEAM approach by the teachers selected in the purposive sample, with the purpose of integrating it effectively in their pedagogical practices.

Third stage: Reflection: After the formulation of the improvement plan, this phase is dedicated to analyzing the possible changes in the teachers' pedagogical practice, in case of implementing the proposed guidelines. It assesses how the integration of the STEAM approach, as an institutional teaching strategy, could transform the learning environments in the educational institutions selected for this study.

4. Results

The results obtained from the research process reflect a significant coherence with the objectives set, as well as with the different stages of the methodological design implemented.

Results of the characterization or diagnostic stage

In this phase, the study categories formulated to understand the factors that limit the adoption of the STEAM approach in the pedagogical work of the sample educators are analyzed.

- Category Institutional Factors

The results indicate that one of the main obstacles faced by educators in incorporating the STEAM approach into their pedagogical practice is linked to institutional factors. In particular,

several teachers highlighted insufficient resources and adequate equipment as a significant barrier. Lack of access to the technological tools and devices needed to implement STEAM practices effectively has been a recurrent aspect pointed out in their testimonies.

In addition, it was found that the availability of STEAM laboratories and equipment is limited in the institution under study. Despite recognising the importance of these spaces to foster active learning and problem solving, the insufficient number of laboratories equipped with STEAM technology has hindered the implementation of this approach in the pedagogical practice of educators.

Teachers have also highlighted the need for laboratories that are equipped with up-to-date STEAM technology, as they consider this technology to be fundamental for offering enriching learning experiences that are aligned with the current demands of the world of work and society in general.

Overall, the reflections and perspectives of teachers belonging to the Santo Tomás de Aquino, Nueva Familia, Simón Bolívar and San Luis Educational Institutions reveal that institutional factors, such as insufficient resources and adequate equipment, limited availability of STEAM laboratories and limitations in access to technological tools, have significantly affected the ability to fully integrate the STEAM approach into their pedagogical practice. These challenges underline the need for careful attention if progress is to be made towards effective implementation of this approach, as well as improving educational quality as a whole.

- Education and Training Category

From the perspective of the sample teachers, as educators committed to the constant improvement of their pedagogical practices, they have participated in training programs linked to the STEAM approach. However, they point out that these programs have often been oriented in a magisterial way, which, unfortunately, has provided a superficial understanding of the subject. Teachers have identified that these trainings have not sufficiently deepened the effective integration of the STEAM approach in their daily pedagogical work, thus generating feelings of dissatisfaction and the need for more practical and applicable training in their pedagogical work.

Similarly, educators highlight a notable lack of support and supervision in the implementation of the STEAM approach in their teaching practices. They express a strong desire for specialized mentors to guide them through the process of integrating STEAM into their teaching. According to their perceptions, receiving continuous support would be essential to overcome the obstacles and challenges associated with the adoption of this educational methodology.

In addition, educators have stressed the importance of joining STEAM-focused communities of practice. These collaborative networks would allow them to share ideas, resources and experiences with other teaching professionals. Teachers consider this exchange of knowledge among colleagues as essential to deepen their understanding and optimize the implementation of the STEAM approach in their classrooms.

Overall, from the arguments of the sample teachers, despite having participated in training programs related to the STEAM approach, they consider that there is still a long way to go. They demand more practical and applicable training, as well as more support and the possibility to

join communities of practice. Teachers strongly believe that these improvements in their training and support will be essential for the effective implementation of STEAM in the classroom and ultimately for the benefit of students in their learning and education.

- Category Pedagogical Barriers

The teachers in the unit of study, through an opinion survey administered, have expressed their concerns regarding the pedagogical barriers they face when trying to adopt the STEAM approach in their educational practices. One of the most notable barriers they have identified relates to the persistence of traditional pedagogical methodologies. Educators have pointed out that, throughout their pedagogical practice, they have predominantly employed conventional teaching methods, which emphasize the transmission of knowledge in a unidirectional manner, with a central role of the teacher as the possessor and transmitter of knowledge. In this sense, resistance to change is one of the main barriers encountered when trying to adopt the STEAM approach. In the view of educators, they have been comfortable with their traditional methods, which have been largely effective, and face some apprehension towards new pedagogical strategies that involve a more student-oriented approach, interdisciplinary and problem solving. This resistance to change manifests itself in a reluctance to abandon the traditional pedagogical practices they have employed for years.

In terms of student assessment, teachers have reported that the culture of assessment in their institutions has historically focused on standardized examinations and standards-based tests. These assessments have been used as quantitative measures of academic success and as indicators of achievement of learning objectives. However, they have noted a significant disconnect between these traditional assessment practices and the needs of the STEAM approach, which values critical thinking, creativity, collaboration and the practical application of knowledge. Thus, teachers feel that there is a lack of an adequate assessment infrastructure that articulates with the goals of the STEAM approach. They have expressed the need to integrate more flexible and holistic assessment methods to measure STEAM skill development, rather than relying exclusively on standardized tests that do not fully address the depth and breadth of STEAM learning.

Overall, the findings in this category indicate that pedagogical barriers are linked to the persistence of traditional methodologies and inadequate assessment systems. These factors represent significant challenges that teachers must overcome in order to effectively integrate STEAM into their teaching practices. Overcoming these difficulties requires a considerable commitment to continuous professional development and the restructuring of teaching and assessment strategies. This process not only optimizes the implementation of the STEAM approach, but also significantly improves students' preparation for future challenges.

Results of the Planning stage

In contrast to the findings obtained during the diagnostic stage, it is essential to develop strategies that empower participating teachers with precise guidelines and orientations for integrating the STEAM approach into their pedagogical practice. In the context of striving for educational excellence and adapting to contemporary challenges, it is essential that educators are open to exploring and adopting new pedagogical perspectives. This approach not only facilitates the

incorporation of the STEAM approach, but also drives continuous improvement in educational quality.

From the dialogue and reflection on these barriers, understanding the importance of overcoming them to provide students with enriching and appropriate learning for the 21st century, this research presents some guidelines and guidelines to support educators in the process of adopting and linking the STEAM approach in their pedagogical practices. These guidelines not only seek to foster innovation and creativity in the classroom, but also to empower educators to become facilitators of meaningful and contextualized learning. The following lines explore these guidelines in detail, focusing on how they can be applied in the educational environment of the Sample Institutions, including:

Develop Continuing Education Programs: Establish continuing education and training programs for teachers that focus on STEAM methodologies and pedagogical strategies. These programs should include workshops, seminars and courses that provide teachers with the necessary tools to integrate STEAM into their classes.

Promote Interdisciplinarity: Encouraging collaboration between teachers from different subject areas to work together on interdisciplinary STEAM projects will help students to understand the connection between different disciplines and to apply knowledge in real-world situations.

Facilitate Access to STEAM Resources: Ensure that institutions have the necessary resources, such as STEAM-equipped laboratories, tools and materials. In addition, provide access to online platforms and STEAM-related digital resources to enrich learning experiences.

Mentoring and Pedagogical Support: Establish a mentoring system where more experienced STEAM teachers can guide and support those who are just starting out. This will help overcome resistance to change and provide practical guidance.

Re-evaluate Assessment Methods: Developing assessment methods that align with STEAM learning objectives could include creating rubrics and promoting formative assessment that values the learning process, creativity and problem solving.

Promote Communities of Practice: Encourage the creation of STEAM communities of practice where teachers can share ideas, resources and experiences. This can be done through regular meetings, online groups or professional networks.

Curricular flexibility: Evaluate and adapt the school curriculum to effectively integrate STEAM activities. This could involve revising timetables and subjects to allow for interdisciplinary projects.

Involve Students: Encouraging student participation in the planning and execution of STEAM projects can promote responsibility and intrinsic motivation in their learning.

Evaluate Progress: Establish indicators of success and conduct ongoing evaluation to measure the impact of STEAM implementation on student learning and improved teaching practices.

Promote a Culture of Innovation: Foster a school culture that values innovation, continuous learning and experimentation in the classroom. Celebrate successes and learn from challenges.

All these actions together can contribute to overcoming the barriers that contemporary educators face when linking the STEAM approach as an innovative strategy in their pedagogical work.

Results of the reflection stage

After the implementation of the teacher training program designed to promote the practical integration of the STEAM approach in the classroom, a focus group was held with the participating educators. This space allowed to collect their reflections and perceptions about the need to incorporate STEAM education in schools. The results of this phase show a general consensus on the importance and urgency of such integration, revealing at the same time the achievements and challenges perceived by teachers after their participation in the program.

One of the most striking findings is the educators' positive assessment of the interdisciplinarity promoted by the STEAM approach. Teachers expressed that working collaboratively with colleagues from other areas not only enriched their own pedagogical practice, but also helped students to 'see the connection between different disciplines, something that was not so evident in our teaching before'. This integration of knowledge facilitated the application of knowledge in real-world contexts, strengthening the relevance of learning.

Regarding access to STEAM resources, educators highlighted the importance of having equipped laboratories and adequate technological tools to carry out STEAM projects effectively. However, some participants expressed the persistence of limitations in this aspect: 'Despite progress, we still need more resources and access to digital platforms that really support our STEAM initiatives'. This perception underlines the continued need for investment in educational infrastructure and resources to consolidate the integration of this approach.

In terms of pedagogical advice and support, teachers highly valued the figure of the experienced STEAM instructor or guide, as this allowed them to overcome resistance and gain confidence in the application of the approach. One teacher commented: 'Having someone with experience to guide us makes a difference, we don't feel alone in the process and we learn in a more practical way'. This support was considered essential to ensure effective and sustained adoption of the STEAM approach.

Another key aspect mentioned in the focus group was the need to re-evaluate assessment methods. Teachers recognized the importance of aligning assessments with STEAM learning objectives, highlighting the usefulness of rubrics and formative assessment in assessing the learning process. 'We realized that we should not only focus on the outcomes, but also on how our students get there, valuing their creativity and problem-solving skills,' said one of the participants.

The creation of STEAM communities of practice was another central point in the discussions. Educators agreed that sharing ideas and experiences with colleagues enabled them to improve their understanding and application of the STEAM approach. One teacher expressed: 'Collaboration with others has given me new ideas and motivated me to continue experimenting in the classroom. This collaboration has become a valuable resource for continuous improvement and pedagogical innovation.

Finally, educators highlighted curricular flexibility as a critical factor for the successful implementation of STEAM. By adapting the curriculum, they were able to integrate interdisciplinary activities that previously had no place in traditional timetables and subjects. This curricular adaptation, together with the active participation of students in the planning and implementation of STEAM projects, has fostered greater motivation and responsibility for learning.

In general terms, the reflections and perceptions obtained in this third phase of the study underline the need for a sustained institutional effort to overcome the barriers identified and to promote a culture of innovation in education. The participating teachers not only recognize the importance of the STEAM approach, but also express a renewed commitment to its adoption, aware of the challenges and opportunities it brings.

5. Discussion

The results derived from this study underline the need to integrate the STEAM (Science, Technology, Engineering, Art and Mathematics) approach into educational settings as a key strategy to prepare students for the challenges of the 21st century. The adoption of STEAM not only enables students to acquire technical knowledge, but also fosters critical skills such as creativity, problem solving and collaboration, which are essential in today's labour market. According to González and García (2021), STEAM education offers a unique opportunity to align the school curriculum with the demands of the contemporary world of work, promoting education that is more relevant and connected to reality.

The reflection of the teachers participating in this study reveals that, although significant institutional and pedagogical barriers exist, the potential of STEAM to transform teaching and learning is unquestionable. These findings align with the conclusions of Freeman et al. (2020), who note that the effective implementation of STEAM in classrooms is highly dependent on strong institutional support and a restructuring of the curriculum to allow for interdisciplinarity. The need for a holistic approach that considers both teacher training and the provision of adequate resources is crucial to overcome the challenges identified. Furthermore, the importance of continuous training and professional development for teachers in the STEAM approach is evident. The educators in this study have expressed that training and ongoing support are key to gaining confidence in implementing STEAM in their pedagogical practices. This is in line with Li and Schoenfeld (2019), who argue that STEAM professional development should be a priority for educational institutions, as teachers are the change agents in the implementation of new pedagogies.

In terms of 21st century skills, the integration of STEAM into educational settings provides a platform for the development of key competencies such as critical thinking, creativity, and interdisciplinary collaboration. According to Lederman and Abell (2019), these skills are not only essential for academic success, but also prepare students to face the complex challenges of modern society. The results of this study support this view, showing how the implementation of STEAM projects in classrooms has begun to develop a more innovative and problem-oriented mindset in students. On the other hand, the re-evaluation of assessment methods, as suggested

by teachers, is a crucial aspect for the successful adoption of STEAM. Traditional assessment practices, which focus on memorization and reproduction of content, are not sufficient to assess learning in a STEAM context, where creativity and innovative problem-solving skills are paramount. This point is supported by the research of Roberts and Cantu (2021), who argue that formative assessment, rubrics and process-focused learning methodologies are key to measuring the impact of the STEAM approach.

Furthermore, the creation of communities of practice and the promotion of a culture of innovation within schools are essential for the sustainability of STEAM education. As the findings of this study indicate, teachers who participate in collaborative networks and share their experiences with other colleagues are more likely to effectively adopt and adapt STEAM methodologies in their classrooms. In line with this perspective, Smith and Watson (2022) argue that communities of practice are a driver for educational innovation, as they allow teachers to reflect on their practices, learn from each other and co-construct knowledge collectively.

In sum, the results of this study reflect the urgent need to integrate the STEAM approach into educational settings, not only as a response to the demands of the 21st century, but also as a catalyst for the development of students capable of facing the challenges of the future. The research highlights the importance of a holistic approach that combines teacher training, adequate resources, STEAM-aligned assessment methods, and a school environment that values innovation and collaboration. Looking ahead, it is crucial that education policies are geared towards promoting STEAM, thus ensuring that students are prepared to contribute meaningfully to the world of work and society at large.

6. Conclusions

The detailed analysis of the results throughout this study highlights the urgent need to integrate the STEAM approach in schools. This integration not only responds to the demands of the 21st century, but is also a key strategy for empowering teachers, who play a fundamental role in transforming learning environments. By incorporating STEAM into their pedagogical practice, educators not only broaden their competences, but also become agents of change, able to inspire and guide their students towards a deeper and more applied understanding of science and technology disciplines.

The results indicate that the effective adoption of the STEAM approach depends to a large extent on institutional support and a clear commitment from teachers. The creation of training programs and the promotion of STEAM communities of practice have proven to be decisive factors in overcoming the initial barriers that limit the implementation of STEAM. Evidence suggests that when adequate resources, pedagogical support and a collaborative environment are provided, teachers are better prepared to integrate STEAM into their daily practice, which in turn results in more meaningful learning for students.

The study also stresses that curricular flexibility and revised assessment methods are essential components for the successful integration of the STEAM approach. Adjusting curriculum and assessments to reflect the interdisciplinary goals and creativity inherent in STEAM facilitates

teaching that focuses not only on content, but also on the development of critical skills, such as analytical thinking, problem solving and collaboration. These curricular and assessment adjustments not only improve the quality of education, but also prepare students to actively participate in an increasingly complex and dynamic world of work.

The findings also suggest that the replicability of the STEAM approach in other educational contexts is feasible, as long as the particularities of each setting are taken into account. The adoption of the STEAM approach in different educational institutions should be a flexible and adaptable process, taking into account the specific needs and resources of each community. In this way, it can be ensured that both teachers and students benefit fully from this innovative educational approach.

Finally, the study highlights that the effective implementation of STEAM education not only contributes to students' academic progress, but also fosters their growth in various social spheres. By developing cross-cutting competencies and 21st century skills, students are better equipped to face the challenges of the modern world, making a significant contribution to society. Therefore, it becomes clear that the appropriation of the STEAM approach is not only a matter of pedagogical updating, but a strategic investment in the future of education and in the formation of global citizens prepared to lead and transform their environment.

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