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DEVELOPING NEW TRENDS IN THE CLASSROOM: FROM THE SCIENCE, TECHNOLOGY AND SOCIETY APPROACH TO IMPLEMENTING THE STEAM APPROACH

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CTS AND CTSA APPROACH

The Science Society and Technology (SST) approach seeks to understand the social dimension of science and technology from the point of view of both its social antecedents and its social and environmental consequences.

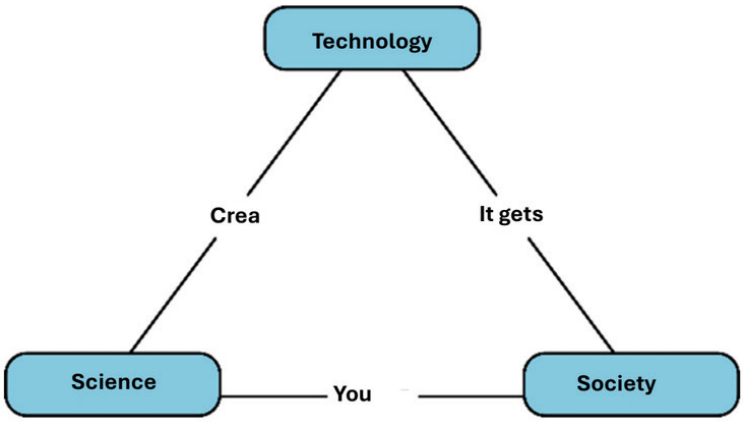
CTS studies began in the 60s and 70s. As well as stimulating discussion on technological and scientific issues, the CTS approach also disseminated broader reflections on the worsening environmental problems resulting from human activities on nature, thus giving rise to the CTSA approach (Science, Technology, Society and Environment). The CTSA approach is considered by many authors to be an offshoot of the CTS approach with an emphasis on the environmental aspect. CTSA studies show a central concern with the social and environmental aspects related to the applications of science and technology, which is directly linked to the formation of citizenship. CTSA studies in education aim to motivate students to learn science with a more authentic, critical and reflective view of their relationship with technology and its social and environmental impacts. To this end, meaningful learning must be employed, with the student as the central actor in the knowledge-building process, appropriating investigative knowledge in order to form citizens who are more participative in their environment. Using the CTSA approach, science and technology content is studied by discussing its historical, ethical, political and socio-economic aspects.

The characterization of the CTS movement in the USA and Europe highlights three directions of the movement: in the field of research; in the political sphere and in education. In the classroom, the main objective of the CTS approach is to promote scientific literacy among citizens so that they are able to intervene critically in the social context in which they are inserted, through the development of knowledge, skills, attitudes and values that enable them to make responsible and conscious decisions on issues relating to science and technology in society. It should promote interdisciplinary and contextualized approaches. The CTS approach should be dealt with through themes that are relevant to the context in which the student is inserted, and local, regional and global themes can be addressed. Different strategies can be used to implement the approach in the classroom, such as lectures, debates, problem-solving, projects, field research, community action, among others.

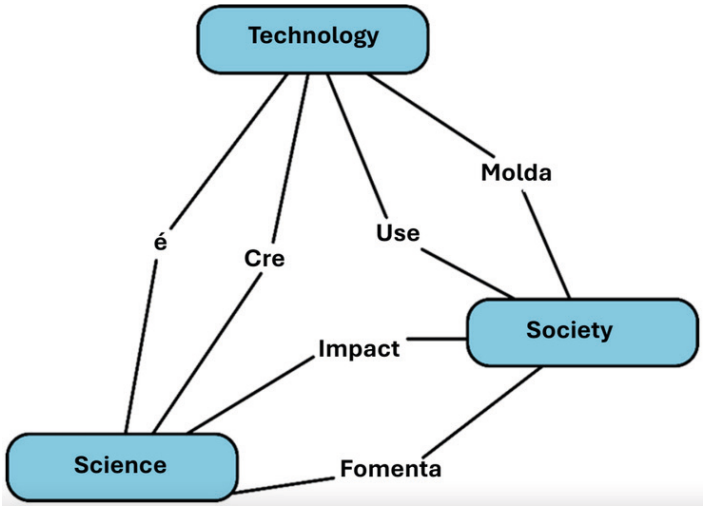
Science teaching with a CTS approach would have as its function the acquisition of knowledge, the use of skills and the development of values. The general objectives of the CTS approach in education can be highlighted:

- Promote students' interest in relating science to technological and social aspects;
- Discuss the social and ethical implications related to the use of science and technology;
- Understand the relationship between science and scientific work;
- To train citizens who, through scientific literacy, have more dynamic, critical and reflective knowledge, generating more assertive decision-making in relation to the collective and the environment;
- Develop critical thinking.

In the CTS approach, the interrelationships between the terms Science, Technology and Society can be presented in various ways. A simplistic perception of this relationship is shown in the following diagram.



This simplistic conception creates a problem for CTS teaching, as the relationship between science and technology is not simple, because although science leads to the creation of technology, the reverse is also true. Science and technology can be understood as two different forms of knowledge. A better relationship between the three terms is shown in the following diagram, which highlights that society is impacted by scientific knowledge and interferes in science, changing its course.



THE CTS APPROACH AND THE LEGAL DOCUMENTS GOVERNING BASIC EDUCATION

In basic education, there are two problems that hinder the promotion of scientific literacy in the CTS approach: the compartmentalization of knowledge and the inability to articulate it. In order for there to be critical and reflective contextualization, there needs to be a more comprehensive relationship between contents. The National Curriculum Parameters (PCNs) emphasize the importance of promoting the relationship between Science, Technology and Society in the classroom, both in primary and secondary schools, thus generating an understanding of the origin and application of artefacts and also of the facts in today's society.

The Common National Curriculum Base makes it possible to address issues associated with STS education in the area of Natural Sciences. For secondary education, the BNCC defines competences for areas of knowledge and for primary education, the document defines competences for areas of knowledge and specific competences and skills for each

curricular component. The competences and skills make it possible to work on problem situations that involve the interrelationships between Science, Technology and Society, being integrated into the CTS or CTSA approach.

The document defines that the curricula of the Basic Education segments should include contemporary cross-cutting themes, "which affect human life on a local, regional and global scale", such as the issue of environmental problems, consumerism, and scientific and technological development with its consequences for society and the environment. The contemporary cross-cutting themes highlighted by the BNCC can also help with the CTS approach. The contemporary transversal themes explained by the BNCC are topics that permeate different areas of knowledge and are integrated into the school curriculum to foster a more comprehensive and critical education. The contemporary transversal themes are divided into six areas:

- Health: Food Education, Nutrition Education and Health;
- Economics: Work, Financial Education and Tax Education;
- Environment: Environmental and Consumer Education;
- Multiculturalism: Cultural Diversity and Education for the valorization of multiculturalism in Brazilian historical and cultural matrices;
- Citizenship and civic-mindedness: Children's and Adolescents' Rights, Family and Social Life, Traffic Education, Human Rights Education and the Ageing Process, respect and appreciation of the elderly; and
- Science and technology.

The Common National Curriculum Base defines ten general competences that should be worked on throughout basic education, with the aim of helping to train citizens with skills such as critical thinking, autonomy, leadership and decision-making. From the implementation of the ten general competences (such as the second which is scientific, critical and creative thinking, the sixth which is work and life project, the ninth which is empathy and cooperation and the tenth which is responsibility and citizenship) the CTS approach can be highlighted. By working on the general competences, it is possible to work on the implications of science and technology for society and the environment, the development of critical thinking, decision-making and the formation of attitudes and values.

CTS APPROACH TO STUDYING SCIENCE

With the aim of enhancing critical skills in citizen education, the CTS approach should be addressed within the study of science. Currently, many science curricula work on content using thematic units that bring together the development of content based on a central socio-scientific theme.

The approach based on thematic units makes it possible to present the social role of science, with its Science-Technology-Society interrelationships, highlighting the role of society in controlling science and technology. The contents of the natural sciences in both primary and secondary schools should not be approached in a neutral or simplistic way, as if scientific knowledge brought technological advances or was largely responsible for today's environmental problems. Instead, it should be emphasized that decisions about science and technology are related to the actions of man, who as a citizen should focus on active and committed participation in society. With this approach, it is possible to undo the negative associations that have been made between science, technology and society.

The fragmentation of content within a curriculum unit can result in the content losing its meaning, as students are unable to correlate it. The traditional teaching method is based on

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the fragmentation of knowledge. During the learning process we always relate new knowledge to previous knowledge. Connecting new knowledge with previous knowledge facilitates the process of familiarization with the content and also the development of the student's knowledge. However, there is no concern to articulate content presented within the same curricular unit, so students are unable to perceive the links between the content, which discourages the student. The National Curricular Parameters emphasize articulation between different areas and between curricular units in each area, but show no concern for linking content presented within the same curricular unit. The lack of articulation of content not only hinders learning and generates a lack of interest among students in scientific curricular units, but also discourages critical activity and intellectual curiosity. Linking content within the same curricular unit allows students to see important connections more clearly and to verify the importance of certain content that may seem very loose and abstract. By interlinking content, students are able to rework their mental models and have a more critical and reflective analysis of the content.

Environmental problems related to science should be discussed, exploring technological alternatives that science has provided and which can help to reduce its environmental impact. The CTS approach in Science should explore the positive and negative aspects in order to emphasize that the development of Science and Technology depends on the actions of human beings, which is why the role of each citizen in the decision-making process on the fate of scientific and technological development should be highlighted. The CTS approach makes a significant contribution to educating citizens and developing attitudes of responsible engagement with socio-environmental issues, helping to shape future societies that are fairer and more equal.

CTS APPROACH AND METHODOLOGIES

In relation to the application of methodologies that are related to the CTS approach, what tools could provide differentiated teaching for students in order to promote the development of a critical view of the impacts of Science and Technology on socio-cultural reality?

Paulo Freire proposed, through progressive pedagogy, an education that went beyond the "banking conception of education". In other words, education should go beyond the concept of transposing content to students, and focus on the process of building students' knowledge, so that they use their previous knowledge to reformulate new knowledge, thus assuming a leading role and autonomy in the educational process. Freire's method of thematic investigation proposes the selection of content based on the identification of themes that deal with everyday situations. This type of thematic approach is similar to CTS approaches.

Currently, the classroom context is made up of a great diversity of students with different abilities, backgrounds and needs, which requires a look from the perspective of individualization (which takes into account the individual understanding of each student in order to teach them in a way that makes sense to them) and pluralization (which takes into account that the construction of knowledge must involve various forms in order to serve as many students as possible). Active Methodologies are a solution for innovative education. Active methodologies transform classes into more lively and meaningful learning experiences for students. Active methodologies encourage problem-solving, decision-making exercises, individual or group debates; these resources are essential in CTS or CTSA educational processes.

Among the methods associated with Active Methodologies, we can highlight the inverted classroom, project-based learning, contextualization of learning, STEAM curriculum development, among others.

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STEAM APPROACH

Nowadays, there is no way of not linking Science and Technology. One of the strands that arises from the relationship between Science and Technology is the area of Engineering, which encompasses the understanding of Arts and Mathematics concepts. The term STEAM is an acronym for Science, Technology, Engineering, Arts and Mathematics. Engineering, Arts and Mathematics. See below what each acronym aims to achieve.

S *(*Science): Uses scientific concepts to understand different natural, social and technological phenomena present in everyday life.

T (Technology): Involves tools for obtaining, organizing, analyzing or sharing information, as well as resources for designing solutions (robotics and programming, for example).

E (Engineering): Helps build logical thinking, planning skills, problem solving and product development.

A (Art)*:* Enables the development of an artistic and cultural sense. It also helps develop socio-emotional skills such as empathy, collaboration and communication. It also covers humanities demands by helping to develop critical and reflective skills.

M (Mathematics): Allows the development of logical reasoning, problem-solving skills, improvement of mathematical resources (such as measuring, calculating and analyzing data) related to research.

A BRIEF HISTORY

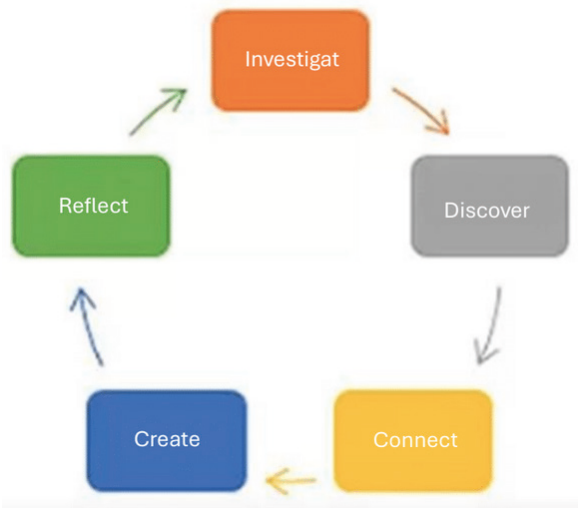
The STEAM approach integrates knowledge of the arts, sciences, technology, engineering and mathematics, making it possible to prepare students for the challenges of everyday life and the job market. The STEM approach first emerged, emphasizing Science, Technology, Engineering and Mathematics to prepare students for a world of constant scientific and technological advances. As the 21st century progressed, it became clear that problem-solving could not be reduced to the STEM disciplines alone, so the arts and humanities were incorporated into the approach, promoting interdisciplinary collaboration and providing students with a more holistic understanding of problems and their solutions. The STEAM approach represents a broader and more balanced approach than the STEM approach, due to the addition of arts and humanities.

The STEAM approach prepares children for world's problems through innovation, creative and critical thinking, cooperation and communication, based on new information. In fact, art is fundamental to the development of creativity. Similarly, innovation is essential for producing new products and solutions to problems. This is why incorporating art into the STEM approach is so important, as it allows creativity and innovation to be integrated. Art is subjective and intuitive, while the other STEM disciplines are objective, logical and analytical.

CHARACTERISTICS OF THE STEAM APPROACH

The STEAM approach addresses the development of knowledge from the integration of academic disciplines, forming a globalized, project-based curriculum, helping to train citizens with the knowledge, skills and competences needed to face future challenges. The STEAM approach encompasses solving real problems in the students' social context in an interdisciplinary way, exploring what is known as problem-based learning in the field of education, the concept of hands-on (maker), experimentation, Design Thinking and the use of digital information technologies. Due to the integration of different areas of knowledge, the STEAM approach allows content to be defragmented, awakening creativity, empathy and autonomy.

STEAM encourages the active participation students in the process of building knowledge by promoting a process focused on investigation and interaction with the aim of developing scientific, technological, mathematical and artistic literacy. The STEAM approach generally covers five stages: investigate, discover, connect, create and reflect.



The development of a STEAM project should help students explore the following points:

STEAM APPROACH AND INTERDISCIPLINARITY

Interdisciplinarity is the intersection of content from two or more disciplines. This intersection allows the content to be defragmented, enabling the student to develop a broader, more reflective and critical view of the issues being addressed. Interdisciplinarity can also be interpreted as the possibility of mutual exchange and reciprocal integration between various sciences. The STEAM approach explores the construction of knowledge from different areas through problem-solving, which establishes holistic learning.

Interdisciplinarity allows us to get closer to interpreting the real world, because reality is integrated and complex. Teaching must therefore consider and integrate the knowledge of each area of knowledge, seeking connections, interactions and implications between the different fields of knowledge

The interdisciplinary nature of the STEAM approach broadens and consolidates knowledge by stimulating the construction of connections between knowledge, giving more meaning and significance to the information that is processed and stored through the student's central nervous system. It also provides meaningful learning, as the contents of different areas interact with each other, giving a logical, critical and reflective sense to the students' reality.

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