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A conceptual framework for steam education: a proposal from and for the Global South

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Abstract

STEAM education (Science, Technology, Engineering, Arts, and Mathematics) has gained global recognition as an innovative educational model, yet in Brazil and across the Global South it remains insufficiently disseminated, with limited research guiding teachers in its implementation. A persistent misconception reduces STEAM to the simple addition of disciplines, overlooking its core as a pedagogical approach rooted in investigative and creative practices - an understanding central to this study. This paper introduces a conceptual framework for STEAM tailored to Brazil, while addressing broader challenges of the Global South, developed through document analysis, literature review, and empirical research. The framework defines STEAM as an interdisciplinary pedagogical strategy that fosters active methodologies, rejecting reductionist interpretations of STEM+Arts. Rather than prescribing a rigid methodology, STEAM is framed as a flexible approach that empowers teachers to design problem-based learning sequences and engage students in defining problems. By emphasizing interdisciplinarity and real-world problem solving, the framework contests disciplinary silos and reinforces the teacher's role as facilitator of inquiry-driven learning. Practical guidelines are provided for educators, particularly in under-resourced K-12 settings. Ultimately, this study informs educators, training programs, and policymakers in Brazil and the Global South, positioning STEAM as a catalyst for innovation, equity, and social transformation.

Keywords: STEAM education. Conceptual Framework**.** Educational Innovation. Interdisciplinarity. Global South.

Um marco conceitual para a educação STEAM: uma proposta a partir e para o Sul Global

Resumo

A educação STEAM (Ciência, Tecnologia, Engenharia, Artes e Matemática) tem ganhado reconhecimento global como um modelo educacional inovador; contudo, no Brasil e em todo o Sul Global, ela permanece insuficientemente disseminada, com pesquisas limitadas que orientem os professores em sua implementação. Uma concepção equivocada persistente reduz a STEAM à simples adição de disciplinas, desconsiderando seu cerne como uma abordagem pedagógica fundamentada em práticas investigativas e criativas — compreensão central para este estudo. Este artigo apresenta um arcabouço conceitual para a STEAM, adaptado ao contexto brasileiro e, ao mesmo tempo, voltado aos desafios mais amplos do Sul Global, desenvolvido a partir de análise documental, revisão de literatura e pesquisa empírica. O arcabouço define a STEAM como uma estratégia pedagógica interdisciplinar que promove metodologias ativas, rejeitando interpretações reducionistas de STEM+Artes. Em vez de prescrever uma metodologia rígida, a STEAM é compreendida como uma abordagem flexível que possibilita aos professores elaborar sequências de aprendizagem baseadas em problemas e envolver os estudantes na definição dos próprios problemas. Ao enfatizar a interdisciplinaridade e a resolução de problemas do mundo real, o arcabouço confronta os compartimentos disciplinares e reforça o papel do professor como facilitador de uma aprendizagem orientada pela investigação. São apresentadas orientações práticas para educadores, especialmente em contextos da educação básica com recursos limitados. Por fim, este estudo contribui para informar

educadores, programas de formação e formuladores de políticas públicas no Brasil e no Sul Global, posicionando a STEAM como um catalisador de inovação, equidade e transformação social.

Palavras-chave: Educação STEAM. Arcabouço conceitual. Inovação Educacional. Interdisciplinaridade.Sul Global.

Un marco conceptual para la educación STEAM: una propuesta desde y para el Sur Global

Resumen

La educación STEAM (Ciencia, Tecnología, Ingeniería, Artes y Matemáticas) ha adquirido reconocimiento a nivel mundial como un modelo educativo innovador; sin embargo, en Brasil y en el conjunto del Sur Global sigue estando insuficientemente difundida, con una investigación limitada que oriente a los docentes en su implementación. Una concepción errónea persistente reduce la educación STEAM a la simple adición de disciplinas, pasando por alto su esencia como un enfoque pedagógico fundamentado en prácticas investigativas y creativas, comprensión central para este estudio. Este artículo presenta un marco conceptual de la educación STEAM adaptado al contexto brasileño, al tiempo que aborda desafíos más amplios del Sur Global, desarrollado a partir del análisis documental, la revisión de la literatura y la investigación empírica. El marco define la educación STEAM como una estrategia pedagógica interdisciplinaria que promueve metodologías activas, rechazando interpretaciones reduccionistas de STEM+Artes. En lugar de prescribir una metodología rígida, la educación STEAM se concibe como un enfoque flexible que capacita a los docentes para diseñar secuencias de aprendizaje basadas en problemas e involucrar a los estudiantes en la definición de los problemas. Al enfatizar la interdisciplinariedad y la resolución de problemas del mundo real, el marco cuestiona los compartimentos disciplinares y refuerza el papel del docente como facilitador de un aprendizaje guiado por la indagación. Se ofrecen orientaciones prácticas para educadores, especialmente en contextos de educación básica con recursos limitados. En última instancia, este estudio informa a educadores, programas de formación y responsables de políticas públicas en Brasil y en el Sur Global, posicionando a la educación STEAM como un catalizador de innovación, equidad y transformación social.

Palabras clave: Educación STEAM. Marco conceptual. Innovación educativa. Interdisciplinariedad. Sur Global.

Un cadre conceptuel pour l’éducation STEAM : une proposition issue du Sud global et destinée au Sud global

Résumé

L’éducation STEAM (Sciences, Technologie, Ingénierie, Arts et Mathématiques) a acquis une reconnaissance mondiale en tant que modèle éducatif innovant ; toutefois, au Brésil et dans l’ensemble du Sud global, elle demeure insuffisamment diffusée, avec un nombre limité de recherches guidant les enseignants dans sa mise en œuvre. Une idée reçue persistante réduit l’éducation STEAM à la simple addition de disciplines, négligeant son essence en tant qu’approche pédagogique fondée sur des pratiques d’investigation et de créativité, une compréhension centrale à la présente étude. Cet article propose un cadre conceptuel de l’éducation STEAM adapté au contexte brésilien, tout en abordant des défis plus larges propres au Sud global, élaboré à partir d’une analyse documentaire, d’une revue de la littérature et d’une recherche empirique. Le cadre définit l’éducation STEAM comme une stratégie pédagogique interdisciplinaire favorisant des méthodologies actives, rejetant les interprétations réductionnistes de STEM+Arts. Plutôt que de prescrire une méthodologie rigide, l’éducation STEAM est envisagée comme une approche flexible qui permet aux enseignants de concevoir des séquences d’apprentissage fondées sur des problèmes et d’impliquer les élèves dans la définition de ces problèmes. En mettant l’accent sur l’interdisciplinarité et la résolution de problèmes ancrés dans le monde réel, le cadre remet en question les cloisonnements disciplinaires et renforce le rôle de l’enseignant en tant que facilitateur d’un apprentissage guidé par l’enquête. Des orientations pratiques sont proposées aux éducateurs, en particulier dans des contextes d’enseignement primaire et secondaire disposant de ressources limitées. En définitive, cette étude informe les éducateurs, les programmes de formation et les décideurs politiques au Brésil et dans le Sud global, en positionnant l’éducation STEAM comme un catalyseur d’innovation, d’équité et de transformation sociale.

Mots clés: Éducation STEAM. Cadre conceptuel. Innovation éducative. Interdisciplinarité. Sud global.

1. INTRODUCTION

The STEAM (an acronym for Science, Technology, Engineering, Arts, and Mathematics) has emerged in various countries as a central axis in discussions on educational innovation, particularly in K-12 Education. Its integrative approach proposes the articulation of different knowledge domains, promoting a holistic education (D'Ambrósio, 2019) that prepares students for the demands of contemporary society and a world in constant transformation. Faced with a world of uncertainties (Moran, 2000), it is imperative that students are equipped with diverse skills to meet future challenges. Thus, pedagogical practices are needed that allow students to develop skills that go beyond school subjects, enabling them to act autonomously and critically in society. In this context, practical and socio-emotional skills have also been in demand since the beginning of this century, as seen in "The four pillars of education" - learning to know; to do; to live together and with others; and to be -, disseminated by Unesco (Delors, 1996).

In this context, Fullan & Langworthy (2014) identify six competencies essential for deep learning and citizenship in the 21st century: collaboration, communication, creativity, critical thinking, citizenship, and character education - the "6 Cs." By exploring investigative and creative practices, STEAM fosters these core competencies, along with the cognitive skills related to its constituent knowledge fields (Maia et al., 2024a). This empowers students to critically reflect on and address problems within their own context (Freire, 1987) in the pursuit of solutions, while also developing the attitudinal skills necessary to carry out activities. More than just knowledge of its component disciplines, the STEAM approach is an innovative pedagogical proposal that articulates conceptual, practical, and socio-emotional knowledge from diverse fields through an inter- and transdisciplinary lens (D'Ambrósio, 2019).

Conversely, a persistent terminological plurality in the literature hinders the consolidation of STEAM as an innovative pedagogical approach among educators. Three common conceptual reductionisms are frequently observed: (i) the simplistic equation of STEAM with STEM, mistakenly treating them as synonyms; (ii) a limited understanding of STEAM as the mere juxtaposition of the acronym's disciplines, viewed either as isolated fields of knowledge or as professional career paths; and (iii) a narrow characterization of STEAM as a teaching methodology focused exclusively on the Natural and Exact Sciences. This conceptual ambivalence - oscillating between fragmented views (STEM/STEAM as a set of disciplines or knowledge fields) and integrative ones (STEAM as an innovative pedagogical proposal) - reveals the need for a clear epistemological demarcation. This study adopts precisely this position by advocating for STEAM as an investigative and creative pedagogical approach that transdisciplinarily integrates diverse knowledge to solve real-world problems.

Within the Brazilian context (and apparently other countries in the Global South), STEAM education is a relatively recent educational innovation that remains insufficiently consolidated in the educational landscape. This reality contributes to the persistence of conceptual inaccuracies even among teachers who have already been introduced to the proposal (Lopes et al., 2022). Furthermore, review studies such as that of Rodríguez-Aparicio (2023) point to the need for research that establishes the epistemological foundations of the STEAM approach. The author highlights that most of the studies analyzed in Latin America focus on the practical application of STEAM and on the teacher–student dynamics, evidencing the need to understand the foundational bases of this approach in order to refine pedagogical practices. The study also emphasizes the importance of making explicit how the fields represented in the acronym are conceptually articulated.

This situation underscores the urgency for a twofold strategic action: on one hand, the widespread dissemination of STEAM's potential as an investigative and creative pedagogical approach in K-12 Education; on the other, the development of autochthonous models that transcend the mere replication of foreign paradigms. Consequently, this article argues for the critical contextualization of the approach in Global South countries, where its implementation must organically engage with specific sociocultural demands, avoiding the uncritical transplantation of models developed in different realities. This perspective highlights the importance of constructing a self-referenced conception of the STEAM approach, capable of articulating educational innovation with local relevance.

This paper discusses the foundations of the STEAM approach in order to propose a contextualized conceptual framework for its implementation in Brazil. It introduces an application model for K–12 education, theoretically grounded in an exploratory documentary analysis of classical and recent STEAM literature, including scientific studies identified through international and regional databases, and combined with reflections derived from research and initiatives conducted by a Brazilian research group focused on creative and investigative teaching practices, with which the authors are affiliated. The study seeks to offer both a theoretical foundation and practical guidance for K–12 educators, with potential for adaptation to other contexts facing similar educational challenges, particularly in Global South settings.

Beyond this introduction, which has presented the study's motivation and objectives, this paper is structured into three additional sections. The following section provides a theoretical-conceptual discussion on the foundations underpinning the proposed STEAM framework. The third section presents the conceptual framework itself, discussing its characteristics and implementation guidelines. Finally, the preliminary conclusions enabled by this study are presented.

2. THEORETICAL BACKGROUND: CONCEPTUAL FOUNDATIONS OF THE STEAM APPROACH

2.1. A Brief History of the STEAM Approach

The STEAM approach, as a contemporary pedagogical proposal, has historical antecedents dating back to efforts to articulate the relationship between education and technological development (Maia et al., 2024). Its embryo emerged in the United States of America (USA) in the late 1990s under the acronym SMET (Science, Mathematics, Engineering, and Technology) - later reformulated as STEM - with the objective of fostering curricular innovation, meeting the demand for professionals in technological fields,

and reversing both low academic performance and student disinterest in the Exact Sciences (Sanders, 2009; Breiner et al., 2012).

However, significant criticisms were leveled against this proposal. For instance, D'Ambrósio (2019), who participated in the curricular discussions in the U.S., pointed out the reduction of knowledge from these fields, especially Mathematics, to a merely instrumental function, disregarding its humanistic dimension. This limitation stems partly from a conception that understands STEM as a simple representation of knowledge fields without genuinely promoting their interdisciplinary articulation.

Thus, by the mid-2000s, the Arts were incorporated into the acronym - resulting in the STEAM approach - which sought precisely to address those gaps by expanding the scope of the approach to include elements of the humanities, alongside creativity, critical thinking, and design. It is important to highlight that the inclusion of artistic and design expressions, although essential, does not exhaust the approach's potential. It is also necessary to integrate competencies from the Social Sciences and Humanities, which are fundamental for developing a critical and contextualized view of reality. In this sense, the expansion to STEAM aimed to balance technical training with socio-emotional and cultural skills, giving learning greater meaning and connection to students' lives. Despite this, conceptual inaccuracies and misconceptions persist in part of the literature, especially the treatment of STEM and STEAM as synonyms.

STEAM cannot be reduced to a mere terminological update of STEM, nor could it be, as the former emerged in opposition to the latter (Rodrigues-Silva & Alsina, 2023). Beyond the mentioned aspects concerning the Arts component, STEAM constitutes a pedagogical reorientation that values interdisciplinarity and the holistic formation of the individual. It is, therefore, an interdisciplinary pedagogical approach aligned with active learning strategies, which utilizes various active teaching methodologies.

On this point, it also cannot be understood as a teaching methodology per se, not least because it does not propose fixed steps and actions to be followed. If it did, it would be doomed to limitation, restricting the diverse possibilities of approaching problems with the variety of areas within Science itself (Exact, Natural, Social, Humanities, etc.). Its operationalization occurs through active methodologies such as Project-Based Learning (PBL), as noted by Bacich & Holanda (2022), Maia, Carvalho & Appelt (2021), and Rodrigues-Silva & Alsina (2023). PBL provides stages for developing solutions starting from a guiding question, through investigative and production procedures, to the communication of results (Bender, 2014).

The STEAM approach fosters active learning through investigative, creative, and interdisciplinary projects in which students explore real-world problems related to their context. These projects encourage decision-making, situation assessment, and reflection on the outcomes of their interventions, stimulating complex cognitive processes such as perception, reasoning, generalization, and conceptual re-elaboration, in addition to mobilizing practical and socio-emotional competencies (Maia et al., 2024a).

2.2. Theoretical and Pedagogical Foundations of the STEAM Approach

Proceeding, from the understanding of STEAM as a pedagogical approach that promotes collaboration, student agency, and autonomy through investigation and creativity applied to real problems, its connection to the ideas of scholars like John Dewey (1859–1952), Paulo Freire (1921–1997), and Seymour Papert (1928–2016) becomes inevitable.

Dewey (1938) argued that genuine education emerges from reflective experience, that is, from practical activities that engage students in situations requiring thought, decision-making, and the articulation of interdisciplinary knowledge in problem-solving. Such conceptions resonate with the STEAM approach, particularly in the integration of creativity, investigation, and collaboration within projects that reject the fragmentation of knowledge. Accordingly, the emphasis on practical activities should reflect this vision, promoting the effective integration of knowledge and bringing schools closer to the concrete challenges of society.

Another characteristic is that the problems addressed in STEAM projects should not be artificial or distant from the student's reality. In line with the Freirean conception, it is necessary that they emerge from the learners' lived context and be treated critically, aiming at their emancipation and civic formation (Freire, 1987). Problematizing reality becomes the starting point for STEAM practices, promoting dialogue among peers, the identification of issues relevant to the community, and student engagement, as they see themselves represented in the proposals. Beyond delivering technical solutions, it is crucial to question: for whom and why they are proposed. It is at this point that the "A" for Arts plays a central role, fostering an ethical, aesthetic, and cultural perspective in approaching problems, avoiding a merely technicist view of technology.

In turn, Papert's Constructionism (2008), as an offshoot of Piagetian Constructivism, is present in the STEAM approach by emphasizing the creation of concrete artifacts as an essential element of learning. This same conception appears in Resnick's (2014) proposal for Creative Learning, a disciple of Papert, who argues that learning is more meaningful when students actively engage in creating personally relevant projects, using tools that encourage exploration, collaboration, and creative expression. From this perspective, technology - whether digital or analogical - functions as a means to express ideas, solve problems, and collaborate creatively. Practices using the STEAM approach, therefore, only fully reach their potential when students not only learn about the different disciplines involved but begin to think and act like scientists, artists, and engineers, creating and sharing their own worlds (Papert, 2008).

Thus, the STEAM approach goes beyond the simple execution of scientific projects or the development of technological solutions. It constitutes investigative and creative pedagogical practices, anchored in the critical analysis of real problems, aiming to build contextualized solutions that respond to the community's needs. For this, the articulation between different fields of knowledge is indispensable to confront the complexity of contemporary challenges with the depth they require.

2.3. Epistemological Roles of the STEAM Fields

The STEAM approach transcends the mere juxtaposition of disciplines or the occasional application of active methodologies, establishing itself as an innovative educational proposal that organically articulates the diverse knowledge of the fields represented in its acronym. This integrative perspective enables the realization of pedagogical practices in which: the rigorous methods of the Sciences - Exact, Natural, Social, and Humanities - guide the investigation of problems; Technologies provide means of representation and solution; Engineering inspires prototyping and product development; the Arts introduce aesthetic, critical, and humanistic dimensions; and Mathematics supports the analysis of patterns and relationships of phenomena. Consequently, in investigative and creative projects using the STEAM approach, each field of the acronym assumes a distinct epistemological role in addressing problems: Sciences ground the **"Why?"** of the investigation, establishing the theoretical basis and guiding questions; Technology materializes the **"What?"** through artifacts and concrete solutions (including digital and immaterial ones); Engineering operates the **"How?"** through prototyping and practical implementation processes; the Arts contextualize the **"For whom?"** by integrating humanistic and people-centered design dimensions; and Mathematics answers **"With this?"**, serving as the universal language that models natural phenomena, validates hypotheses, and optimizes solutions (Figure 1). By promoting such convergence, the STEAM approach breaks with the traditional boundaries between disciplines through interdisciplinary actions, potentially reaching, at a deeper level, an authentic transdisciplinarity essential for addressing the complex challenges of contemporary society (Maia et al., 2024).

In this scenario, the need for developing a conceptual framework for the STEAM Approach tailored to Brazilian and other countries of the Global South reality, especially in the context of K-12 Education, becomes evident. This framework should guide investigative and creative practices supported by active methodologies. This perspective moves away from the reductionist understanding that sees STEAM merely as the articulation between specific fields or, furthermore, as a teaching methodology. On the contrary, it is a flexible and adaptable pedagogical approach that requires teacher intentionality in planning instructional sequences that mobilize different skills and competencies present in the summoned curricular components. This also implies seeking partnerships within and outside the school, as well as ensuring the active participation of students in all stages of the project, from the problem definition to the presentation of the final product, as the culmination of the knowledge built throughout the process.

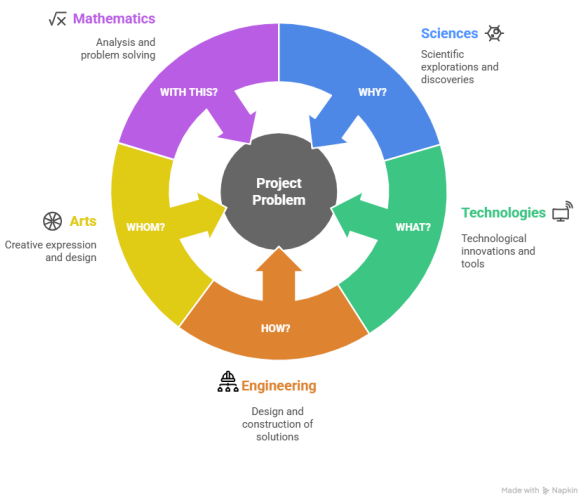

Figure 1: Epistemological roles of the STEAM fields in projects.

Source: Produced by the authors

In Brazil, the STEAM approach is not widespread among teachers, and few studies guide educators on its implementation. Research conducted at the beginning of this decade identified only eight Brazilian works explicitly addressing the STEAM approach as research on experiences anchored in this innovative pedagogical model (Maia, Carvalho & Appelt, 2021). Considering a country of continental dimensions and cultural and economic plurality, this is a very small number of studies on the topic.

Bacich & Holanda (2022) suggest that Brazil, considering its social, cultural, and educational specificities, should follow the example of other nations that have already implemented STEAM in their curricula and have achieved good results. The national curricular reform, promoted by the implementation of the Common National Curriculum Base (BNCC) in 2017, reflects this concern with developing students' scientific, critical, and creative thinking. Among the BNCC's ten general competencies, the second one states: "Exercise intellectual curiosity and resort to the specific approach of the Sciences, including investigation, reflection, critical analysis, imagination, and creativity, to investigate causes, elaborate and test hypotheses, formulate and solve problems and create solutions (including technological ones) based on knowledge from different areas" (Brasil, 2017, p.9). Therefore, an alignment is perceived between the STEAM approach, as defended in this article, and its potential for transversal treatment across all fields of knowledge within the Brazilian curricular framework. For this reason, it is necessary to develop and disseminate an understanding of the approach adopted in the country that reflects the aspirations and idiosyncrasies of Brazilian education.

Rodrigues-Silva & Alsina (2023) propose a conceptualization of STEAM as an interdisciplinary pedagogical approach that articulates the five fields of the acronym in its educational practices. Although this perspective shows significant convergence with the theoretical framework adopted in the present study, two fundamental divergences are observed: (i) the categorical

rejection of transdisciplinarity as a dimension of the STEAM approach, and (ii) the requirement that all STEAM "disciplines", linked to the five fields of the acronym, be necessarily contemplated to characterize a pedagogical practice as a STEAM approach; otherwise, the authors understand it would only be STEAM activities.

Taking as a reference the conception of transdisciplinarity proposed by D'Ambrosio (2019) for the STEAM approach, the goal is not to erase the specificities of different fields of knowledge, but to perceive them as naturally interconnected, with the artistic component playing a key role in this integration. Real-world problems require solutions that transcend the fields represented by the acronym and demand a non-hierarchical integration of knowledge. Thus, transdisciplinarity does not deny the disciplines; rather, it places them in dialogue, including with non-academic forms of knowledge - such as traditional or community knowledge - which are essential for a critical and contextualized education.

Furthermore, the requirement for the presence of all five fields, referring to them as formal STEAM curricular components, even if not simultaneously, also appears incongruent, since although the authors define STEAM as an interdisciplinary approach among five formal disciplines (Science, Technology, Engineering, Arts/Humanities, and Mathematics), this conception faces clear limitations in the Brazilian context. In Brazil, the fields of Technology and Engineering are not recognized as disciplines in K-12 Education; instead, they are addressed transversally and integrated into other curricular areas, as proposed by the BNCC and its complementary document BNCC Computing, within the axes of Digital Culture, Computational Thinking, the Digital World, and Entrepreneurship. Therefore, the STEAM approach should be reinterpreted in a contextualized manner, considering the transversality of "T" and "E" as articulating axes of the interdisciplinary process, rather than as autonomous disciplines.

Moreover, suggesting a disproportionate emphasis on certain areas - especially the technological and Exact Sciences, as some critiques of the STEAM movement indicate - can be restrictive for K–12 teachers in Brazil, given the absence of specific disciplines such as Engineering and Technology in the official curriculum. This often leads teachers to feel insecure about addressing knowledge from fields in which they have not been trained, particularly in contexts with limited resources, support, and professional development opportunities.

However, all STEAM fields can be mobilized within projects, though not necessarily articulating the full diversity of disciplines that can be linked to each area. Considering that the school knowledge mobilized during the project's trajectory will depend on the problem investigated and the direction given by the involved teachers, the STEAM fields will be mobilized not only as specific content from the school curriculum but can also emerge in the procedures developed by the students. This is the case for Technology and Engineering, which are involved primarily in the procedures students develop in seeking solutions and can be associated with knowledge from various school subjects. In this sense, it is identified that a practice using the STEAM approach may place greater emphasis on some fields but not necessarily omit the presence of others. As Bacich & Holanda (2023) state, "(...) it is important to deconstruct the idea that projects will have contributions from all fields in the same proportion, or even that they alone will be capable of developing all the learning objectives of a curriculum" (p.23). The fields can be contemplated in different ways within each proposal. To illustrate how the different STEAM fields can be mobilized within a real context, a hypothetical case will be presented later.

A more practical model should distinguish levels of integration of the fields based on pedagogical practices using the STEAM approach, where: (i) the Basic level (involving predominantly at least two fields) for more modest contexts and initial attempts; (ii) Intermediate level (three to four), for projects with more favorable conditions for developing solutions or more robust prototypes; and (iii) Advanced level (five or more fields) for situations allowing more time for execution and depth, capable of delivering innovative solutions to the addressed problems with significant and effective potential for societal impact. In Brazil, the finalist projects at the Brazilian Science and Engineering Fair (FEBRACE) are examples of the diversity of STEAM practices at these different levels of field integration (Maia et al., 2024b).

While the framework by Rodrigues-Silva & Alsina (2023) advances by defining STEAM as interdisciplinary and non-methodological, its rejection of transdisciplinarity and rigid requirement of all five disciplines may limit its application in diverse educational contexts. A more flexible model, allowing for partial and transversal integrations, including transdisciplinarity as an option, would be more useful for researchers, teacher trainers, and classroom educators. The essence of the STEAM approach lies not in the amount of disciplinary content addressed in projects, but in the quality of the connections it promotes among knowledge, students, and society.

3. A PROPOSED FRAMEWORK AND ITS ILLUSTRATIVE APPLICATION

Based on the preceding reflections, a conceptual framework for the STEAM approach is proposed, adapted to the Brazilian context, which can serve as a reference for countries with similar characteristics, particularly those in the Global South. Grounded in the fields of the acronym, STEAM is configured as an interdisciplinary pedagogical proposal with transdisciplinary potential, materialized through the following dimensions:

- **Sciences:** The approach to real-world problems with the methodological rigor characteristic of scientific plurality (Exact, Natural, Social, and Human Sciences), without hierarchizing or neglecting their different epistemologies. The Sciences provide the guiding questions that drive investigative and creative practices.
- **Technology:** The representation of solutions (artifacts) in physical, digital, or procedural formats, understood as the body of applied knowledge for problem-solving. It is essential to recognize its diverse applications and interactions with other fields.

- **Engineering:** The prototyping and development of solutions, encompassing everything from planning to the implementation of what will be produced. This dimension stimulates ingenuity and the practical application of concepts.
- **Arts:** The integration of humanistic and design aspects into all stages - from problem identification to the proposed solution - always considering the "why" and "for whom" the project is intended. The Arts ensure that solutions are contextualized and socially relevant.
- **Mathematics:** The application of the quantitative and logical properties of real phenomena throughout the process, functioning as the universal language of the Sciences and Engineering.

To illustrate the operationalization of the proposed framework, consider a hypothetical project for first-year high school students on water security, developed in a municipality within Brazil's Northeastern semi-arid region. This example articulates the five dimensions of the advocated STEAM approach in an integrated yet flexible manner. Regarding the levels of integration presented in the previous section, this is an example of a project that fits into Advanced Level of integration:

- **Sciences:**
    - *Guiding Question:* How can the production of an accessible and sustainable filter expand access to potable water in communities of the Brazilian semi-arid region?
    - *Plurality of the Sciences:* Investigation of water purification methods (Natural Sciences - Chemistry, Biology, and Physics), analysis of pathogens and physical and chemical properties of water; and investigation of public policies for confronting water scarcity in the region, consumption habits, and community practices for collecting and storing rainwater (Human and Social Sciences - History, Geography, and Sociology).
    - *Procedures:* Students interview residents to understand ancestral water storage practices (traditional knowledge), combining them with scientific principles of filtration. They investigate water quality, considering physico-chemical parameters and the presence of contaminants.
- **Technology:**
    - *Proposed Solution:* Development of an integrated system for capturing and purifying rainwater, made from recyclable (PET bottles, repurposed metal sheets) and low-cost materials, composed of:
        - A funnel optimized to maximize water collection.
        - A reservoir with a solar heater to boil the water.
        - A filter with activated carbon and sand to remove impurities.
- **Engineering:**
    - *Materials:* How to use local resources (clay, bamboo) to build the artifact?
    - *Efficiency:* What is the ideal positioning to maximize water capture and solar exposure?
    - *Prototyping:* Tests for the system's resistance and durability.
- **Arts:**
    - *Beneficiaries:* Identification of the families who will use the system, considering their cultural needs.
    - *Design:* Modeling of an artifact aligned with local water storage practices.
    - *Social Impact:* Creation of visual campaigns to raise awareness about the sustainable use of water.
- **Mathematics:**
    - *Calculations:* Volume of water capturable per rainy season, necessary surface area for the funnel, temperature required for purification.
    - *Costs:* Comparison of materials to minimize expenses (e.g., cost-benefit of metals vs. recycled plastics).
    - *Efficiency:* The filter's purification rate (liters/hour).

Through this hypothetical project, it is possible to verify that the various areas are integrated throughout the process, in addition to considering the diversity within Science itself. Furthermore, transdisciplinarity is present through the incorporation of traditional knowledge and non-academic understandings with knowledge and procedures from different fields of knowledge. Finally, the proposal addresses the reality of Brazil's Northeastern semi-arid region (resource scarcity, high temperatures) and the needs of the community, promoting student engagement and critical thinking. Figure 2 presents a storytelling representation of the development of the project's actions in this hypothetical case.

Figure 2: *Storytelling representing key moments of the project.* Source: Produced by the authors

Regarding the integration of the STEAM fields, Table 1 synthesizes the project development stages, highlighting the mobilization of the areas within the presented investigation and the epistemological roles of the STEAM fields elucidated earlier in Figure 1.

Table 1: *Integration of STEAM fields in a project on water security*. Source: Produced by the author

SCIENCES Why?	**TECHNOLOGY** What?	**ENGINEERING** How?	**ARTS** For whom?	**MATHEMATICS** With This?
It underpins the project; **Preparation of the guiding question:** ● How can the production of an affordable and sustainable filter increase access to drinking water in communities in the Brazilian semiarid region? **Actions:** ● Pathogen analysis	**Materializes solutions;** **Problem solution:** ● Integrated rainwater collection and purification system, made with recyclable and low-cost materials; **Actions:** ● Performs the artifact.	**Prototypes and implements;** **Materials:** ● Local resources available to build the artifact; **Efficiency:** ● Ideal positioning to maximize water capture and sun exposure;	**Focus on people;** **Beneficiaries:** ● Identification of families that will use the system; **Design:** ● Modeling of artifact aligned with local water storage practices; **Social impact:** ● Campaigns to raise awareness about the sustainable use of water.	**Properties of phenomena;** **Calculations:** ● Volume of water that can be collected per rainy season; ● Surface area required for the funnel; ● Temperature required for purification; **Costs:** ● Comparison of materials to minimize expenses

SCIENCES Why?	TECHNOLOGY What?	ENGINEERING How?	ARTS For whom?	MATHEMATICS With This?
• Community interviews.		**Prototyping:** • System resistance and durability tests.		**Efficiency:** • Filter purification rate.

This project exemplifies how the STEAM framework can effectively integrate diverse curricular components, initially in an interdisciplinary manner (as the identity of the disciplines is preserved) but with a transdisciplinary end goal, where listing which component stands out becomes meaningless. Throughout the stages, it is possible to incorporate the diversity of the Sciences (Exact, Natural, Social, and Humanities), as well as Languages (Portuguese and Arts), Mathematics (Geometry, Algebra, Statistics), and eventually skills like programming, woodworking, among others not present in the school curriculum. Consequently, teachers can start from their domains of expertise and, throughout the project, identify aspects where they can guide their students and others where they will need to seek partnerships with colleagues from other subjects, or even field professionals with specific expertise who can contribute punctually to the proposal. Thus, in the hypothetical project presented, the starting point could have been Sociology classes, where Chemistry and Biology teachers led the water quality analysis, the mathematics teacher assisted with efficiency calculations, the Physics teacher collaborated on material resistance and durability tests, and a student's relatives, a local artisan, contributed techniques for building the artifact. This approach balances curricular structure and pedagogical flexibility, essential characteristics of an authentic STEAM approach.

4. CONCLUSION

This paper presents a conceptual model for the STEAM approach, adapted to the Brazilian educational reality, which articulates theoretical-conceptual foundations with a viable example of practical application. The developed framework aims to overcome reductionist views that limit STEAM to a mere methodology or disciplinary juxtaposition, proposing instead a flexible approach that enables everything from partial and transversal integrations (two or more fields) to complex transdisciplinary projects through investigative and creative practices. This intentional flexibility allows for adaptation to diverse school contexts, even incorporating traditional community knowledge essential for solving authentic local problems.

The proposal sought to demonstrate that STEAM practices anchored in real-world challenges - such as the cited example of a water security project in the Brazilian Northeast semi-arid region - can transcend traditional curricular boundaries without losing the essence of the involved disciplines. The feasibility of the approach is evident even in scenarios with limited resources, provided that interdisciplinary teacher collaboration, organic engagement with the community, and the creative use of accessible materials are valued. These elements are particularly relevant for Global South countries, where educational inequalities and cultural diversity demand non-standardized and culturally sensitive pedagogical models. The model aims to replace imported conceptions with an autochthonous STEAM approach that responds to the specific challenges of Brazilian education, serving as a reference for classroom educators, teacher trainers, and researchers alike.

As an educational innovation strategy, the proposed conceptual model for the STEAM approach possesses transformative potential to guide foundational investigative and creative pedagogical practices, moving beyond isolated initiatives. For its consolidation, the creation of collaborative networks among schools, universities, and communities is recommended; alongside the development of open repositories with contextualized examples; and public policies that incentivize teacher experimentation. This framework constitutes a starting point for future research and educational practices that, by balancing conceptual rigor and applicability, can effectively promote pedagogical innovation and social transformation in Brazilian education and similar contexts.

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