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# Proposal for Teacher Training Model in Steam Education

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**Abstract**

*This research is developed by systematizing the literature on STEAM education in relation to skills, strategies, training, implementation and competencies. An SLR methodology is applied focused on the field of education, 46 articles were selected from the Scopus, Eric and WOS Database from the last five years, complemented with quantitative research to verify the frequency of the variables in the documentary review. The results are articulated in a design to propose a teacher training model in STEAM education, for which three dimensions are taken into consideration based on the educational actors (pre-professional, professional and expert) in order to work on the different indicators that allow a logical and systematic sequence to implement STEAM education in current educational contexts that require the development of complex competencies, mediated by emerging technologies. It is evident that teachers, from their initial training to their professional development as experts, face the challenge of preparing new generations to solve complex problems and effectively promote the development of 21st century skills, in this way, Teacher training programs contribute significantly to their professional performance, playing a crucial role in the transformation of pedagogical practice, strengthening teaching professionalism and promoting a culture of research, generating a positive impact on the quality of current education.*

**Keywords:** *STEAM Education, Model, Teacher Training, Stem, Innovation.*

## Introduction

21st century learning presents dizzying changes that require the development of complex and holistic competencies, mediated by emerging technologies, raising the level of difficulties and challenges in the performance of teachers, from their initial training in pre-professional, professional and experts; With this, education faces the challenge of preparing new generations to solve complex problems and adapt to these environments. In response, some strategies are proposed that constitute the theoretical basis for their development, such as self-directed learning and a model of maturity of capabilities, which involves receiving professional competence and affective education, as well as achieving specific knowledge about teaching, developing practical skills in the classroom, learning to evaluate teaching and acquiring self-evaluation skills in various aspects of their professional development (Chen & Lai, 2022b).

Indeed, in these contexts marked by constant uncertainty, Iwata et al. (2020) argue that digital fabrication activities can provide learning opportunities for 21st century skills and computational thinking practices. Likewise, Reddy et al. (2022) mention that digital literacy provides the opportunity to develop capabilities such as finding, evaluating, using, sharing and creating ideas, in a responsible and ethical manner, effectively contributing to the individual and social development of people.

In this way, the STEAM (Science, Technology, Engineering, Art and Mathematics) approach has emerged as an innovative response to these needs, integrating diverse disciplines to develop students' critical, creative, communication, teamwork, collaborative and problem solving (Fernández et al., 2021b), as an active methodology, not only transforms the way teaching and learning is taught, but also promotes equity, inclusion and helping those who have low learning motivation Lu et al. (2022), therefore considers multidimensional educational objectives that combine cognitive and non-cognitive results Schiepe-Tiska et al. (2021).

Indeed, also, the integration of STEAM and PBL (project-based learning) are proposed for solving problems through the creation of STEAM projects Adriyawati et al.(2020), making education more accessible and relevant for everyone, revolutionizing the educational landscape, enhancing both personal development and the skills necessary to face global challenges, thus aligning itself with the demands of a globalized world driven

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by technological innovation, thereby not only transforming the educational experience , but also prepares students to actively contribute to an interconnected and sustainable world.

## Literature Review

*Training*

The training process of future teachers, according to Chen & Lai, (2022a), is related to the development of professional and affective competencies, which are based on self-directed learning and a capacity maturity model; This process entails the acquisition of specific teaching knowledge, practical skills in the classroom, evaluation of one's own performance and self-assessment in various areas of professional development; Likewise, self-evaluation is crucial for the continuous improvement and comprehensive preparation of teachers in pedagogical and emotional matters.

Teacher education students go through a process of learning and professional development before becoming teachers, using self-directed learning and a capacity maturity model as a theoretical basis for their development. This process involves receiving professional competence and affective education, acquiring specific knowledge about teaching, developing practical skills in classrooms, learning to evaluate teaching, and acquiring self-assessment skills in various aspects of professional development Chen & Lai (2022), therefore , teachers must develop their strategies considering constructivist pedagogies (Funa & Talaue, 2021). Thus, to effectively promote the development of knowledge as a cognitive tool, teacher training programs contribute significantly to their professional performance (Abdurrahman et al., 2019).

*Training Dimensions*

Continuous training is the fundamental basis of educational policies; it is a key element for the modernization of school systems and for achieving greater educational effectiveness. Its implementation allows teachers and education professionals to adapt to current demands, improving the quality of learning and ensuring more effective and updated education.

On this topic, some research has been carried out, reference is made to (Quiroz, 2015 cited in Aguirre-Canales et al., 2021), for whom continuous training encompasses various dimensions that comprehensively impact teacher development. Firstly, the educational dimension is related to updating processes, adapting to curricular changes and adjusting to educational reality. Secondly, the pedagogical dimension focuses on the applicability of the acquired knowledge, which is reflected in teaching practice. Thirdly, the human dimension highlights how continuous training contributes to the personal and professional development of teachers, promoting their integral and holistic growth. Finally, the investigative dimension drives educational innovation through the strengthening of the cognitive skills developed in these processes in a systematic way that promote the development of critical, reflective and creative thinking skills for problem solving.

The analysis of the studies shows that continuous training is key to transforming pedagogical practice, developing teaching professionalism and promoting a research culture. In addition, continuing training programs improve pedagogical skills and have a positive impact on teachers' daily work (Aguirre-Canales et al., 2021).

## Methodology

This study was born from a systematic literature review of 46 articles from the Scopus, WOS and ERIC databases, all in the last five years and focused on STEAM education, in relation to skills, strategies, training, implementation and competencies; This research is complemented with quantitative research to verify the frequency of the variables in the documentary review.

To create the model (**Fig 1)**, three dimensions were taken into account based on the educational actors (pre-professional, professional and expert) in order to work on the different indicators that allow for a systematic logical sequence to implement STEAM education in current educational contexts.

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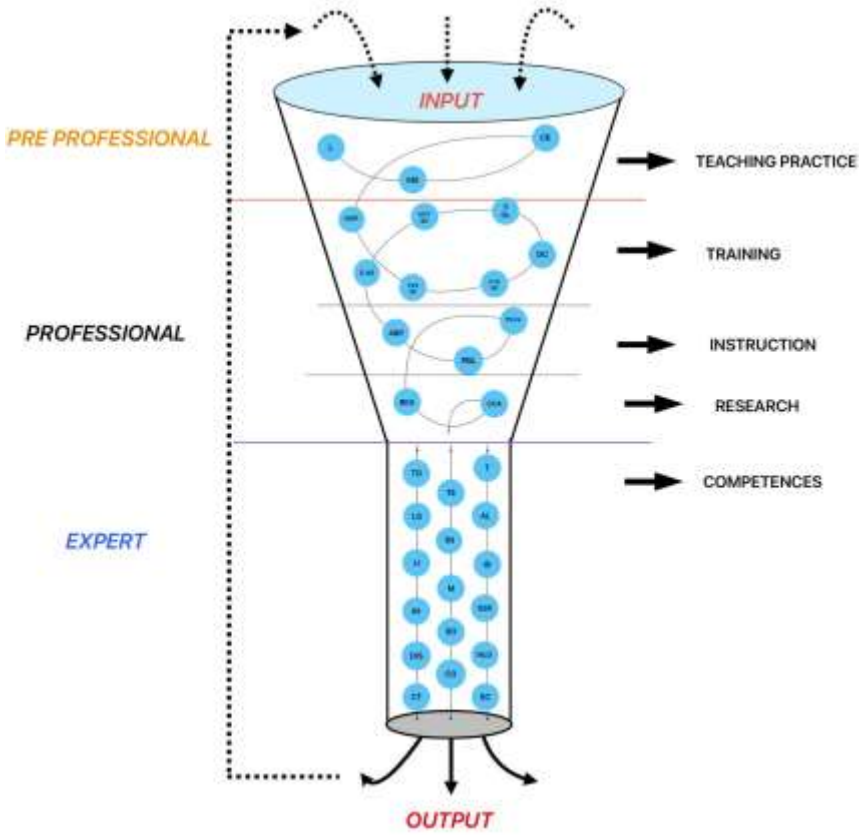
**Figure 1.** Teacher Training Model Proposal




## Results

*Preprofessional*

*Teaching Practice*

*Literacy (L)*

Digital literacy involves developing skills to find, evaluate, use, share and create ideas in an ethical and responsible manner through the use of ICT and the Internet, thus contributing to individual, social and national development (Reddy et al., 2022). However, there is a tension between teaching based on individual needs and promoting a multiple literacy aligned with the curriculum, reflecting the coexistence of traditional and innovative teaching practices. For Nygård et al. (2022), reflecting on these tensions can drive change and professional growth in teaching.

Another important point according to Lu et al. (2022), is scientific research literacy, for which a creative workshop is proposed to promote self-efficacy and scientific research capacity in students, considering gender and motivation as mediating factors. Along these lines, POGIL "Process Oriented Group Inquiry Learning" proposes learning as an effective way to foster active and collaborative learning by providing students with an effective learning experience that influences scientific literacy and critical thinking, Aiman et al. (2020).

*Multiple Skills (MS)*

According to Mokaya & Kebaya (2022), teacher training involves the development of multiple skills, teacher training involves the development of multiple skills such as creative and critical thinking, cognitive, numerical, collaboration and environmental awareness, therefore, teachers must use several innovative strategies with

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teaching resources from the first years of education.

*Constant Evaluation (EC)*

To carry out the best practices of the teaching-learning process in remote educational environments, constant evaluation is essential (Yuebo et al., 2022), providing key data to modify approaches, adapt content and promote an environment of continuous improvement, ensuring that educational interventions are relevant and timely.

*Professional*

*Training*

*Growth Mindset Pedagogy (Gmp)*

Growth Mindset Pedagogy (GMP) implemented by teachers has a significant impact on students' emotion regulation as it normalizes difficulties as part of the learning process. For Rissanen et al. (2021), this perspective fosters an environment in which errors are seen as opportunities for growth, promoting a resilient attitude and continuous improvement.

*Technical and Vocational Education and Training Programs (TVETP)*

The Technical and Vocational Education and Training (TVET) programs seek to train students to face the world of work by developing technical and transversal skills. They integrate academic and non-academic skills, preparing them for qualified and competent jobs based on current needs. Likewise, to Ngware et al. (2022), highlights the influence of educational resources and infrastructure on the success of these programs and on the comprehensive training of young people. Which is reflected in the performance of students from institutions with greater resources in their infrastructure, equipment and geographical location, due to the opportunities they provide them.

*Comprehensive Youth Development Skills Development (CYDSD)*

In the new scenarios, the development of academic and non-academic skills, known as comprehensive youth development (WYD) skills, includes technical, cognitive, socio-emotional, and problem-solving skills, which allow young people to successfully face life's challenges. and work. In this sense, Ngware et al. (2022), mention that the objective is to achieve a balanced development that promotes employability, personal well-being and active participation in society; through Technical and Vocational Education and Training (TVET) programs.

*Data Science (DC)*

Data science is an interdisciplinary field that uses statistical methods, algorithms, and analysis techniques to extract knowledge from structured and unstructured data. Its objective is to transform large volumes of data into useful information for decision making, trend prediction and service personalization. Digital manufacturing activities, characteristic of the current technological era, offer opportunities to develop 21st century skills, such as computational thinking, essential for the context of technological innovation (Iwata et al., 2020), which are crucial for exponential growth. of the amount of data available, thus, data science training programs provide young people with the necessary skills to integrate into this emerging field, with a special focus on women and girls, trying to reduce the gender gap in technology (Babirye et al., 2022).

*Self-Directed Learning (SDL)*

Self-directed learning is a process in which students take responsibility for their own learning, setting goals and evaluating their progress independently. At the same time, it promotes autonomy and the capacity for continuous learning, adapting to personal interests and needs. Hence, teacher training students go through a

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process of learning and professional development before becoming teachers, based on self-directed learning and a maturity model of capabilities for their development. For Chen & Lai (2022a), this process encompasses the acquisition of professional and educational skills, specific knowledge about teaching, the development of practical skills in the classroom, as well as the ability to evaluate and self-evaluate in different areas of professional growth.

*Maturity of Capabilities As A Theoretical Basis for Their Development (MCTBD)*

Capability maturity refers to a framework that describes the progressive development of skills and competencies necessary to perform effectively in your profession. With this, teacher training students go through a learning and professional development process called pre-professional practices in which, through self-directed learning, they follow a capacity maturity model as a theoretical basis for their development. Process that involves receiving professional competence and affective education, acquiring specific knowledge about teaching, developing practical skills in classrooms, learning to evaluate teaching and acquiring self-evaluation skills in various aspects of professional development (Chen & Lai, 2022a) in this way they manage to address tasks and challenges more effectively.

*Self-Assessment Skills (SAS)*

The development of self-evaluation skills allows you to reflect on your own performance, identifying areas for improvement and adjusting your practices based on that evaluation, allowing your professional growth. With this criterion, Chen & Lai, (2022a) refer to the fact that the teacher training process is based on self-directed learning and a capacity maturity model, facilitating future teachers to develop professional skills, specific pedagogical knowledge and affective education. In addition, it includes the acquisition of practical skills in the classroom, the evaluation of teaching and the development of self- assessment in various professional areas. All this contributes to comprehensive and constant growth in your professional development

*Instruction*

*Implement PBL-PBL Strategies (ABP-PBL)*

The current changing and flexible educational contexts need to implement strategies such as Project Based Learning (PBL) and Problem Based Learning (PBL) to strengthen 21st century skills, such as teamwork and the practical application of knowledge, especially in areas of sciences and mathematics (Viro et al., 2020). Along these lines, also Fernández et al. (2021a). The current changing and flexible educational contexts need to implement strategies such as Project Based Learning (PBL) and Problem Based Learning (PBL) to strengthen 21st century skills, such as teamwork and the practical application of knowledge, especially in areas of sciences and mathematics. Along these lines, also Chinchua et al. (2022) suggest a gamified model within a digital learning ecosystem (DLE) to improve programming skills, using PBL, gamification and programming self-efficacy (PSE), thus demonstrating greater innovation effectiveness with interactive and digital methods in education. modern.

*Professional Learning Communities (Plcs)*

Professional learning communities (PLCs) constitute collaborative groups of teachers who seek to improve their practice and student learning through joint reflection. Wan (2020) investigates how teachers' perceptions of PLCs are related to their use of differentiated instruction (DI). It highlights three key dimensions of engagement in PLCs: student learning, reflective dialogue, and shared and supportive leadership, all essential elements for more effective teaching tailored to the individual needs of students.

*Investigación Research*

*Research Through Experimentation (Rex)*

Inquiry-based learning allows students to develop a deeper understanding of the scientific process and improve

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their experimental skills through challenging activities guided by scientific methodologies (Khumraksa & Burachat, 2022).

Likewise, it is necessary to incorporate science texts to work with graphic representations to achieve learning with the integration of concepts and elements (Vojíř & Rusek, 2019).

As a complement, technological support research through fundamental experimentation in the classroom facilitates teachers' effective use of modern technology by providing comfort in its implementation (Dalle et al., 2021), such as the use of Open Educational Resources (OER) videos focused on sustainable development with which students acquire skills in ideation, research and social skills (Chiu, 2021), also the integration of creative scientific research workshops reinforce the self-efficacy of students in this field and emphasizes the need for a STEAM curriculum that addresses gender differences and motivates those who have little interest in learning (Lu et al., 2022a). Together, these strategies underscore the importance of experimental research as a means to enrich science education and foster key competencies in students.

*Challenging Contextualized Activities (CCA)*

Developing experimental skills in students is achieved effectively through participation in challenging, age-appropriate activities with an explicit scientific methodology guide mediated by their teachers (Khumraksa & Burachat, 2022), applying some strategies such as blended learning ( BL) with which students participate positively in all activities, empowering them to be leaders, coaches and mentors of their peers, Tupas & Linas-Laguda (2020).

*Expert*

*Competences*

*Digital Technologies (Dt)*

Digital technologies offer new opportunities through the transformation of experiences to continually strengthen skills and knowledge (Abedini et al., 2021), making their applicability essential, with this, gamification is presented, according to Pozo-Sánchez et al. (2022) is a training model that promotes the incorporation of active methodologies in educational environments, which favors the development of autonomy, creativity and the exploration capacity of students together with Problem-Based Learning (PBL), Digital learning ecosystems (DLE) and programming self-efficacy (PSE) are consolidated as pillars for the formulation of a preliminary gamified model and a digital learning ecosystem, whose purpose is to support students in the development of programming skills (Chinchua et al., 2022).

In this way, coding is one of the phases within the programming process, and as a process of writing instructions in a programming language for a computer to perform specific tasks, it is considered according to Jiang et al. (2022), a highly valued skill in various disciplines globally, especially, has a significant relationship with the learning of mathematics since they share similar cognitive processes, such as problem solving, logical thinking, abstraction and sequencing. steps, to create efficient and functional software in current digital contexts.

*Transdisciplinarity (T)*

Transdisciplinary learning as an approach promotes mutual and transformational learning, transcendence, problem solving and transgression, it is reflected in the values of active participation of students and their orientation towards solving real-world problems, the combination of disciplinary knowledge and the construction of new knowledge, skills, competencies and values, this is what Lavrinoviča (2021), it also contributes significantly to developing competencies needed for life through teamwork (Eronen et al., 2019). So too, science educators are putting every increasing emphasis on the development of students' interdisciplinary competence when it was identified that disciplinary, cognitive and affective factors could explain individual differences (Song & Wang, 2021).

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*Teamwork (TE)*

To strengthen 21st century skills such as teamwork, strategies are proposed through Project-Based Learning (PBL) and Problem-Based Learning (PBL) (Viro et al., 2020), in this way teamwork and Problem solving gives students the opportunity to give their opinions, strengthening their life skills (Eronen et al., 2019).

*Troubleshooting (TR)*

Problem solving in the educational field is the ability to identify, analyze and address complex situations or challenges that do not have obvious solutions, to do so, prior knowledge and skills are applied in new contexts for effective decision making, promoting critical thinking and creativity. Along these lines, Lavrinoviča (2021) proposes transdisciplinary learning that promotes mutual and transformational learning, transcendence, problem solving and transgression, with the active participation of students and their orientation towards solving real-world problems. , combining disciplinary knowledge, collaborative work between classmates, teachers and society; In this sense, with the integration of STEAM projects (Adriyawati et al., 2020).

*Life Skills (LS)*

From an educational perspective, life skills transcend not only the acquisition of academic content, they go further, in the comprehensive development of students, promoting not only disciplinary knowledge, but also the ability to apply that knowledge in real situations. , in this sense, the authors Mutohhari et al. (2021) ) mention that 21st century learning requires developing complex competencies due to the profound changes that technology has produced in educational processes, both in teaching methodologies and in the ways in which students acquire knowledge and develop competencies throughout. which is known as transformations of technology-based learning, also the development of non-cognitive skills, in this way, the context of makerspace (incubators – Spin Off) allows ample opportunities for digital competence of students through operational, cultural and criticisms (Kumpulainen et al., 2020), therefore, for Eronen et al. (2019) this can be achieved through teamwork, problem solving, critical thinking.

*Liberacy (LI)*

Talking about literacy in current contexts refers not only to functional literacy, related to the daily use of reading and writing, but also multiple literacy, which includes skills in various areas, such as digital, media, informational, scientific. and numerical. With this, there is a tension between teaching literacy based on individual needs and promoting multiple literacy in line with the established curriculum, together with both traditional and innovative teaching practices. In this sense, Nygård et al.(2022) emphasizes that the Modern literacy constitutes a key competence for life, which allows one to interact critically and actively with knowledge, technology and constantly changing social contexts.

*Critical Thinking (CT)*

Critical thinking is the ability to analyze, evaluate and synthesize information in an objective and reflective manner; which involves questioning assumptions, identifying biases, considering diverse perspectives, and using evidence to support conclusions in order to make the best decisions to solve problems. It is crucial that teachers design meaningful experiences for their students because it encourages the development of higher cognitive skills, such as interpretation, logical reasoning, and the ability to relate concepts critically and autonomously; and with this, Ma et al. (2021) affirm that critical thinking may need to become an essential and explicit result of science education.

*Matematics (M)*

Mathematics plays a fundamental role in the development of key competencies in students, since it not only encourages the learning of abstract and logical concepts, but also enhances skills such as critical thinking, problem solving and decision making. For this reason, at an international level, the integration of physics, mathematics and computer science in educational curricula has been promoted, recognizing that

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interdisciplinary teaching is key to developing the necessary skills in the 21st century, allowing students to address problems in an critical and creative (Basson, 2021).

Through mathematics, (Viro & Joutsenlahti, 2020), students learn to analyze, interpret data and develop models that allow them to understand complex phenomena in various areas, in an interdisciplinary manner from natural sciences to social sciences. With this, through project work, it is promoted to articulate mathematical concepts that by their nature are abstract and represent difficulties in learning, reflecting the positive correlation with their general grades in this subject

*Ideation (ID)*

Chiu (2021), highlights that ideation is a key competence for students to develop innovative ideas in the creation of OER videos in Digital Sustainability. This initial phase is essential, since it allows the entire creative process to be guided, and teachers must support its development to ensure a coherent structure that is strengthened by transdisciplinary research and reflection.

*Investigation (IN)*

Research competence is strengthened through the creative scientific research workshop, which improves students' self-efficacy in this area. Furthermore, it promotes broader reflection on informal science education and provides key empirical evidence to optimize these skills Lu et al. (2022). Likewise, Dullas & Soliven, (2021), points out that research is an essential skill that should be encouraged in all secondary mathematics teachers, since those with training and experience in research are able to more easily recognize strategic thinking, as well as interpretation and synthesis, which allows complex problems to be addressed more effectively.

*Social (SO)*

Sustainable development projects, due to their intrinsically social nature, are fundamental for the development of social skills in students. In this sense, Chiu (2021) highlights that the creation of OER videos on five sustainable development topics—such as sustainable lifestyle, campus, community, business, and planetary development—requires students to integrate social skills along with ideation, research and disciplinary knowledge. Likewise, Project Based Learning (PBL) not only promotes the development of cognitive and linguistic skills, but also emphasizes the strengthening of social skills, which encourages active participation, motivation and creativity of students (Hidalgo & Ortega-Sánchez, 2022).

In this sense, MacDonald et al. (2021) summarizes that social, cultural and ecological dilemmas are interconnected problems that require critical analysis, in such a way that paying attention to the dynamics of knowledge through life experiences and individual narratives allows us to enrich the understanding of these challenges.

*Disciplinary (DIS)*

Disciplinary competencies are equally essential, as they allow you to apply knowledge specific to your area of study, integrating ideation, research and social competencies into a coherent approach. Likewise, Chiu (2021) emphasizes that, by following a structured process that ranges from idea generation to transdisciplinary reflection, not only the creation of digital products in sustainable development is strengthened, but also the ability of students to address complex problems. from a disciplinary perspective.

*Autonomous Learning (AL)*

Self-directed learning increases your motivation and commitment, as well as gives you the opportunity to adapt effectively to the online learning environment. Through this process, students develop both cognitive and affective attitudes, which reflects their self-regulation in their own learning. This ability to manage their learning independently is key to their success in flexible educational environments (Putri et al., 2021).

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*Communication (CO)*

Communication competence according to Benítez & Barreto (2022) is strengthened by improving reading comprehension through two key elements: the direct teaching of comprehension strategies and the integration of ICT in the educational process, therefore, they must be prioritized in educational plans. teacher training and applied both in schools and in university teacher training programs, which contributes to enhancing communication and understanding skills in students, becoming essential to achieve significant learning. In this sense, Wu & Chen( 2021) point out that, in a multicultural communication class, the aim is to preserve indigenous cultural knowledge holistically and promote its integration into higher education through lifelong learning.

*Self-Efficacy of Scientific Research (SSR)*

For Lu et al. (2022), self-efficacy in scientific research is strengthened through the creative research workshop, demonstrating its effectiveness in fostering students' confidence in their research skills. Furthermore, this approach stimulates the debate on informal science education and provides empirical evidence that supports the continued development of research self-efficacy, essential for academic and professional success in the scientific field.

*Multidominio (MLD)*

Multidomain competence is promoted with STEAM education by focusing on the integration of knowledge and skills addressed in an inter- and transdisciplinary manner to solve complex problems in an innovative way. Therefore, when designing multidomain study plans, they are approached in a holistic and transdisciplinary manner, this implies designing activities that integrate several areas of knowledge and promoting skills such as critical thinking, collaboration and innovation, also considering factors such as equity of gender and learning motivation. Furthermore, according to (Lu et al., 2022b) this approach not only improves inquiry capacity and scientific performance, but also addresses the mediating effect of gender and motivation in the development of research skills, by promoting inclusive and equitable learning.

*Socio-Emotional (SC)*

Socio-emotional competence is essential for the well-being and training of citizens capable of facing the challenges of the 21st century, where technological, economic and social changes require individuals prepared to learn throughout their lives, collaborate with others, adapt to new situations and actively contribute to their community. In addition, it allows you to manage your emotions, develop resilience and face challenges with confidence in a safe and motivating learning environment. In this framework, growth mindset pedagogy (GMP) plays a key role by integrating emotional regulation into the learning process. Rissanen et al. (2021) emphasize that to improve students' socio-emotional development, teachers can foster a positive attitude toward errors, thus promoting self-efficacy and resilience.

A significant contribution is that of Li & Shein, (2022), when mentioning that holistic and contextualized learning is achieved by incorporating local and traditional ecological knowledge of the community since this provides many experiential learning opportunities for students to develop not only aspects cognitive, and behavioral, especially socio-emotional, associated with the sense of place.

## Conclusions

The proposed teacher training model is comprehensive because it allows the development of pedagogical, technical and socio-emotional competencies in its three dimensions: pre-professional, professional and expert, aligned in the different indicators that allow for a systematic logical sequence for the implementation of STEAM education in current educational contexts, mainly oriented to problem solving by integrating several disciplines that leads to inter- and transdisciplinary learning, thus strengthening knowledge of the various areas, a contextualized and transformative education, in this way, students will be able to face the challenges of daily life with an integrative and innovative vision.

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The model of the proposal highlights that continuous and constant training is presented as an essential element for teacher renewal in a changing educational environment, which is articulated through educational, pedagogical, humanistic and investigative aspects, which allows significant progress in pedagogical practices, ensuring their relevance to technological and social progress. This is where training is presented as an essential element for teacher renewal in a constantly changing educational environment. Teachers must apply active methodologies, such as PBL and problem-based learning, which prove to be the most effective for the development of scientific and transversal skills, to promote cooperation, critical reasoning and the usefulness of knowledge in real situations.

It is important to emphasize that digital literacy is fundamental in teacher education in this digital era, since it allows you to provide innovative technologies in your teaching work, allowing you to enhance your work performance and encourage independent learning and cooperation among students. The model emphasizes research and experimentation tasks since it enhances teachers' ability to develop innovative educational methods that promote self-efficacy in research and the application of scientific techniques to solve educational problems. Likewise, social-emotional competencies play a key role in integrating emotional regulation into the learning process, developing resilience and facing challenges with confidence in a safe and motivating learning environment.

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