DIALOGUES AND REFLECTIONS BASED ON FEENBERG'S CRITICAL THEORY OF TECHNOLOGY: APPROACHES TO TECHNOLOGICAL TEACHING AND ENVIRONMENTAL EDUCATION

DIÁLOGOS E REFLEXÕES FUNDAMENTADAS NA TEORIA CRÍTICA DA TECNOLOGIA DE FEENBERG: ABORDAGENS PARA O ENSINO TECNOLÓGICO E EDUCAÇÃO AMBIENTAL

DIÁLOGOS Y REFLEXIONES A LA LUZ DE LA TEORÍA CRÍTICA DE LA TECNOLOGÍA DE FEENBERG: APROXIMACIONES A LA ENSEÑANZA TECNOLÓGICA Y A LA EDUCACIÓN AMBIENTAL

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ABSTRACT: In the contemporary scenario, in which technological advances and environmental issues intertwine, there is an urgency to explore the relationship between technological teaching and environmental education. The reflections on Andrew Feenberg's Critical Theory of Technology stand out as tools for understanding the implications of this encounter. By examining the interactions between technology, society, and nature, this approach offers a critical view of how the teaching of technologies can promote ethical awareness and make citizens capable of facing environmental challenges. This study uses interpretative bibliographic research to explore reflections on this convergence, highlighting the importance of critical perspectives in technological education for a more sustainable approach. The conclusions highlight the complex interconnection between technology and the environment, emphasizing that technological decisions have profound repercussions on the ecosystem, and it is essential to understand this relationship to deal with environmental problems.

KEYWORDS: Sustainability. Science. Technology. Technological Education. Environmental education.

***RESUMO**: No cenário contemporâneo, em que avanços tecnológicos e questões ambientais se entrelaçam, há uma urgência em explorar a relação entre ensino tecnológico e educação ambiental. As reflexões da Teoria Crítica da Tecnologia de Andrew Feenberg se destacam como ferramentas para compreender as implicações desse encontro. Ao examinar as interações entre tecnologia, sociedade e natureza, essa abordagem oferece uma visão crítica para analisar como o ensino das tecnologias pode promover uma conscientização ética e formar cidadãos capazes de enfrentar os desafios ambientais. Este estudo utiliza pesquisa bibliográfica interpretativa para explorar as reflexões dessa convergência, destacando a importância de perspectivas críticas no ensino tecnológico para uma abordagem mais sustentável. As conclusões ressaltam a interconexão complexa entre tecnologia e meio ambiente, enfatizando que as decisões tecnológicas têm repercussões profundas no ecossistema, sendo decisivo compreender essa relação para lidar com as problemáticas ambientais.*

***PALAVRAS-CHAVE**: Sustentabilidade. Ciência. Tecnologia. Ensino Tecnológico. Educação Ambiental.*

***RESUMEN**: En el escenario contemporáneo, en el que los avances tecnológicos y las cuestiones ambientales se entrelazan, existe la urgencia de explorar la relación entre la enseñanza tecnológica y la educación ambiental. Las reflexiones sobre la Teoría Crítica de la Tecnología de Andrew Feenberg se destacan como herramientas para comprender las implicaciones de este encuentro. Al examinar las interacciones entre tecnología, sociedad y naturaleza, este enfoque ofrece una visión crítica para analizar cómo la enseñanza de tecnologías puede promover una conciencia ética y formar ciudadanos capaces de enfrentar los desafíos ambientales. Este estudio utiliza una investigación bibliográfica interpretativa para explorar reflexiones sobre esta convergencia, destacando la importancia de perspectivas críticas en la educación tecnológica para un enfoque más sostenible. Las conclusiones destacan la compleja interconexión entre la tecnología y el medio ambiente, enfatizando que las decisiones tecnológicas tienen profundas repercusiones en el ecosistema, y es esencial comprender esta relación para hacer frente a los problemas ambientales.*

***PALABRAS CLAVE**: Sostenibilidad. Ciencia. Tecnología. Educación Tecnológica. Educación ambiental.*

Introduction

The relationship between human beings and the environment has always resulted in significant impacts. The intertwining of science, technique, and technology with the exploitation of natural resources and human intervention in the environment has reached proportions that require deep analysis. Many of these actions have exceeded the limits of sustainable resource use, creating dangers and threats to life on our planet. Two main perspectives emerge: one that sees technology as a necessary evil and another that recognizes environmental education as a vital space for critical and reflective debates that promote an ethical understanding of the environment.

An essential question that arises is whether technology can play a beneficial role in environmental preservation. In this sense, technological education emerges as a hope, preparing teachers and students to create and apply new knowledge productively, adjusting and integrating them into the new social context that surrounds us. This is a path to ecological awareness.

Ultimately, it is imperative to recognize the intricate complexity of the relationships between humans, society, and nature. The pursuit of a balance between technological progress and environmental conservation must be informed by a holistic understanding of the interconnections at play.

In this regard, Andrew Feenberg, a scholar of Philosophy of Technology, emerges as an author who has offered perspectives for this discussion. During the 1960s, Feenberg was one of Herbert Marcuse's followers in the United States, and Marcuse, in turn, studied under Martin Heidegger at the University of Freiburg, Germany. For Feenberg, these two thinkers play a fundamental role as the oldest roots of his own thought, with Marcuse holding a prominent position in this context. However, Feenberg acknowledges that his theory is rooted in the tradition of the social critique of the Frankfurt School, including its subsequent developments led by Habermas (FEENBERG, 2005a).

A. Feenberg's proposal materializes in his conception of technology and the Critical Theory of Technology he formulated. Through this theory, technology is approached as an ambivalence that oscillates between its functional and social dimensions.

In this context, the purpose of this article is to explore Feenberg's Critical Theory of Technology as an approach to examine the connection between technological education and environmental education. Feenberg (2004) posits that technology is not constituted as an

absolute determinant of social progress, but rather as a malleable social construct subject to transformations through human intervention. In this sense, incorporating environmental education within the scope of technological education becomes of paramount relevance, as technology plays a fundamental role in shaping our interaction with the environment. Through a critical analysis of existing technologies, it is possible to discern how they impact the natural environment and seek alternatives based on sustainability.

Methodological Procedures

This study adopts the method of interpretative bibliographic research, which involves a reflexive analysis of relevant bibliographic sources to understand the complexities and nuances of the topic under discussion. Stumpf (2011) perceives that bibliographic research culminates in producing a systematized text, addressing the literature examined by the researcher and giving voice to both the ideas of the researched authors and the perspectives of the investigator.

Bibliographic research goes beyond the generation of new knowledge, promoting immersion in a specific field and becoming one of the main vehicles for the researcher's intellectual updating and development, as affirmed by Lakatos and Marconi (2003). This research aims to gather and analyze a wide range of sources, including books, academic articles, and documents related to Feenberg's Critical Theory of Technology, technological education, environmental education, innovation, and sustainability. The interpretative analysis goes beyond collecting information and exploring connections, trends, and underlying implications in the selected works.

Boccato (2006) highlights that bibliographic research aims at surveying and critiquing published documents on the investigated topic, aiming to update and enhance knowledge, thus contributing effectively to research development. By using this method, the research seeks not only to understand the essential concepts of the Critical Theory of Technology, as described by Feenberg (2004) but also to interpret its repercussions on technological education and environmental education. Interpretative bibliographic research enables a broader and more enriching view of the subject, contributing to the construction of a solid and grounded understanding of the proposed approaches.

Intersections between science, technology, and society: exploring complex relationships

The interconnection between society and technology is as intrinsic as it is indispensable, constituting an inseparable link that shapes and is mutually shaped. This complex connection, though necessary, also reveals a striking contingency. However, it is noteworthy that within this interaction, technology often emerges in a position of protagonism, assuming a deterministic perspective. This is clearly explained as a social theory that argues not only for technology's physical and biological importance but also for its role in human relations and social practices (MACKENZIE; WAJCMAN, 1999).

The realization that society and technology are interdependent is fundamental to understanding contemporary dynamics. Technology is not just a neutral tool that society uses; it is, in fact, an inseparable component that influences the ways we interact, communicate, work, and live. Technology shapes our culture, values, and behaviors and is, in turn, influenced by society's needs and desires.

However, this relationship is not unidirectional. Technology can also be perceived as a factor that influences and even determines social organization and patterns of life. The deterministic view of technology suggests that its development and adoption can drive changes in various aspects of society, from the economy to power structures.

Mackenzie and Wajcman (1999) emphasize the theoretical dimension of this complex relationship. Their approach argues that technology is not just a set of physical tools but also plays a significant role in shaping social interactions and daily practices. This perspective broadens the understanding of technology as more than physical objects, recognizing its impact on human interactions, cultural norms, and social dynamics.

According to Baumgarten (2006), technology can be broadly described as a socially coordinated activity, grounded in plans and primarily practical in nature. Therefore, technology encompasses sets of knowledge and information employed in creating products and services derived from various sources, such as scientific discoveries and innovations, acquired through various methods and aligned with specific goals and practical purposes. Similar to any human creation, it is essential to approach technology considering its roots in social relations and its historical progress (BAUMGARTEN, 2006).

Regarding the comprehensive definition of technology, this conception considers it as an endeavor deeply intertwined with society, driven by deliberate plans and practical objectives. The notion that technology consists of knowledge and information applied in producing goods

and services reflects its applied nature and relevance to everyday life. The emphasis on social and historical contextualization highlights that technology is not isolated but shaped by evolving social, economic, and cultural factors over time. This broad perspective offers a more comprehensive understanding of how technology is a force that transcends the technical aspect and is intertwined with human experience in various dimensions.

The assertion that there is no society without technology and vice versa is a constant reminder of the intricate relationship between these two elements. By highlighting its influence on social practices, the deterministic view of technology underscores the importance of understanding not only technological development itself but also how it shapes and is shaped by society. This emphasizes the importance of an interdisciplinary approach integrating social and technological dimensions for a more comprehensive understanding of our constantly evolving world.

The Science, Technology, and Society (STS) approach encompasses the analysis of the complex interactions between science, technology, and society, shaping a domain intended for academic research and public policy formulations. This field has its roots in new investigative currents in philosophy and sociology, focusing on understanding the interconnection between science, technology, and society (BAZZO *et al*., 2000).

Regarding science, Kuhn (2013) proposed that understanding what constitutes science requires a reassessment of the dynamic aspects of the discipline, originating a revolutionary change in the approach to the problem from a real historical analysis of science. The author also argued that scientific advancement occurs in leaps, not following a linear progression, as science experiences phases of stability, termed "normal science," as well as periods of "scientific revolutions," in which alternative paradigms emerge.

The perspective of science, technology, and society recognizes that science and technology do not exist in an isolated vacuum but are intrinsically shaped and influenced by social, economic, and cultural dynamics. This approach examines how scientific and technological decisions affect people's lives and communities, as well as how the values and needs of society influence the direction of scientific research and technological development.

According to Pinto (2005), understanding the social nature of technology leads to a perception of technology as a human achievement deeply imbued with social dimensions. Feenberg (2005b) also supports this view, emphasizing that this social aspect of technology is not inherent to its internal logic of operation, but rather to the way this logic interacts with a social context.

The idea expressed in this statement is that technology is not an isolated phenomenon, operating independently of the environment in which it is embedded. Instead, it is influenced by and influences the social context in which it is developed and used. Technological decisions are not purely technical; they reflect values, interests, and powers present in society.

Echeverría (2003) offers a comprehensive definition of technology, characterizing a technological achievement or application as a set of regulated actions, of an industrial nature, and linked to science. Specific agents carry out these actions and use instruments to achieve their goals. This action is intentionally directed towards the transformation of other systems, with the purpose of achieving valuable results, while seeking to avoid any negative consequences or unwanted risks (ECHEVERRÍA, 2003, p. 58). Echeverría's definition underlines technology's intricate and purposeful nature, while highlighting its multifaceted impact on different spheres of society.

Arocena (2004) expands on this perspective, emphasizing that technology has played a significant role in multiplying and qualitatively transforming the power to produce and destroy, heal and harm, enrich human culture, and generate risks to life. This power, along with its potential dangers, is not evenly distributed socially and regionally, presenting a striking disparity.

This inequality in the distribution of power linked to technology is deepened by Arocena (2004), who highlights that this power has been concentrated in the hands of a restricted group of individuals. This aspect is crucial for understanding how science and technology, despite their transformative and beneficial potential, can also be a source of inequalities and imbalances in the social sphere.

It is essential to consider not only the benefits but also the consequences and unequal distributions of power that technology can bring. This reminds us that the reflection on science and technology should encompass progress and the social and ethical impacts emanating from their use and development.

By understanding the interconnection between science, technology, and society, the STS perspective promotes a broader and contextualized view of innovation and technological advancement. This enables critical analysis of the ethical, social, economic, and environmental ramifications of choices related to science and technology. Furthermore, it underscores the importance of involving the public and various social actors in the decision-making process involving technological and scientific issues.

Bazzo (1998) highlights the undeniable contribution that science and technology have made in recent years. However, it is essential not to place excessive trust in them to the point of becoming insensitive due to the daily convenience provided by their devices and technical equipment. This attitude can be dangerous because, in this numbness induced by a fascination with technological modernity, we risk neglecting that science and technology incorporate social, ethical, and political aspects.

In this context, the STS approach plays an essential role in recognizing that science and technology are activities embedded in society, and that understanding their interactions with the social context is crucial for a comprehensive and responsible assessment of the impact of technological innovation on our lives.

Feenberg's Critical Theory of Technology: Fundamentals and Principles

The selection of technologies is often justified by their technical efficiency, based on the logic of instrumental rationality, and considered an indicator of success. However, according to Feenberg's perspective (2005b), technical efficiency is not the determining factor in this decision-making process. He argues that social issues deeply influence technological choices. In this context, different sets of values guide the choices, generating a variety of viable options that compete with each other.

Feenberg's approach (2004) highlights the complex and multifaceted nature of the technological selection process, questioning the primacy of technical efficiency as the sole criterion. His ideas resonate with the notion that technology is not only a product of science and engineering but is also shaped by cultural values, political interests, and social dynamics.

Considering distinct values in the process of selecting technologies emphasizes the importance of taking into account not only their technical functionality but also the social, ethical, and environmental impacts they may entail. Feenberg's argument invites us to question how technologies are chosen, who influences these choices, and the broader implications of such decisions.

Feenberg's Critical Theory of Technology (2004) is an approach that seeks to understand the relationship between technology, society, and culture, analyzing how technological decisions shape and are shaped by human values, social structures, and cultural contexts. Some of the key ideas present in this theory include:

- Technology as a social construction: Feenberg argues that technology is not a neutral object or an external force, but rather a product of human action and social choices. It is shaped by decisions that reflect interests and values and, therefore, can be transformed through human intervention (FEENBERG, 2004).
- Technological neutrality is a myth: The Critical Theory of Technology rejects the notion that technology is neutral or impartial. Feenberg argues that technologies incorporate decisions about how they function, who they are designed for, and how they are used. These decisions are not value-free and have social implications (FEENBERG, 2004). The Critical Theory of Technology is marked by its lack of neutrality, as it incorporates the values intrinsic to its creation and is subject to human control, being subservient to human interests (DAGNINO, 2007).
- Politics of technology: Feenberg proposes that technologies be seen as political arenas where different groups and interests vie for influence. The way technologies are designed, implemented, and used reflects power relations and political decision-making (FEENBERG, 2004).
- Public participation: The Critical Theory of Technology emphasizes the significance of public participation in technological determinations. Feenberg contends that those impacted by technology should be included in the choices that shape its development and application, aiming to broaden accountability and justice (FEENBERG, 2004). However, the configuration of technology may inadvertently perpetuate a system that privileges a small group at the expense of the majority (FEENBERG, 2006).
- Social and ethical dimensions: Technological analysis should consider not only the technical aspects but also the social and ethical dimensions. This involves assessing technologies' cultural, economic, political, and environmental impacts (FEENBERG, 2004).
- Building alternatives: The Critical Theory of Technology advocates the idea that it is possible to construct alternative technologies that serve different values and objectives. This implies reimagining and reformulating technologies to meet human and social needs more appropriately (FEENBERG, 2004).
- Technological awareness: The theory encourages awareness of the hidden influences of technologies and how they shape our lives. This involves education that empowers

people to understand the complexities and implications of the technologies they use (FEENBERG, 2004).

Overall, Feenberg's Critical Theory of Technology offers a critical and socially engaged perspective on the relationship between humans and technology, seeking to promote understanding, accountability, and empowerment to shape technological development more in line with human values and social needs.

The social and technical relationship is characterized by reciprocal interdependence, a bond that conventional technical focus has failed to recognize (LATOUR, 2002). The author points to the idea that innovation does not occur in isolation but within a broader context involving social, cultural, and technological factors. The innovating agent cannot simply introduce a new technology without considering how it fits into and is influenced by the environment in which it will be implemented.

It is suggested that the relationship between the social and the technical is more complex than traditional thinking tends to assume. This underscores the need for a more comprehensive approach to understanding how technology and society mutually interact and highlights the importance of considering the social and cultural implications when undertaking technological innovations.

It is essential to emphasize that humanity is currently endowed with unprecedented knowledge, technology, creativity, and resources. However, to ensure fair utilization of these elements by all, it is necessary to introduce new concepts and values that encourage collective collaboration. This process demands a reevaluation of our technological development paradigm, along with the ethical commitment to reaffirm values such as equality, equity, and solidarity in the economic context (SACHS, 2008).

The Critical Theory of Technology, developed by Feenberg (2004), argues that in any situation where social interactions are mediated by modern technology, it is possible to implement more democratic controls and reconfigure technology to incorporate a greater diversity of specialized knowledge and initiatives (FEENBERG, 2004, p. 2-3).

Feenberg's theory proposition incorporates a critical approach to understanding the connection between technology, society, and the environment. Feenberg (2004) argues that technology is not inherently neutral; rather, it is shaped by human values, making it susceptible to reconfiguration and adaptation. He underscores the relevance of contemplating the ethical

and social dimensions of technology, emphasizing how technological choices generate both direct and indirect impacts on environmental sustainability.

In practice, an essential reflection encompasses awareness of the environmental effects of employed technologies. An illustrative example is the production and disposal of electronic devices, capable of generating substantial amounts of waste and contributing to environmental pollution. In this context, the importance of promoting responsible consumption practices and encouraging the recycling and reuse of these equipment is highlighted.

Feenberg (2004), in presenting his critique of technology, emphasizes that his analysis is not fundamentally ontological, although it is influenced by Herbert Marcuse's ontological critique, with whom he had the opportunity to study. His focus extends the investigations carried out by the Frankfurt School, seeking to restructure the conception of socialism through a deeply radical philosophical perspective on technology (CUPANI, 2004).

These ideas lead us to understand the complexity of the approach adopted by the author. His analysis is not limited solely to technology but also incorporates the influence of prominent thinkers, such as Marx, and neo-Marxists like Marcuse, Habermas, Hawls, and Adorno, among others. This demonstrates the wide range of influences that have shaped his critique of technology and illustrates how his perspective is rooted in a comprehensive context of critical thinking.

It is relevant to emphasize how the author approaches his critique of technology, highlighting its connection to the analyses conducted by the Frankfurt School. His perspective is rooted in a deep technology philosophy and influenced by various currents of critical thought. This aspect amplifies the complexity and depth of his argumentation, endowing it with a solid and comprehensive foundation that transcends the boundaries of superficial analysis.

Perspectives of Critical Theory of Technology in Educational Context

The adoption of the Critical Theory of Technology within the realms of technological education and environmental education is a highly effective strategy for promoting a more conscious and ethical approach to innovation. This entails questioning technology's presumed neutrality, examining innovations' ecological impacts, and encouraging public participation in technological decisions.

By addressing the Critical Theory of Technology in technological education, students not only acquire technical skills but also become aware of the social, cultural, and ethical aspects that permeate the development and application of technologies. This enables them to actively participate in technology-related decision-making, understanding how their choices can influence society and the environment.

In environmental education, the Critical Theory of Technology fits intrinsically. By examining the links between technology, society, and the environment, students are encouraged to reflect on how technological innovations affect the sustainability and health of the planet. They learn to analyze the implications of their technological decisions in the broader context of environmental concerns and to seek solutions that promote harmony between technological advancement and environmental preservation.

In the view of educators, while not an absolute consensus, the advocacy for restructuring the curriculum and methodological approach stands out as a clear demand for an education focused on citizenship. This implies adopting a critical perspective on the interactions between Science, Technology, and Society (LEDERMAN, 1992).

Incorporating Environmental Education into discussions of Science, Technology, and Society broadens the critical approach, encompassing social and technological dimensions and environmental impacts. Understanding how human actions, often mediated by technology, influence ecosystems and sustainability is essential for the formation of responsible and conscious citizens.

The curricular and methodological reorganization under this perspective aims to empower students not only to understand the complex interconnections between science, technology, society, and the environment but also to critically evaluate the ethical, environmental, and cultural challenges arising from these interactions. Thus, education for citizenship extends beyond individual and social spheres, incorporating a broader concern for the sustainable future of the planet.

The initiative to introduce discussions about the interactions between science, technology, and society in the educational context has been disseminated through the National Curriculum Parameters (PCNs), fitting within the scope of Technological Education. This approach is not limited to the mere creation of objects but also seeks to promote an understanding of the origin and purpose of these objects, as well as the underlying concepts of contemporary society.

The theme of interactions between science, technology, and society is incorporated into the National Common Curricular Base (BNCC) as one of the thematic axes that cut across all levels of Basic Education in Brazil. The BNCC acknowledges the need to understand the intricate relationships among these three elements and emphasizes the importance of empowering students to critically analyze the social, ethical, economic, and environmental impacts of science and technology in their lives and in society as a whole.

The inclusion of this theme in the BNCC reflects a contemporary educational approach that goes beyond the mere transmission of technical knowledge and seeks to develop skills in analysis, interpretation, and critical reflection. The goal is to educate informed citizens capable of making informed decisions in the face of the challenges and dilemmas arising from ongoing scientific and technological innovations.

In this context, the BNCC proposes a cross-cutting approach to the interactions between science, technology, and society across various disciplines, such as Science, Physics, Chemistry, Biology, Philosophy, Sociology, and other areas of knowledge. This enables students to understand how scientific and technological advances affect the world around them, influence social and cultural development, and bring with them ethical and moral challenges.

In summary, the inclusion of the debate on interactions between science, technology, and society in the BNCC reinforces the relevance of education that transcends technical content, promoting the formation of critical and conscious citizens aware of the complexities of the contemporary world. They will be equipped to actively participate in discussions and decisions that shape the future of society.

To achieve this purpose, it is crucial to develop technological education according to the vision proposed by Palacios *et al*. (1996). In this perspective, students are guided to understand the social dimension of science and technology, exploring the social contexts that shape them to the social and environmental consequences that arise from them. In summary, it is necessary to address technological education by considering the social, political, and economic factors that shape scientific and technological transformations, as well as the ethical, environmental, and cultural implications resulting from these changes. This approach provides students with a more comprehensive and critical understanding of the intricate interactions between science, technology, and society.

Final considerations

In light of the assumptions outlined throughout this article, there emerges a clear perception that Feenberg's Critical Theory of Technology (2004) provides an invaluable conceptual framework for incorporating environmental education into the context of technological education. The adoption of this critical perspective translates into an opportunity to raise awareness about the environmental impacts of technologies.

Moreover, the Critical Theory of Technology also calls us to question the power dynamics inherent in the production and use of technologies. In this sense, it is imperative to reflect on who benefits from certain technologies and who is harmed, whether socially or environmentally. This reflection, in turn, drives the search for solutions that nurture equity and justice in the environmental realm.

The integration of environmental education within the scope of technological education offers a diverse range of approaches. The possibility of incorporating sustainability and environmental preservation content into the curricula of technological disciplines is a tangible avenue. Furthermore, the conception of practical projects addressing environmental issues, such as the development of green technologies or the analysis of the life cycle of technological products, also emerges as an effective strategy.

Equally relevant is to encourage a critical and reflective stance regarding technology. It is imperative to prompt students to question the environmental consequences of existing technologies, urging them to seek innovations capable of concretely contributing to sustainability.

Therefore, the dialogue between Critical Theory of Technology and environmental education within technological education not only enhances students' understanding of the complex relationships between technology, society, and the environment but also empowers them to become informed and responsible agents of change. This approach helps shape a generation of individuals capable of critically analyzing technologies, considering their impacts, and contributing to a more ethical, sustainable, and socially just technological development.

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