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STS Education and STEM Education: A Comparative Analysis

Educação CTS e Educação STEM: Uma Análise Comparativa
Educación CTS y Educación STEM: Un Análisis Comparativo

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Abstract

In recent years the STEM (Science, Technology, Engineering, Arts and Mathematics) approaches have been disseminated throughout the world, and have also reached Brazil, where they are disseminated at events, published in periodicals and on educational websites, articles, dissertations and theses. The objective of this study was to analyze STEM considering the premises established by the STS Movement and Historical-Critical Pedagogy. The research was based on qualitative approaches and data collection was carried out through a survey of articles, dissertations, theses, books and book chapters. To analyze the data, we adopted the analytical cycle proposed by Robert Yin. In the results, we present characteristics that demarcate STEM and identify differences in relation to STS Education. We argue that one of the main differences between these currents is the critical perspective assumed by STS Education, at least in the Latin American context, corresponding to a curricular proposal that envisions the full exercise of citizenship, mainly with regard to social participation and interests linked to social transformation, contrasted with the pragmatic, economistic and market-oriented perspective typical of STEM projects, signaling an education that directs students primarily towards their professional choices, in the sense of meeting the specific demands established by the economy and the labor market.

Keywords: STEM, STS Education, Historical-Critical Pedagogy

Resumo

Há algum tempo são disseminadas pelo mundo as chamadas abordagens STEM (Science, Technology, Engineering, Arts and Mathematics), chegando também ao Brasil, sendo difundidas nos eventos, publicações em revistas e em sites educacionais, artigos, dissertações e teses. O objetivo deste trabalho foi analisar as abordagens STEM à luz das premissas estabelecidas pelo Movimento CTS e pela Pedagogia Histórico-Crítica. A pesquisa foi baseada nas abordagens qualitativas e a coleta de dados foi realizada por meio do levantamento de artigos, dissertações, teses, livros e capítulos de livros. Para análise dos dados adotamos o ciclo analítico proposto por Robert Yin. Nos resultados apresentamos características demarcadoras de STEM e identificamos aproximações e distanciamentos em relação à Educação CTS. Argumentamos que uma das principais diferenças entre as referidas correntes está na perspectiva crítica assumida pela Educação CTS, pelo menos no contexto latino-americano, correspondendo a uma proposta curricular vislumbrando o exercício pleno da cidadania, principalmente no que diz respeito à participação social e aos interesses ligados à transformações da sociedade, contrastada com a perspectiva pragmática, economicista e mercadológica típica dos projetos STEM, sinalizando para uma educação que direciona os estudantes prioritariamente para suas escolhas profissionais, no sentido de atendimento às demandas específicas estabelecidas pela economia e pelo mercado de trabalho.

Palavras-chave: abordagens STEM, CTS, Pedagogia Histórico-Crítica

Resumen

Desde hace algún tiempo, los enfoques llamados STEM (Ciencia, Tecnología, Ingeniería, Artes y Matemáticas) se difunden en todo el mundo, llegando también a Brasil, siendo difundidos en eventos, publicaciones en revistas y sitios web educativos, artículos, disertaciones y tesis. El objetivo de este trabajo fue analizar los enfoques STEM en vista de las premisas establecidas por el Movimiento CTS y la Pedagogía Histórico-Crítica. La investigación se basó en enfoques cualitativos y la recolección de datos se realizó mediante la encuesta de artículos, disertaciones, tesis, libros y capítulos de libros. Para analizar los datos, adoptamos el ciclo analítico propuesto por Robert Yin. En los resultados, presentamos características definitorias de STEM e identificamos similitudes y distancias en relación con la Educación CTS. Sostenemos que una de las principales diferencias entre las corrientes antes mencionadas es la perspectiva crítica asumida por la Educación CTS, al menos en el contexto latinoamericano, correspondiente a una propuesta curricular que contempla el ejercicio pleno de la ciudadanía, principalmente en lo que respecta a la participación y los intereses sociales. vinculado a la transformación social, en contraste con la perspectiva pragmática, economicista y de marketing típica de los proyectos STEM, señalando una educación que orienta a los estudiantes principalmente hacia sus elecciones profesionales, con el fin de satisfacer las demandas específicas establecidas por la economía y el mercado laboral.

Palabras clave: STEM, Educación CTS, Pedagogía Histórico-Crítica

Introduction

For a long time, science teaching was carried out from a traditional perspective, basically guided by the idea of transmitting abstract conceptual content that was far removed from the students' reality. The objectives of this teaching were associated with the transmission of scientific knowledge and the general education of students, mainly with a view to their access to courses linked to technical and/or higher education. The problems and shortcomings of traditional teaching have already been widely discussed in the Science Education (SE) literature. Faced with this scenario, at least in the last four decades, many alternatives have been sought to create solutions to the problems pointed out in relation to the formative weaknesses contained in teaching developed in its more traditional forms. Recently, a new proposal has become popular around the world: the so-called STEM approaches. They have been disseminated in various spaces, events and publications, such as meetings and congresses, educational magazines, articles, dissertations, theses, among other communication vehicles. We also noticed that it is a teaching perspective that has been disseminated and, to a certain extent, experimented with in Brazil. It was noteworthy that STEM appears in academic and educational publications, sometimes being described as an approach, sometimes as a curriculum proposal, sometimes as an educational movement (Colucci-Gray et al., 2019; Pugliese, 2017; Toma & Garcia-Carmona, 2021; Maia et al., 2021).

For our part, we have been working with STS Education[1] for some time, being part of a research group linked to STS studies in the area of Science Education[2], with the definition of the research topic for the master's degree of the first author of the article being precisely within this research program[3].

Based on our experiences with STS references, when we came into contact with some texts on STEM, we identified, at first, some possible similarities, such as the fact that the two approaches include Science and Technology (S&T) in their acronyms, are proposals aimed at teaching science and advocate the use of interdisciplinary approaches for teaching and learning processes in the area. However, we have no systematized knowledge of the pedagogical intentions contained in STEM programs, which, in a way, calls for research into the subject. In fact, we have defined the following problem to guide our research: considering that the STS and STEM approaches are alternative proposals for teaching science, what approximations and distances could be identified between these two perspectives?

The aim of the work reported here was to identify the similarities and differences between these approaches, based on a comparative analysis of their singularities and the existing literature on the subject. In addition, we developed a critical analysis of the STEM approaches in the light of the premises established by STS Education thought of in conjunction with the contributions offered by Historical-Critical Pedagogy (HCP), since in our research group we work in conjunction with these theoretical references (STS/HCP).

Therefore, this study was justified given the scarcity of research on STEM within a critical approach in our country. We consider non-critical works to be those that only present STEM with the aim of encouraging its implementation, without establishing an analysis of its potential and suitability in relation to the teaching traditionally carried out in our schools, since, in our research, especially in the initial review of the bibliography, the works found were characterized precisely by this uncritical bias. In the same way, we didn't find any papers that promoted a pertinent dialog between the perspectives in question, through comparative analysis. In addition, in our initial readings, we realized that the texts dealt with the subject in a superficial way, especially in the sense that they did not explain the educational and pedagogical bases that support this perspective, hence the fragmented systematized knowledge we have about this approach. Therefore, our contention is that it is essential for one to better understand its origins and intentions, including discussions on conceptions of education and curriculum, objectives, methods, the role of the school, the role of the teacher, the role of the students and the resources and didactic strategies needed to apply this new trend. With this research, we intend to

1 We consider *STS Education* to be part of the *STS Movement*, which engages in studies, reflections, research and practices dedicated to applying STS premises in the area of Science Education. This manuscript derives from the master's degree work of the first author of the article.

2 We participate in the research group GP - STS: Research Group on Science Education and Movement STS, linked to the Postgraduate Program in Science Education and Teacher Training. See the group's homepage at the following address: http://www2.uesb.br/grupos/gpcts/

3 For a discussion of STS education as a research program, see Teixeira (2024).

contribute to the literature on this subject, offering the community of science educators the possibility of obtaining more information and elements for a critical analysis of this approach, which is now being disseminated in our field

Theoretical Background

According to Teixeira (2003a), the STS Movement emerged simultaneously in several countries around the world, due to concerns that arose about the use of scientific and technological knowledge and its repercussions on society and the environment. In this sense, the Movement argues that people, in general, should get closer to these issues and understand them, with the aim of acting in society, exercising their citizenship. Considering that traditional teaching tends not to foster criticality-driven education challenging such issues, the premises of the STS Movement were brought to the educational field, at least within the area of science teaching. This led to the emergence of STS education, which proposed changes to the curricular structures for teaching subjects in this area (Santos & Mortimer, 2000; Pinheiro et al., 2007; Santos & Auler, 2011).

Santos and Mortimer (2000) pointed out that the aim of STS proposals is to make students scientifically and technologically literate, providing them with adequate training so that they can actively participate in society, making decisions about socio-scientific issues, i.e. training individuals to exercise citizenship. Therefore, we have seen several references in the literature to the objectives proposed for STEM education, and they generally involve training students to exercise citizenship and preparing them to take part in decision-making processes (social participation). However, considering Teixeira (2020; 2022), in our view, it makes no sense to discuss the objectives of the teaching processes involved in STS practices without thinking and reflecting on the conception of education and its role in society that would underlie these practices themselves. For this author, in the Latin American context, STS researchers seek to assume a

> conception of emancipatory education, focused on a project to train people who are critical of the exclusionary society in which we live, considering the most varied aspects; and who seek, instrumentalized by the teaching and knowledge they receive, alternatives for social transformation (Teixeira, 2023, p. 335).

When it comes to the content covered, the planning of STS classes, subjects and courses is carried out using as a starting point a social problem connected to subjects and issues of scientific and/or technological interest: "in an STS-type course, the teaching focus is not necessarily linked to concepts. Social issues are at the heart of the program" (Teixeira, 2003a, p. 24). By working on social issues, the idea of neutral S&T becomes the object of problematization and is deconstructed. In addition, the mere teaching of laws and concepts that explain phenomena is broken and students are directed to reflect on the political and social uses of this knowledge and to socio-scientific discussions (Pinheiro et al., 2007; Conrado & Neto, 2018).

Still on the subject of students, Pinheiro et al. (2007) discuss the role of students in STS proposals. The authors point out that these proposals seek to break with pedagogy as a teacher control tool. Students are no longer passive and subservient and work together with the teacher to construct/produce knowledge and practices (Pinheiro et al., 2007). Considering all this, according to Teixeira (2003a), the role of teachers in STS courses involves coordinating learning situations, acting as mediators during the development of activities.

The uniqueness of the work developed within the GP-STS lies in the adoption of an STS perspective articulated with Historical-Critical Pedagogy (HCP), given that Brazil is a country undergoing unequal development and immersed in a strong crisis that affects our civilization process and even our democracy. As a result, it is essential that we highlight discussions about the problems related to the asymmetries and social injustices that mark the country reality. Considering this context, the articulation of STS references with HCP is justified because Historical-Critical Pedagogy is a theoretical-pedagogical current that raises important questions for thinking about the dilemmas of Brazilian education, and which, associated with STS contributions, strengthens the critical potential of our practices (Teixeira, 2020). HCP is a counter-hegemonic pedagogical theory, as it seeks to "guide education with a view to transforming society, positioning itself against the existing order" (Saviani, 2019, p. 17). Below, we will explore in more detail the premises of HCP used in our research and then address some points of approximation of this theoretical contribution with the ideas defended by the STS Movement, in its educational expression, that is, STS Education.

HCP is a pedagogical current conceived by Professor Dermeval Saviani in the 1970s. Saviani (2011) comments that this era was marked by the development of analyses on the role of education in contemporary society, and that part of these analyses brought harsh criticism of some currents that influenced pedagogical thinking in our country, including traditional teaching and the various nuances of scholasticism developed here in the country until the 1980s (Teixeira, 2003b). In the wake of these analyses, Teixeira (2003), Campos (2017) and Coelho and Campos (2022) pointed out that the area of Science Education often tends to adopt non-critical ideals in so-called innovative proposals, but which end up assuming politically disinterested perspectives, collaborating to maintain naive views of the school and its relationship with wider society and its contradictions.

In the HCP conception, "the first condition for acting consistently in the field of education is to know, as precisely as possible, how society is structured " (Saviani, 2013, p. 26). This author highlights the fundamental role of the school in overcoming the capitalist system and the unequal context to which we are subjected. He states that there is no way to understand education without reflecting on the work carried out in schools, and that this work is necessary in the sense of cultural development, which contributes to the general development of the subjects, that is, we also think of an education that is concerned with the formation of critical consciousness. According to Saviani (2011),

the school itself is understood on the basis of the development of society throughout history, which is why they are institutions that represent essential elements in the search for a more just and socially egalitarian society.

Over the years, supporters of HCP have been striving to advance in the sense of maturing its constitutive theoretical principles and, at the same time, practicing practices that are consistent with them, offering support for the construction of teaching practices aligned with projects aimed at shaping thinking and understanding concrete reality (Saviani, 2019; Liporini & Diniz, 2022). In this sense, these are structuring premises for the work to be carried out:

> i) A concept of emancipatory education, geared towards a project of training people who are critical of the exclusionary society in which we live, taking into account the most varied aspects; and who seek, instrumentalized by the teaching and knowledge they receive, alternatives for social transformation.
>
> ii) Objectives of science education, together with the other subjects and activities experienced by students in schools, centered on training for the exercise of citizenship and the constitution of a socially significant scientific culture.
>
> iii) Teaching content that adequately articulates aspects of Science, Technology and Society, marked by the treatment of social issues of interest to students and of relevance to society in general, in which scientific content (concepts, attitudes and skills) are instruments for social participation and to support well-founded decision-making processes.
>
> iv) Didactic strategies and resources mobilized to create dynamic activities, within a formative atmosphere marked by student participation and interactive and dialogical methods of study, dissemination and discussion of socio-scientific issues.
>
> v) Evaluation centered on the process, always seeking to improve classes, courses and other training processes, in an attempt to guarantee consistent learning and quality training for all (Teixeira, 2023, pp. 335–336).

Thus, STS and HCP offer invaluable elements for understanding the role of educational proposals linked, for example, to the area of Science Education. For this reason, in this paper we use their contributions to reflect on the premises and orientations that end up influencing the so-called STEM approaches.

Methodology

The work carried out was based on qualitative approaches to educational research (Bogdan & Biklen, 2000). Within the scope of qualitative research, among the modalities available, considering our object of investigation, we carried out bibliographic research. According to Malheiros (2011) "the purpose of bibliographical research is to identify scientific contributions on a specific topic in the available literature. It consists of locating what has already been researched and studied in various sources, comparing their results" (p. 81). With this, it is possible to examine the results found in various works, comparing their ideas in order to verify the points of divergence and similarities on the subject being researched. Data was collected through a survey of articles, dissertations, theses, books and book chapters on STEM approaches. This bibliographic material was located in databases such as the Scientific Electronic Library Online (SciELO), Google Scholar, the Capes Journal Portal, the Digital Library of Theses and Dissertations, and dissertation and thesis databases linked to postgraduate programs. To do this, we used the following keywords during the search process: STEM; STEM Approach(es); STEM Education; STEAM.

As pointed out in the introductory section of the article, STEM approaches are relatively recent in our country. Something important to note is that not all of the texts selected for analysis come from Brazil, i.e., some of the texts were published in media outlets in other locations, but even so, they were included in the analysis because they are texts that influence the formation of the Brazilian ideology regarding this educational current. Based on the searches carried out, considering the textual material selected, we found that in the production of works on STEM in Brazil there is a predominance of interventional proposals, since we found several works on applications of didactic sequences, extension projects, workshops, among other activities. However, as the focus of the research was not to develop a mapping study of these productions, but rather to understand the essence of the STEM proposals, comparing them in relation to the premises defended by STS Education in conjunction with HCP (STS/HCP), we focused attention only on the general aspects that allow us to minimally characterize the so-called STEM approaches. Thus, the database was composed only of texts that focused on the conceptual discussion of these proposals. In fact, the preference was to use theoretical texts, i.e. those that provided elements that would allow us to characterize these proposals, analyze them preliminarily and establish some basis for comparison with STS/HCP.

The search process initially gave us 27 papers, ten of which were discarded because they were far from the research objectives. As a result, the corpus of analysis was defined by 17 texts published between 2009 and 2023.

Figure 1

Composition of the corpus of bibliographic materials analyzed in the research

Code	Bibliographical references	Authors' nationality
T1	Bacich, L., & Holanda, L. (2020). STEAM: integrando as áreas para desenvolver competências. In L. Bacich, & L. Holanda (Eds.), *STEAM em sala de aula* (pp. 1–12). Penso.	Brazil
T2	Colucci-Gray, L., Burnard, P., Gray, D., & Cooke, C. (2019). A critical review of STEAM (Science, Technology, Engineering, Arts, and Mathematics). *Oxford Research Encyclopedia of Education*, 1–26.	United Kingdom
T3	Moreira, M. A. (2018). O ensino de STEM (Ciência, Tecnologia, Engenharia e Matemática) no século XXI. *Revista Brasileira de Ensino de Ciência e Tecnologia*, *11*(2), 224–233.	Brazil
T4	Ortiz-Revilla, J., Sanz-Camarero, R., & Greca, I. M. (2021). Una mirada crítica a los modelos teóricos sobre educación STEAM integrada. *Revista Iberoamericana de Educación*, *87*(2), 13–33.	Spain
T5	Pugliese, G. O. (2017). *Os modelos pedagógicos de ensino de ciências em dois programas educacionais baseados em STEM* (Dissertação de Mestrado, Universidade Estadual de Campinas, Campinas, São Paulo). Repositório da Produção Científica e Intelectual da Unicamp.	Brazil
T6	Pugliese, G. O. (2021). *STEM education no contexto das reformas educacionais: os efeitos das políticas de educação globalizantes no currículo e na profissionalização docente* (Tese de Doutorado, Universidade de São Paulo, São Paulo). Biblioteca Digital USP.	Brazil
T7	Pugliese, G. O. (2020a). STEM education: um panorama e sua relação com a educação brasileira. *Currículo sem Fronteiras*, 20(1), 209–232.	Brazil
T8	Pugliese, G. O. (2020b). Um panorama do STEAM education como tendência global. In L. Bacich, & L. Holanda (Eds.), *STEAM em sala de aula* (pp. 13–28). Editora Penso.	Brazil
T9	Sánchez, D. L. V., & García-Martinez, A. (2021). Educación STEM, um campo de investigacíon emergente: análisis bibliométrico entre 2010-2020. *Investigações em Ensino de Ciências*, *26*(3), 195–219.	Colombia
T10	Sanders, M. (2009). STEM, STEM Education, STEMmania. *The Technology Teacher*, *68*(4), 20–26.	United States
T11	Toma, R. B., & García-Carmona, A. (2021). De STEM nos gusta todo menos STEM. Análisis crítico de una tendencia educativa de moda. *Enseñanza de Las Ciencias*, *39*(1), 65–80.	Spain
T12	García-Carmona, A. (2023). Integración de la ingeniería en la educación científico-tecnológica desde un prisma CTS. *Enseñanza de las Ciencias*, *41*(1), 25–41.	Spain
T13	Lorenzin, M. P. (2019). *Sistemas de atividade, tensões e transformações em STEAM* (Dissertação de Mestrado, Universidade de São Paulo, São Paulo). Biblioteca Digital de Teses e Dissertações da USP.	Brazil

Figure 1

Composition of the corpus of bibliographic materials analyzed in the research (continuation)

Code	Bibliographical references	Authors' nationality
T14	Furtado, M. K. (2023). *O estado da arte da educação STEAM por meio do bibliometrix* (Dissertação de Mestrado, Universidade Estadual do Paraná, Curitiba, Paraná). Universidade Estadual do Paraná.	Brazil
T15	Perales-Palacios, F. J., & Aguilera, D. (2020). Ciencia-Tecnología-Sociedad vs. STEM: ¿evolución, revolución o disyunción? *Revista de Educación Científica*, *4*(1), 1–15.	Spain
T16	Maia, D. L., Carvalho, R. A., & Appelt, V. K. (2021). Abordagem STEAM na educação básica brasileira: uma revisão de literatura. *Revista Tecnologia e Sociedade*, *17*(49), 68–88.	Brazil
T17	Basile, V., & Azevedo, F. S. (2022). Ideology in the mirror: a loving (self) critique of our equity and social justice efforts in STEM education. *Science Education*, *106*, 1084–1096.	United States

To analyze the data, we adopted Yin's (2016) analytical cycle, consisting of five stages: compile, decompose, recompose, interpret and conclude. According to the aforementioned author, the first phase — compiling — consists of the exploratory treatment of the data obtained during collection, mainly through preliminary readings and compilations of excerpts that initially catch the researchers' attention. The second phase — decomposing — refers to more in-depth readings and the process of breaking down the data into smaller elements (units of meaning). In the third stage — recompose — the researcher identifies broader patterns found in the data, generating, with the help of theoretical-conceptual frameworks, the categories of analysis. The fourth stage — interpreting — consists of giving meaning to the data and interpreting it according to the support provided by the frameworks adopted during the research. Finally, the fifth stage is called concluding, which refers to the process of generating comprehensive statements or a series of inferences that elevate the results of a study to a broader conceptual level (Yin, 2016).

Below, based on the process of recomposing the data, we present the categories considered for the analysis process (Figure 2). These categories were drawn up using Teixeira (2003b) and Teixeira (2020) as references.

Figure 2

Categories of Analysis

Categories of analysis
1. Origins of STEM and STS approaches
2. Conceptions of education and the role of the school
3. Teaching objectives
4. The content dimension in STEM and STS approaches
5. Teaching strategies, methodologies and resources
6. The role of the teacher and the role of the students
7. The nature of science and technology

Results

In this article, for reasons of limited space, we will only discuss the data relating to categories 1, 2, 3 and 4. The other categories mentioned in Figure 2 may be addressed in a future publication. In order to construct the discussion on the above-mentioned cases, we used a strategy based on R. Yin's Analytical Cycle. The following is the text produced from the stages of decomposition, recomposition and interpretation of the data relating to each category. Some quotes from segments that appear in the analysis are written in italics or highlighted from the main text; other segments of text from the data have been paraphrased to make up the analysis presented below. In both cases, the codes T1 to T17 are used to indicate the source of the textual fragment used in each case.

Origins of STEM and STS Approaches

As mentioned above, STS refers to a broad movement that has had repercussions in various areas, and it is a risky task to precisely define the contours of its origins. However, it is beyond dispute that STS Education emerged with the intention of incorporating the premises of this current of studies and research into the educational context (science teaching) (Aikenhead, 2005; Chrispino, 2017; Pinheiro et al., 2007; Teixeira, 2023). More broadly, STS emerged in a context of criticism of the developmentalist model, which generates significant impacts on social organization and the environment; and of reflections on the role of S&T in society (Santos, 2011). In general terms, Chrispino (2017) indicates that the texts alluding to STS mention "the emergence of social movements that opposed the harmful impacts of scientific and technological advances", hence the generation of the idea of the *STS Movement*, but there were also "reflective actions by S&T professionals who initiated discussions about the consequences" (p. 5) of scientific knowledge for the social environment. The author refers to STS as a complex field whose mission is to work towards interpretations of STS as social processes. In addition, STS reflections require contributions from sociology, philosophy, history,

economics, politics, psychology, values and so many other dimensions necessary for building a critical perspective on the scientific and technological enterprise and its repercussions on society.

In the educational axis of this movement, what we call here STS Education, we have curricular proposals that seek to incorporate issues such as concern about the impacts of the use of scientific and technological knowledge on the environment, on people's lives and on life in society into classes and other educational spaces; reflections on the nature of science and technology; encouraging the exercise of citizenship, among other issues that have historically marked the STS agenda in different contexts (Chrispino, 2017; Cachapuz et al., 2008; Teixeira, 2003a; Pinheiro et al., 2007; Santos, 2011). According to Strider (2012), one of the key points of STS education is precisely "to provide a richer and more realistic perspective on the history and nature of science" (p. 16), as well as to make science more attractive and accessible to students.

We note that in the origins of the STS Movement we have groups mobilizing to demand people's participation in discussions that concern society and the environment (STS activism) and groups of academics discussing the games of interests that exist behind scientific and technological development (Silva, 2015). In fact, we understand that these movements flow in the direction of motivating people to get involved in discussions about S&T, from a critical point of view (Teixeira, 2003a), problematizing and questioning the positions and opinions of political authorities, scientists and technologists, understanding that they are not incontestable people and are not even bearers of absolute truths and free of interest (Pinheiro et al., 2007). Therefore, STS education does not focus on "the wonders of science, as the media already does, but rather provides (...) representations that allow citizens to act, make decisions and understand what is at stake in the discourse of experts" (Santos & Mortimer, 2000, p. 3).

Thus, since the 1960s, STS has appeared in the form of social movements and studies and reflections developed in the academic world. There are at least four traditions linked to the Movement: (i) groups of activists critically raising arguments linked to STS, pointing out the risks and other various problems arising from "so-called technological prosperity" (Chrispino, 2017, p. 10); (ii) groups of scholars responsible for so-called STS Studies (some of them linked to the Social Sciences and engineers concerned about the direction of development), divided into at least two parts, one dedicated to the study of public policies linked to ST and the other developing social and political criticism of ST; (iii) groups of educators and researchers concerned with the scientific and technological literacy of citizens, constituting, as we have already pointed out, the educational arm of the movement; (iv) various studies carried out in areas such as Sociology, History and Philosophy of Science and Technology, which offered essential contributions to reflections on the Nature of Science and the scientific and technological enterprise. Thus, the STS Movement and STS Education are currents originating from a complex and heterogeneous set of professionals, activists, academics, philosophers, educators, intellectuals, among other actors who, with diverse concerns, are interested

in the economic, societal, environmental, political, ethical and cultural impacts and seek ways to broaden society's participation in decision-making involving ST (Chrispino, 2017).

STEM education, on the other hand, although it did not emerge within schools, was conceived from the outset specifically for the educational context (T4; T5; T8; T9; T10; T11; T14). However, the factors that drove the drafting of these proposals were not aimed at meeting broader educational demands, such as the critical training of students and training for citizenship, but rather instrumental demands, based on the economic dimension of the social body, with aims linked to technological development and competitiveness for various countries (T5; T14; T17). In T17, for example, the authors point out that "*STEM knowledge is normatively operationalized for corporate economic benefit, often involving the exploitation of marginalized peoples and lands*" (T17, p. 1093).

The origin of STEM education in the United States (US) is marked by political pressure and private corporations that funded educational programs to encourage their propagation and implementation, with the aim of arousing the interest of American students in STEM areas (T5; T14), as these areas, in theory, represented potential for boosting economic and technological development, which would consequently favor the country's growth, strength and competitiveness. Sanders (2009) states that funding for all programs related to STEM approaches has flowed very quickly in the United States. He calls this movement *STEMmania* (T10, p. 20). In the wake of this process, T15 states that in 2009 STEM "*underwent a global expansion based on the social needs established by the National Governor's Association, which defined the promotion of a STEM identity among citizens as a means of maintaining economic competitiveness*" (p. 6).

In the case of Brazil, T14 says that due to the lack of financial support, STEM has been implemented through individual activities, on the initiative of teachers or private schools. T16 corroborates this statement, pointing out that STEM practices are still incipient in the national context. They point out that the predominance of interventional STEM work is more focused on the south of the country, followed by the southeast and central-west regions, and of the work analyzed in their research, most was implemented in the context of secondary education.

Hence, as the analysis showed, the STEM Movement and STEM Education have different origins and different motivations. While the former calls for people to engage in social participation, with a view to training for the exercise of citizenship, the latter aims to encourage people to get involved in STEM areas, in order to qualify them for professional training (T14), and thus has its origins marked and/or guided by typical "learning to learn" mottos, with interests associated with the job market and employability for certain sectors of the population (Saviani, 2010).

With regard to acronyms, in STS Education it is common to find authors who use the acronym "STSA" (Pedretti & Nazir, 2011; Martínez Pérez, 2012; Conrado & Nunes-Neto, 2018; Maestrelli & Lorenzetti, 2021), with the intention of emphasizing environmental issues. Other authors prefer to use only the acronym "STS", using the following argument:

> We have argued that, since its inception, STS Education has implicitly incorporated the objectives of Environmental Education (EE), since the STS Movement emerged with a strong critique of the developmentalist model that was aggravating the environmental crisis and expanding the process of social exclusion. In this sense, we believe that environmental issues are inherent to the analysis of complex STS interrelationships and are present in various social and scientific themes directly related to the environment, which have always been recommended in the various STS curricula (Santos & Auler, 2011, p. 31).

We would point out that whether we choose the term "STS" or "STSE", the importance of environmental issues within the proposals does not change, since in both cases the authors recognize that Environmental Education and, with it, interest in socio-environmental problems has always been on their agenda of study, research and practice.

Because of the proximity between STS Education and research into SSI (Socio-Scientific Issues), there can be some confusion in understanding the relationship between the two currents or even being understood as being the same thing. Nevertheless, working with SSI may indeed involve the study of situations that "can be transposed to teaching, within the scope of a didactic strategy or teaching method that allows students to mobilize and learn about certain content, in a contextualized way" (Conrado & Nunes-Neto, 2018, p. 88). According to these authors, SSI is based on the principles of STS education and is one of the approaches that can be adopted within the STS proposals.

In the context of STEM projects, the acronym SMET (Science, Mathematics, Engineering and Technology) emerged around three decades ago. The term was first used by the National Science Foundation (NSF) in the 1990s in the United States (T4; T5; T8; T9; T10; T11). In 2001, this acronym was replaced by the term STEM, so STEM education quickly became popular, first in the USA and then in other countries around the world (T5; T8; T9; T14). Some countries have already included STEM in education debates, such as: United Kingdom, Australia, Canada, France, China, South Africa, Japan, among others (T5; T14).

Over time, countless variations of the acronym have emerged, creating a series of ambiguities (T10). In addition to the variations in acronyms, T10 points out that even in 2003, few people in the US knew what this meant: the NSF itself used the acronym STEM simply to refer to the four separate fields (Science, Technology, Engineering and Mathematics), i.e. it did not allude to SMET from an integrated education perspective. In any case, the most common variation used is the acronym STEAM, with the addition of the "A" in reference to the arts. Some authors argue that the arts represent an extremely broad field, as they point out that it is an area that is not just limited to literature, music, painting, sculpture, drawing and dance, but includes other dimensions such as sociology, psychology, history, philosophy and even education (T4; T9). However, other authors warn that, within the STEM proposals, these broader issues relating to the arts have not, at least not yet, been adequately explored, and that, indeed, when they do appear, they unveil "a strictly utilitarian view of art: "it serves to illustrate", not properly as a field of knowledge. Another argument is that the arts, based on an instrumentalist view

of entertainment, are useful "*to make* the activities to be developed *interesting*" (T7, p. 212). For example, in T16 the authors point out that "*while knowledge linked to Science, Technology, Engineering and Mathematics has historically* been associated with *technical skills (hard skills), knowledge linked to the Arts (...) highlights the relevance of humanistic and behavioral skills (soft skills), such as creativity and criticality*" (T16, p. 69). In view of this, we agree with (T6) when the author states that the addition of the "A" to the acronym seems more like a "marketing strategy than a real theoretical/methodological concern" (p. 38).

In light of all the abovementioned ideas, the addition of the "Arts" has brought an idea of innovation with the potential to stimulate people's interest. However, none of the works consulted were able to clearly identify the role that the "Arts" play in these proposals. What we have assessed in this regard is that the opinions of the authors of the texts studied are controversial in relation to the role of the arts within the so-called STEM approaches.

Other variations of the acronym found were STHEM with the "H" for humanity (T6, p. 38), STREAM with the "R" for read (T2, p. 5), iSTEM which includes the "i" for imagination (T11, p. 66). However, these others are not often found in the literature. In T14, the author presents a table with other acronyms that refer to STEM education. So, despite noting all these variations, we don't find in-depth discussions about the role of these elements that are being added to the original acronym, so we can't be clear about how they are incorporated and how they influence or not the identity of STEM approaches. As T10 points out, perhaps this confusion of acronyms is part of the very ambiguity that has marked these approaches since they first appeared.

Conceptions of Education and the Role of the School

In the context of *STS* education, at least as we understand it, from a Latin American perspective, we have a concept of emancipatory education, mainly because we adopt an approach inspired by Historical-Critical Pedagogy, a progressive pedagogical proposal, which is committed to making efforts so that educational practice is in tune with the interests of the population for the transformation of society. According to Dowbor (2017), capitalism contributes to increasing social inequalities, being an economic system that favors the accumulation of wealth by a small portion of the population, while most people might not be able to break out of the cycle of poverty. Considering this situation, Saviani (2011) argues that education has a fundamental role to play in overcoming the capitalist system, and that school should be a field for discussing political issues, social problems and the contradictions of capitalism (Saviani, 2013), acting critically to allow students to perceive all the oppression and domination practiced by the hegemonic system. Therefore, the idea is to defend a perspective of critical education, aimed at transforming society, through a process that considers the social, economic and cultural context throughout history (Saviani, 2011). This is a perspective on the role of the school that can be seen in many STS authors here in Latin America (Teixeira, 2003; Santos, 2008; Strider, 2012; Martínez Pérez, 2012; Auler, 2013; Chrispino, 2017).

In the case of STEM proposals, we have the adoption of a conception of education that is not always clearly explained, but which, between the lines, puts the school at the service of government and technology industry demands. For example, in T6, the author states that neoliberal logic is impregnated in these approaches.

> In Brazil, educational policies have increasingly valued STEM areas, as is the case with reforms such as the New High School, which prioritizes technical and vocational education, even though it does not explicitly adhere to the STEM movement. In Higher Education and Basic Education, there is a clear valorization of the "strategic" or "fundamental" areas for the country's progress, as the STEM areas are commonly called, while the humanities and social sciences are devalued and scrapped. In this case, the idea still prevails that the humanities and social sciences do not produce knowledge that is useful to the economy, nor do they make states competitive and are therefore dispensable (T6, p. 48).

In T17, the authors state that within STEM practices, even those that are theoretically aimed at promoting social justice (or just social mobility), the issue of capitalism and its contradictions end up being left untouched and not discussed, representing a serious problem, since capitalism is at the heart of the matter when we think about how much this perspective favors the constitution of asymmetries within societies. As for T11, there is no doubt that STEM takes "*scientific and technological education to maintain the capitalist hegemony of some countries*" (p. 66). Therefore, we note a significant proximity between *STEM Education* and the technicist pedagogies described by Saviani (1999), pedagogical currents which have also strongly influenced the area of science teaching, as in the case of teaching by discovery, teaching by investigation and project pedagogy. The renowned author states that technicist pedagogies conceive of science from a neutral perspective, which takes rationality, efficiency and productivity as its principles, in order to make the educational process objective and operational. In the wake of this process, it would be up to education to provide adequate training "to carry out the multiple tasks continually demanded by the system". In this sense, "education is conceived as a subsystem whose efficient functioning is essential to the equilibrium of the social system [*of which*] it is a part" (Saviani, 1999, p. 25, emphasis added). From this perspective, technicism is characterized as a non-critical pedagogical current, since it ignores the social determinations that impact the educational context, while placing the school and education itself, in the broadest sense, at the service of maintaining the prevailing society.

Through the literature analyzed, we identified all these characteristics within *STEM Education*. Although T2 states that *STEM Education* is committed to preparing students for the challenges of contemporary society, what worries us is that this does not include the political, social, cultural and environmental dilemmas (T6), so we can say that there is a kind of silencing of broader social issues in the STEM literature examined during the research (except in T17). Evidence of this argument is found in T14, a work that aligns STEM within neoliberal conceptions applied to the educational system —

they are neoliberal in the sense of weaving the role of the school especially towards the labor market. The logic in this system is to provide conditions for the production of an education that is completely aligned with the process of economic expansion. From this perspective, "*the school's social function is to train the individual for work, or as the neoliberals call it, for employability*" (T14, p. 28). In effect, the educational system is accommodated in order to docilely adapt to the strategic demands imposed by the capitalist system. T14 mentions some of the characteristics that mark educational perspectives that adopt neoliberal logic: utilitarianism, encouraging competitiveness, work centered on developing competences and skills, valuing efficiency and optimized production, appealing to technology and promoting the idea of students adapting to the prevailing society.

In the case of STEM education, at least in the strand defended by the authors cited here, scientific literacy is envisioned for all students, even those who do not intend to pursue scientific careers, because it is understood that this is a tool that brings the necessary empowerment for people to make responsible decisions on S&T-related issues that influence society. However, even in cases where STS envisages the training of professionals for specific careers, the idea is different from that found in STEM literature. For example, when Zaiuth and Hayashi (2011) think of the STEM Movement in relation to the training of scientists and other professionals, they appeal to the social responsibility of these professionals.

STEM education, on the other hand, seeks to meet economic demands; it seems to suggest that students who do not wish to pursue STEM careers are useless for economic growth (T7). In T17, the authors, from a moment of self-criticism, make the following statement:

> We recognize that our ways forward must necessarily first include a vision of education and learning that is not situated in capitalist enterprises and mechanisms; that regularly recognizes and questions funding structures, speculation, human exploitation and militarism; and that is fundamentally based on pluralist modes of knowledge production (T17, p. 1095, translated by the authors).

In short, while STS education, especially from a Latin American perspective, envisions a school that is active in the formation of critical citizenship, aimed at transforming society through people's active participation, STEM tends to see schools as spaces to promote certain professional careers and help countries achieve competitiveness and economic development goals: in a way, this perspective ends up being yet another instrument for maintaining and strengthening the existing model of society. Clearly, STEM shows a neo-technical bias, linked to the economic perspectives associated with neo-liberalism.

Teaching Objectives

As a result of the discussions formulated in the previous section, as already mentioned, we can point out that the main objective of STEM education is citizenship education, i.e. providing students with an education that enables people to act in society from a critical perspective in relation to the direction of the scientific and technological enterprise, considering its impact on society and the environment (Santos & Mortimer, 2000; Pinheiro et al., 2007). Other noteworthy purposes encompass the acquisition of knowledge, the development of skills and values, the exercise of decision-making, the development of critical thinking and intellectual independence, the ability to discuss social and technological issues, as well as other important requirements to empower social participation (Santos & Mortimer, 2000; Teixeira, 2003a; Chrispino, 2017). Therefore, these are objectives that denote a concern for education that allows people to "understand society permeated by scientific and technological advances and to fight to avoid technocratic regimes in the most different spheres of power and social practices" (Teixeira, 2020, p. 20).

In STEM Education, we identified that several texts (T2; T5; T7; T9; T10; T11) point to objectives strictly linked to the job market, such as encouraging students to take an interest in STEM areas, increasing economic competitiveness, preparing students for the skills and/or professions of the future. T13 advocates "*integrating STEAM into the school curriculum as a means of transforming education [...] with a view to developing S&T in the future*" (p. 48). All these objectives show that the STEM proposals, as T11 corroborates, seem to be close to pedagogical currents linked to educational objectives in which the school is "used as an instrument to adjust [...] to the demands of the market in a globalized economy centred on the much-vaunted knowledge society" (Saviani, 2019, p. 6).

T15 states that STEM Education focuses on the social nature of S&T, and that STEM Education extends interdisciplinary relations to Mathematics and Engineering, with the aim of increasing vocations in the face of the challenge of competing with the new economic powers. There is even an interesting piece of information provided in T10: the authors argue that when Americans came to believe that China and India were well on their way to overtaking North America in the global economy, surpassing the US, funding began to flow and *STEMmania* began. This movement has also been seen in the past, under different circumstances, in the 1950–60s. When the US found itself overtaken by the former Soviet Union in the space race, it undertook a wide-ranging reform of education in that country, with a strong impact on the area of science teaching, generating the idea that science education should be strengthened, prioritizing the training of scientists, with the emergence, among other alternatives, of the Rediscovery Method, known here in the country in the midst of the reforms proposed for science teaching in the 1970–80s. In the case of STEM Education, we have an analogous situation, since, as we have shown, it is aligned with currents of thought that promote the valorization and perpetuation of the socio-economic system in which we are inserted, bringing a logic of training for the workforce, disregarding the multiple factors that permeate human life.

Based on the assumptions of HCP, it is possible to affirm that approaches that bring this bias into play act, even if not deliberately, to increase social inequalities, serving the interests of those with economic power and once again disadvantaging a significant part of the population (Saviani, 2011).

It is clear that, at this point, STS and STEM Education take opposite paths, since STS approaches want to incorporate elements that favor the emancipation of subjects, the search for autonomy and social participation (Teixeira, 2020; 2003a; Pinheiro et al. 2007); in STEM, there is a clear concern with persuading people to choose STEM areas, which on an individual level seeks to promote the employability of certain people, and on a collective level benefits the system by promoting its maintenance and perpetuation. In the works analyzed, the pedagogical objectives are poorly systematized, although some authors (T5, T10 and T14) mention some alignment of STEM with constructivist approaches, which are also characterized as non-critical pedagogies in the analyses provided by HCP. In short, STEM education understands the educational process from a broader perspective, thinking about the society in force and its contradictions, problems, conflicts and other issues. On the other hand, it seems to us that STEM education ends up taking a narrower view, since it focuses only on the issue of the "professions of the future" and employability, disregarding structural issues linked to underemployment or the very contradictions inherent in the capitalist system.

The Content Dimension in STEM and STS Approaches

Within STS education, considering its links with HCP, content is an essential element, given that the population "needs school to have access to erudite knowledge, to systematized knowledge and, consequently, to express in an elaborate way the content of popular culture that corresponds to their interests" (Saviani, 2011, p. 70). The school should not put scientific knowledge (Biology, Physics, Chemistry, Mathematics, Portuguese Language, etc.) on the back burner, since the democratization of content is the primary task of public education. Saviani comments on the importance of content within the perspective defended by HCP.

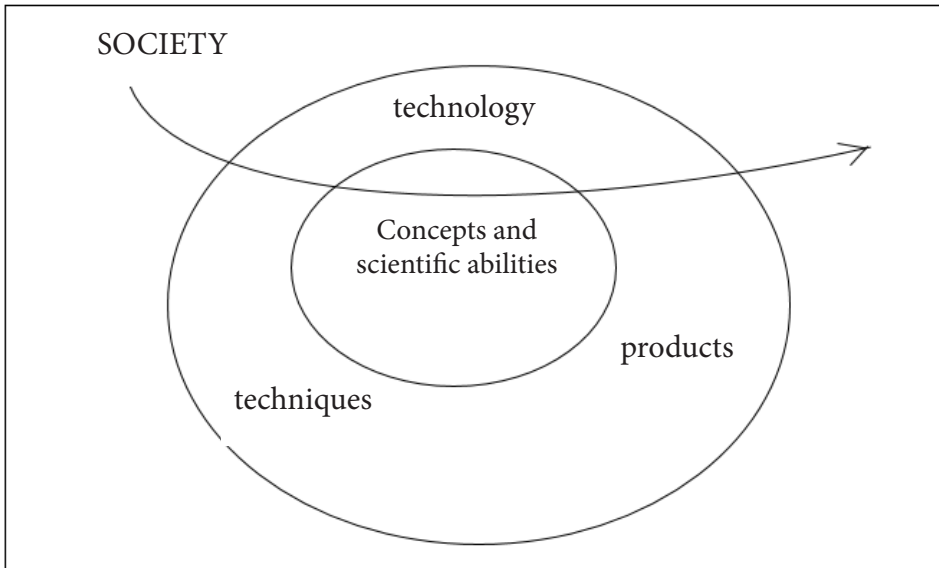
> Content is fundamental and without relevant, (...) meaningful content, learning ceases to exist, it becomes a mockery, (...) it becomes a farce. It seems to me that it is essential to understand this and that, within the school, we act according to this maxim: the priority of content, which is the only way to fight the farce of teaching. Why are these contents a priority? Precisely because mastery of culture is an indispensable tool for the political participation of the masses. If members of the working classes don't master cultural content, they cannot assert their interests, because they are disarmed against the rulers, who use precisely this cultural content to legitimize and consolidate their domination. I sometimes put it this way: the dominated cannot free themselves unless they master what the dominators master. Thus, mastering what the dominant dominate is a condition for liberation (Saviani, 1999, p. 67).

In addition, the author comments that through the assimilation of content, students acquire the conditions to claim their interests, strengthening themselves from a political point of view (citizenship). Therefore, it is through content that teachers turn the educational act into a political act, without necessarily discussing politics in the partisan sense. Furthermore, when Saviani (1999) mentions content, he is not talking about formal, fixed and abstract content, but real, dynamic and concrete content, linked to broader social goals. Within the STS proposals, the contents are worked on based on social themes and should articulate aspects of S&T and society. Furthermore, there is a concern not to compromise the teaching of scientific content, which is essential to support discussions on the proposed themes (Teixeira, 2020). According to Teixeira (2003b), proposals based on STS approaches leave room for dealing with classic content in an approach that goes beyond the conceptual dimension, through problems of social interest. Hence, scientific content, technical-scientific controversies, dilemmas, contradictions, decision-making processes, questions about the nature of science, among other possibilities, come into play

The model proposed by Aikenhead (1990) is interesting for understanding the proposal, but we cannot interpret it as something rigid or inflexible; it is one of the possibilities for developing STS activities.

Figure 3

Model for developing proposals based on STS education



Source: Aikenhead (1990, p. 12).

The stages of this model are as follows:

> 1. introduction of a social issue; 2. analysis of the technology related to the issue; 3. definition of the scientific content according to the social issue and the technology introduced; 4. use of related technology according to the content presented; 5. return to the social issue for final discussion (Aikenhead, 1990, p. 12).

One may note that social themes are configured as axes that structure the study of scientific knowledge. Furthermore, by suggesting the use of social themes, scientific and technological aspects are favored so that they can be discussed from a critical perspective, not taking S&T on its own, but as activities interconnected to the social context, thinking about the impacts, benefits, risks and harms that can affect society or the environment (Pinheiro et al., 2007). Therefore, in S&T education, the use of social themes broadens the vision of S&T, as it allows issues related to the economy, politics, culture, ethics and the environment to emerge by introducing social issues into the classroom, which is why we can say that S&T curriculum proposals point to the development of a critical approach.

The STEM proposals, on the other hand, differ in terms of content, in that they incorporate "*content such as programming, engineering and design concepts, which are generally absent from basic education*" (T7, p. 220). The content can be worked on through social themes or through investigation based on research problems (T13). It is worth noting that STEM Education seeks to work on the content and technical skills of the areas covered by the acronym from a perspective of integration, establishing interdisciplinary connections between the content covered (T13). According to T13, STEM arises to meet the demands of a world that is constantly changing, and that schools must transform the focus on content into lifelong learning. "*What's more, it's about a curriculum geared towards professional training and divided into competencies, so that the knowledge produced at school is productive in future professional activities*" (T7, p. 220). Thus, the contents of these proposals are designed from the perspective of equipping students with what will be useful for the demands of society, especially with regard to the professions of the future.

Although STS and STEM may converge in the sense that they problematize science teaching that is excessively disciplinary and limited to the transmission of conceptual content, it seems that in *STEM* there is more attention to the development of competences and skills (T1). In the texts examined, there are few references to the formal disciplines of the curriculum, although they do highlight the need for interdisciplinary approaches and the inclusion of computer science, technology, engineering and designer themes in the activity proposals (T8, p. 15). It is noteworthy that STEM is also aligned with competence pedagogies.

Final Remarks

This work relied on a comparative study, mapping possible approximations and distances between the two approaches studied. Based on the analysis carried out, we argue that STEM approaches do not bring significant novelties to the field of Science Education. We noticed a certain similarity between STEM and alternatives that have already been formulated in the past, such as teaching by discovery, teaching by investigation or even project-based learning, i.e., proposals marked by working with practical activities and/or projects that seek to give students the chance to take the lead in their learning process, taking charge of carrying out the proposed activities. In addition, these proposals also raise concerns about the training of scientists and professionals in specific areas, just as in STEM, but from different perspectives: while in teaching by rediscovery and teaching by investigation the focus is on training scientists in the natural sciences, in STEM the intention is to train students to develop professional careers [in theory] in tune with current times (technologists, engineers, computer professionals, etc.). In the context of the STEM Movement, we have the establishment of criticism of the scientific-technological enterprise, always thinking about its consequences for the socio-environmental base, as well as projecting the formation of citizens for a world strongly impacted by S&T.

It is important to highlight that, over time, the field of SE has been looking for alternatives to overcome traditional teaching. However, STEM Education was not an alternative that originated in the area, but was disseminated by actors outside the educational context, including interests linked to government and company policies disseminated by the corporate world. Thus, based on the work carried out, we found that there are few points of rapprochement between STEM Education and STS Education. Among the aspects characterized as approximations between the two currents examined here comparatively, we have: the defense of interdisciplinary teaching proposals; proposing activities focused mainly on science teaching; seeking to motivate students to take an interest in scientific and technological issues (albeit with different intentions); aiming to overcome traditional teaching, increasing science classes and taking on alternative teaching strategies.

Once STEM education is new in the country, even after the research reported here, some points are still not clear enough for us to understand its proposals in their entirety. However, based on the results of this study, it became clear that the main difference between the two currents is the fact that STEM has neotechnicalist traits, demonstrating that it corresponds to an educational current aligned with a conservative educational perspective, devoid of the political dimension, and which, as Saviani (2011, p. 48) would say, reduces the school experience to a space where dominant interests impose themselves and remain intact and unproblematized, that is, from this perspective, science teaching ends up collaborating to maintain a naive view of the school in its relations with society (Saviani, 2011; Coelho & Campos, 2022). As Santos (1998) would say, it is yet another expression of educational forms concerned with the professional

dimension, "a pseudo-education that does not lead to an understanding of the world" (p. 41). On the other hand, STS Education, at least in the conception defended here, supported by the assumptions of HCP, adopts a stance closer to a critical and progressive educational vision, that is, it works towards the formation of students' critical thinking and understanding of concrete reality, wishing, from the criticism of this reality itself, the transformation of society on a more just and egalitarian basis.

As Santos (1998) points out, the aim of education should not be to prepare students to compete against each other, but to train people who are able to situate themselves in the world and contribute to improving society as a whole. We believe that in this sense, i.e. within this educational conception, STS education is closer to these aims, whereas STEM seems to be moving further and further away from this type of ideology.

When the origins and objectives of teaching are concerned, these are clearly related to the demands of the labor market, linked to the interests of training skilled labor for the so-called professions of the future. Schools are therefore seen as spaces to propagate STEM careers, helping countries to achieve competitiveness and economic development goals. In our view, this perspective ends up being yet another instrument for maintaining and strengthening the current model of society, which reinforces the idea of a concept of education linked to neoliberal logic.

Some texts referred to STEM education as a tool capable of contributing to the promotion of social justice (T5, T7), but from this research we understand that in STEM social justice is worked on in a very peculiar way, that is, from the perspective of social mobility for people taken in isolation. In other words, through these approaches, it would theoretically be possible to bring students belonging to minority groups closer to professions that are not normally easily accessible to these groups, which could help people individually (social mobility), but if we think from a collective perspective, these initiatives may not be able to bring about changes in society's patterns, which are marked by injustices, inequalities and social asymmetries.

Regarding the works examined in the research, it is worth noting that they are diverse texts. We took care to select texts from different countries, as we wanted to have a broader view of STEM education. At the end of the research, we noticed that in terms of the authors' position on the subject, the texts were also somewhat heterogeneous. Some indicate STEM education as an interesting option for teaching science (T1, T3, T5, T6, T7, T8, T9, T13, T14, T16), others criticize certain elements of the proposal, while still defending it (T2, T4, T11, T12, T15, T17), while (T10), in turn, shows a certain ambiguity, presenting STEM as an interesting proposal, but making some relevant criticisms. It is important to highlight that the way we understand and present STEM Education in this research was the result of studying this sample of texts. Therefore, we have no intention of generalizing our inferences in order to make definitive statements, as, ultimately, there is a vast literature on the subject produced in various parts of the world that we were unable to examine during the course of this research. Even so, this work, in a way, confirms the thesis defended by T15, in which the authors problematize

the idea that there are links between STEM and STS, and even the idea that STEM would be an original and innovative movement for the area. In fact, in our opinion, STEM is not even part of the research program linked to the STS Movement.

Considering that we have only explored theoretical texts on STEM Education, in a search process that was not even exhaustive, an interesting suggestion would be to develop other investigations dealing with the practices developed concretely within this current in schools in the country. Considering that STEM comes from the American scene, and here in Brazil it is defended in the context of the changes taking place in the Brazilian curriculum for Basic Education, with arguments inspired by the BNCC and other neoliberal content reforms, it would be interesting to understand how STEM has been implemented here, since it was shaped according to the needs and demands of the American educational and social context and has a polysemic character that can be developed from different perspectives. The implementation of this approach in Brazil will certainly be different from that in the US, since there are several elements that promote drastic changes in the scenario, for example: economic, cultural, political and social factors, technological advances, the infrastructure of the educational system, the problems of Brazilian public schools, teacher training, among others. Considering that there are significant differences between the US, European and Brazilian realities, there is a need to understand how STEM education has arrived in schools. What forms has it taken? How has it been implemented? For what purposes? These are a set of questions that suggest research for the near future.

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