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ARTICLE

# The Science, Technology and Society perspective in the context of the technological and polytechnic education: first theoretical approaches

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ABSTRACT

The objective of this essay is to analyze possible relationships between the notion of technological education, as developed in the Brazilian context, and the Science, Technology and Society perspective, presenting preliminary approaches to a problem whose dimensions are practical, theoretical, and conceptual. From the definition of structural duality of education, the text has a need for the theme to be situated in the concrete social reality of school contexts. In the specific case, this reality is the Latin American social formations and their condition of economic, scientific and cultural dependence. As conclusion, it is presented the thesis according to which the concept of polytechnic education is a possible mediation between the educational field and Science, Technology and Society epistemology. This mediation is capable to underscore the ethical-political commitment of technological education, based on three elements: criticism of the neutrality of science; connection with the concept of work; and self-organization of the school community.

KEYWORDS

technological education; STS education; polytechnic education; science, technology and society (STS).

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## *A PERSPECTIVA CIÊNCIA, TECNOLOGIA E SOCIEDADE NO CONTEXTO DA EDUCAÇÃO TECNOLÓGICA E POLITÉCNICA: PRIMEIRAS APROXIMAÇÕES TEÓRICAS*

RESUMO

O objetivo do presente ensaio é analisar possíveis relações entre a noção de educação tecnológica, tal como desenvolvida no contexto brasileiro, e a perspectiva Ciência, Tecnologia e Sociedade, apresentando aproximações preliminares a um problema de dimensões prática, teórica e conceitual. A partir da definição de dualidade estrutural da educação, o texto levanta a necessidade de que o tema seja situado na realidade social concreta dos contextos escolares. No caso específico, trata-se das formações sociais latino-americanas e sua condição de dependência econômica, científica e cultural. Como conclusão, apresenta-se a tese segundo a qual o conceito de educação politécnica é uma mediação possível entre o campo educacional e a epistemologia Ciência, Tecnologia e Sociedade. Tal mediação é capaz de ressaltar o compromisso ético-político da educação tecnológica, baseando-se em três elementos: crítica à neutralidade da ciência; vínculo com o conceito de trabalho; e auto-organização da comunidade escolar.

PALAVRAS-CHAVE

educação tecnológica; educação CTS; educação politécnica; ciência, tecnologia e sociedade (CTS).

## *LA PERSPECTIVA CIENCIA, TECNOLOGÍA Y SOCIEDAD EN EL CONTEXTO DE LA EDUCACIÓN TECNOLÓGICA Y POLITÉCNICA: PRIMERAS APROXIMACIONES TEÓRICAS*

RESUMEN

El propósito de este ensayo es analizar posibles relaciones entre la noción de educación tecnológica, tal como se desarrolla en el contexto brasileño, y la perspectiva Ciencia, Tecnología y Sociedad, presentando acercamientos preliminares a un problema de dimensiones prácticas, teóricas y conceptuales. En base a la definición de la dualidad estructural de la educación, el texto plantea la necesidad de situar el tema en la realidad social concreta de los contextos escolares. En el caso específico, se trata de las formaciones sociales latinoamericanas y su condición de dependencia económica, científica y cultural. Como conclusión, presentamos la tesis de que el concepto de educación politécnica es una posible mediación entre el campo educativo y la epistemología Ciencia, Tecnología y Sociedad. Dicha mediación es capaz de resaltar el compromiso ético-político de la educación tecnológica, basado en tres elementos: crítica de la neutralidad de la ciencia; vinculación con el concepto de trabajo; y autoorganización de la comunidad escolar.

PALABRAS CLAVE

educación tecnológica; educación CTS; educación politécnica; ciencia, tecnología y sociedad (CTS).

## INTRODUCTION

The notion of technological education has been discussed in Brazil since at least the late 1980s, after the approval of the 1988 Federal Constitution and the beginning of the debates about the new Law of Directives and Bases (LDB) of Education. Whether in parliamentary and institutional instances, in academic production or in political parties and social movements, the theme has been present, even directing conceptions underlying educational policies, in general, and high school and technical education, in particular. Garcia and Lima Filho (2010) show that the term itself was mobilized to give meaning to the articulation between general education and professional training, according to the correlations of forces in society at each historical moment of the New Republic. It is possible to identify, thus, in the literature and in public policies, diverse interpretations for technological education. The meanings given to the term vary from approximations to the critical idea of polytechnics to deterministic readings that impute economic strategies to education (Garcia and Lima Filho, 2010).

At a more specific level of abstraction, the concept of science education is situated, which addresses the relationship between teaching and learning of the natural sciences. Research in the area has shown several possibilities of approaching pedagogical practices in science education, one of them being the perspective[1] that takes into account the organic relationship between Science, Technology, and Society (STS). As Von Linsingen (2007) discusses, contributions that are affiliated with this perspective and, at the same time, respond to regional problems, whether they stem from historical, economic, political, or cultural peculiarities, still intervene little in educational research in Latin America. There is no doubt that the development of studies and practices in science education already allows us to speak of a "STS educational perspective", which even goes beyond the teaching-learning of natural sciences. However, the gaps that still exist in the Latin American debate call attention and should be problematized.

The objective of the present work is delimited from this assumption. We intend to analyze possible relations between the notion of technological education, as developed in the Brazilian context, and the STS perspective, presenting preliminary approaches to a problem of practical, theoretical, and conceptual dimensions. This multidimensionality results from the terrain in which the discussion takes place, which, in Brazil, is conventionally called Professional and Technological Education (PTE) or Professional, Scientific and Technological Education (PSTE), mainly from the significant transformations undergone by the technical training policy in the years 2000.

1 We use the term "perspective" aware of the existence of various terminologies to deal with STS: approach, view, studies, focus, area, field, movement, etc. The issue is controversial and requires in-depth discussion, so we have opted only to situate the reader beforehand. In this work, the relations between Science, Technology, and Society constitute an epistemological position that allows us to scientifically analyze the educational process, which leads us to adopt the notion of perspective, even though it should be subject to a more rigorous debate if thought of in a way that is not restricted to education.

Such changes ended up expressing the nuances and contradictions of the notion of technological education and the STS perspective. New debates have permeated school practices and the official documents guiding the State Education Networks, the Federal PSTE Network, and even non-public organizations, such as the institutions of the S System and private technical education centers. In any case, the context of Brazilian professional education in the last decades presents specific characteristics in relation to other countries, for having made emerge the possibility of an integrated articulation between the dimensions of science and technique in school programs. Thus, it tensioned the trace of structural duality that underlies the country's educational system since its origins and that goes back to the very development of Brazilian dependent capitalism (Frigotto, 2018). Objectively, Federal Decree No. 5,154/2004 (Brasil, 2004) laid the foundation for the conception of integral human education of a polytechnic nature, providing meaning to the notion of technological education and mobilizing educational perspectives critical to the neutrality of science. It is in the context of this scenario that the theoretical reflection proposed here is developed.

We discuss, in the section following this introduction, the notion of technological education, showing that its very development in the Brazilian context was important for the new legal definitions of the 2000s. Next, we reflect about a possible reading for the STS educational perspective, in light of Brazilian and Latin American peculiarities. In the third section, we present a way forward for the STS perspective that considers the ethical-political commitment to analyze and transform reality, drawing on the theoretical potential of the concept of polytechnic education. Finally, we consider questions for further research on the topic.

## TECHNOLOGICAL EDUCATION, POLYTECHNICS AND BRAZILIAN SECONDARY AND TECHNICAL EDUCATION

The problem of the relationship between science and technology has always been, directly or indirectly, present in the definitions of educational policy in the Brazilian Republic. Since the 1980s, with the end of the military dictatorship, this issue has received new theoretical contributions, especially in the discussions about the historical problem of the lack of identity of the high school. Several works have dedicated themselves to understanding the fundamental condition of this lack of identity, in other words, the duality characteristic of the capitalist education system, in general, and the Brazilian one, in particular. Just to name a few, we recall the analyses by Frigotto (1984), Machado (1989), Nosella (1998), Kuenzer (2000), and Ramos (2005), all important components of a field of studies that has been consolidated around the theme.

The thesis common to these elaborations basically identifies two distinct school systems according to their function in the production and reproduction of the prevailing social relations. On one side, the school of a propedeutic nature, whose public is composed of the middle classes, the small bourgeoisie, and sectors

of the dominant classes, who prepare themselves in high school to continue their higher education studies and occupy productive positions of control, conception, and direction. On the other side, the technical school, intended for the children of the working classes, who usually learn a profession in a detached way from general scientific knowledge, preparing themselves for future productive execution. From a theoretical point of view, the duality gets the adjective "structural" precisely because it has its bases in the separation between the direct producer and the means of production and in the consequent specifically capitalist division of labor. Thus, it is not an attribute related only to school contents but refers to the field of social structures.

As has been known since Marx, this characteristic results from the contradiction between increasingly social production and the private appropriation of the products of labor, which, on the level of knowledge, manifests itself as a split between manual labor and the intellectual one. The classic passage sums up the matter: "Hence, the supervisory work previously mentioned is fully developed, dividing the workers into manual laborers and labor supervisors, into foot soldiers and sub-officers of the army of industry." (Marx, 2010, p. 484, our translation).

This brief discussion justifies the fact that the mentioned field of study has been given the title Work-Education[2] and is based on the theoretical bedrock of historical-dialectical materialism, despite its internal differences. Going back to the beginning of the section, it is important to mention that the very relation between labor and human formation started to guide a good part of the disputes around the definition of a new legal framework for Brazilian education, after the approval of the 1988 Federal Constitution (Garcia and Lima Filho, 2010). In this scenario, possibilities for tensioning the structural duality were opened, through the valorization of general content in high school, revealing progressive and conservative positions in the interpretation of the new Constitution. Thus, the debate on the relationship between scientific knowledge and technical knowledge in school education was put back on the agenda, giving rise to the notion of technological education.

As Garcia and Lima Filho (2010) show, the return of reflections about the role of labor in the educational process found echoes in the claims of organized sectors of workers, such as unions, class and research associations, and representative entities. In this broth of ideas that emerged and were reformulated in the wake of a process of re-democratization, classic notions and concepts were also retaken, such as, for example, the idea of polytechnics. In summary, polytechnic education was presented as one of the ways of linking science and technique in school curricula, a way that brought the Marxist critique of capitalism and the need for the appropriation, by all citizens, of the multiple productive and labor techniques. The mentioned authors mention, in this case, the decisive role played by Dermeval Saviani.

2 An updated state of the art of the Work-Education field can be found in Bomfim (2016).

In his 1987 speech at the Joaquim Venâncio Polytechnic School of Health, entitled *On the conception of polytechnics* (Saviani, 1989), the intellectual recalled the elaborations of one of the exponents of the 1917 Russian Revolution in the field of education, Pistrak, to highlight the pillars of what would be the articulation between manual labor and intellectual labor required for a polytechnic school critical of capitalism. The elaboration was even incorporated into one of the preponderant proposals for the Law of Directives and Bases (LDB) of Education, in 1991. It was a draft law organized by Congressman Otávio Elísio, gathering suggestions from various social sectors (Garcia and Lima Filho, 2010).

However, the context of neoliberalization, State reform, and the influence of multilateral organizations in Brazilian education presented, in parallel, an important set of ideological notions, such as "knowledge society", "professional skills", and "employability". The incorporation of such notions by the new legal framework was one of the counterparts to the application of neoliberalism in Brazil, which led the then Ministry of Education (MEC) to create, already in 1990, a specific body to manage technical and professional education, the National Secretariat of Technological Education (SENETE, in the Brazilian acronym). The political force of these new propositions demanded from the sectors that defended polytechnics a strategy of action in the pre-LDB debate, as reported by Garcia and Lima Filho (2010, p. 38, our emphasis, our translation): "The same strategy was adopted so that the concept of polytechnic education was preserved in the LDB proposals that were under discussion, substituting this term, considered also unpalatable by the congressmen, by the term *technological education*.".

A hybrid situation was created: in content, the meaning given was that of polytechnic education. In form, that is, in the letter of the law, technological education exhibited the possible contours that high school curricula and vocational training could take. In its finally approved format, the LDB No. 9,394/1996 (Brasil, 1996) synthesized social contradictions and ended up leaving, to schools, states, municipalities and, mainly, to new legal frameworks, the continuity of the disputes. The expression included in the final text was articulation between professional education (technical/manual knowledge) and regular education (scientific/intellectual knowledge), whose interpretation could have the most varied meanings.

Like other dimensions of education policy in the post-LDB period, this hybridism oscillated, manifesting disputed interests. Thus, it produced official documents whose content tended sometimes toward a split between professional education and high school, sometimes toward confronting the structural duality. The second situation was marked by a series of debates, studies, and seminars organized by MEC at the beginning of the first Lula administration (2003–2005), with intense participation from the Labor-Education field and the so-called organized civil society. The synthesis was the promulgation of Decree No. 5,154/2004 (Brasil, 2004), which considered some possible meanings for the generic LDB terminology. Among the three possibilities listed

was the organization of a single curriculum integrating professional education and high school.[3]

The content of the decree was incorporated into the LDB four years later, including changing the title of one of the chapters from "On Professional Education" to "On Professional and Technological Education". The change was not simply textual but expressed the transformations in the political content of technical education, allowing the meaning given to technological education to come closer to the concept of polytechnics. In terms of educational supply, the inclusion of the possibility of a unitary curriculum provided the basis for a sequence of policies to stimulate Integrated High School Education (IHSE), which, in turn, induced a deepening in the elaboration and theoretical reflection of the curriculum guidelines themselves. An obvious example is one of the guiding documents formulated in 2007, which justified the novelty by resorting to the historical characteristics of the Brazilian social formation:

> This perspective, by adopting science, technology, culture, and work as the structuring axes, contemplates the bases on which a technological or polytechnic education can be developed and, at the same time, the *stricto sensu* professional training required by the harsh socioeconomic reality of the country. (Brasil, 2007, p. 24, our translation)

From this starting point, the document continues the guidelines by defining epistemological bases for curricular integration, whose synthesis becomes the notion of integral human formation:

> The idea [sic] of integrated formation suggests overcoming the human being historically divided by the social division of labor between the action of executing and the action of thinking, directing, or planning. It is a matter of overcoming the reduction of preparation for work to its operational, simplified aspect, stripped of the knowledge that is at its scientific-technological genesis and in its historical-social appropriation. As human formation, what is sought is to guarantee the adolescent, the youth, and the adult worker the right to a complete formation to read the world and act as a citizen belonging to a country, integrated with dignity in its political society. Formation that, in this

3 The three possibilities were defined by the Decree in its Art. 4th: "§1º The articulation between high school technical professional education and high school will be done in the following ways I - integrated, offered only to those who have already completed elementary school, the course being planned so as to lead the student to the technical professional qualification of high school level, *in the same educational institution, counting on single enrollment for each student*; II - concomitant, offered only to those who have already completed elementary school or are attending high school, in which the complementarity between technical high school professional education and high school presupposes the existence of distinct enrollments for each course [. ...] III - sub-secondary, offered only to those who have already completed high school. (Brasil, 2004, our emphasis)

> sense, presupposes the understanding of the social relations underlying all phenomena. (Ciavatta *apud* Brasil, 2007, p. 41, our translation)

These perspectives were the basis for, for example, a program to encourage the offer of IHSE in all State Education Networks, between 2007 and 2012, called Brasil Profissionalizado (Professionalized Brazil), with investments of around R$ 2.4 billion. In addition, the Federal PSTE Network started to have the IHSE as its main offer modality, with a policy that foresaw its own teaching staff dedicated exclusively to the institutions, laboratory, and classroom infrastructure, and verticalization of the PTE according to the local productive, territorial, and cultural arrangements. This process was responsible for the generation of 1,176,486 new enrollments in technical education, which represented the expansion of the modality in almost three times between 2003 and 2014, assuming as axis of expansion the unitary and integrated curriculum (Pelissari, 2019).

It is necessary to emphasize, as a possible synthesis, that the connecting thread of the approximation between the notion of technological education and the concept of polytechnics has two dimensions: one historical-political and the other theoretical-epistemological. The first is to confront the structural duality of Brazilian education and its historical specificities as a capitalist country with a colonial past, which has not yet universalized the democratic right to basic education. The second is a dialogue with critical perspectives on conceptions of the neutrality of science and technology. In this scope, the integrated curriculum becomes, although technical-professional, knowledge-oriented and, exactly for this reason, polytechnic. As Ramos (2005, p. 124, our translation) discusses: "This is not to be confused with giving preeminence to practical activities over the construction of concepts. But concepts do not exist independently of objective reality.". According to the author, the basis of a curriculum guided by integral human formation is the tension between the contradictions of reality and the movement of thought, which leads to the overcoming of common sense by scientific knowledge throughout schooling. Let's see, next, how the question is posed in the face of the STS educational perspective.

## THE SCIENCE, TECHNOLOGY AND SOCIETY EDUCATIONAL PERSPECTIVE AND LATIN AMERICA

Initially publicized as "social studies of science and technology" or "studies in science, technology, and society" (SSTS), the SSTS perspective has its historical roots in the early 1960s. Motivated by different works, but with a common line in terms of theoretical and practical problematization, it is possible to identify two well-defined origins, one North American and the other European. The point of contact between the two was the examination of essentialist and/or linear conceptions of science and technology, subjecting the positivist framework of neutrality to critical analysis, based on events in international geopolitics. This axis consolidates, already by the end of that decade, an important network of researchers worldwide, with backgrounds in diverse scientific fields (Bazzo, Von Linsigen and Pereira, 2003)

But what is the theoretical status of the STS perspective? Is it an epistemological position that can be applied to any area of knowledge? Or is it restricted to research on philosophy of science, history of science and related areas? Von Linsingen (2007) provides clues to address these questions by discussing the influence of theoretical elaborations prior to the STS perspective, which acted as intellectual precursors. This is the case, for example, of Charles P. Snow, in his 1959 book *The two cultures and a second reading*, in which the debate about the progressive estrangement between two incommunicable cultures is inaugurated: the scientific-technological culture and the humanistic culture. "His credit was precisely to have made apparent the existence of two cultures that supposedly oppose each other." (Von Linsigen, 2007, p. 6, our translation) but which, from the point of view of their role in interpreting reality, complement each other, especially in raising problems about the relations of science and technology with social determinants. In fact, the phenomenon of the two cultures only reveals fundamental characteristics of modern science's own conception of neutrality, eventually producing the "[…] polemical split of intellectual and practical life in the West into two diametrically opposed groups, separated by an abyss of mutual incomprehension […]" (*idem*, p. 9, our translation).

The central thesis defended by the author is that the incorporation of the STS perspective into education studies can contribute to filling this gap. The critical eye allows one to bring out, for example, technical and technological implications of the development of the Social Sciences or philosophical and sociological aspects of discoveries in the Natural Sciences and Engineering. In this sense, it is possible to speak of a STS educational perspective, highlighting a place for scientific knowledge in schoolwork and in the process of human formation. The reflection brings us back to the issues listed above, allowing us to state that STS is an epistemological position that can encompass study objects from the most different areas, including constituting interdisciplinary and interscientific investigative processes. Finally, it should be noted that the relationship between education and STS can be useful for the philosophical understanding of this perspective itself.

From these statements arise two assumptions that we think are fundamental, both raised by Von Linsingen (2007, p. 9, our translation). First, he shows that the very democratic tradition that originated STS studies calls for a "[…] reorientation and continuous analysis of the pedagogical policies of technological education institutions, along with broader social participation in science and technology public policies.". On the other hand, he asserts that, in Latin America, the field of education still receives few contributions from the STS perspective, especially contributions that take into account the region's problems. What seems to us is that the two statements are imbricated and a deeper understanding of both helps to analyze our object.

One characteristic that constituted the Latin American economy and politics from the mid-twentieth century until the end of the 1980s was the hegemony of the developmentalist ideology. Both in the intellectual debate and in the sphere of institutional politics, diverse views on industrial development have presented themselves, from the importation of models from the center of capitalism to the claim of

socialism by the Marxist Dependency Theory. The fact is that the developmentalist pact established between fractions of the region's bourgeoisies implied the prevalence of science and technology policies based on an almost organic relationship between the university and the business market. For Dagnino (2010), this link embodied a line of action that has become virtually unquestioned in Latin American societies since the late 1960s.

It is in this context that the author places the emergence of Latin American Thinking on Science, Technology and Society (LATSTS). At a time when research efforts were all aimed at finding solutions for industrialization, Argentinean intellectuals from the "hard sciences" started to politically influence the group of researchers that claimed the autonomy of the scientific and technological process in that country.

> His central argument in this debate was that the just support demanded by the research community presupposed a "National Project" that radicalized the popular-democratic component of national developmentism and contained, therefore, an original scientific-technological challenge. (Dagnino, 2010, p. 24, our translation)

It happens that the claim has always come up against the low democratic intensity of Latin American capitalism, a preponderant factor in the composition of what Florestan Fernandes (2014) classified as autocratic capitalist states. The development model adopted by the region's military dictatorships, for example, deepened social inequalities and was based on a type of economic growth that did not generate a greater demand for knowledge. On the contrary, the LATSTS project foresaw an autonomous technological matrix directly linked to the expansion of the mass domestic market, producing, as an immediate consequence, the demand for higher education and new knowledge. To this end, a program to solve the fundamental social problems and backwardness of Latin American nations should direct the resources of science and technology public policies.

Once the developmentalist pact was broken, the autocratic conditioning remained, since it constituted the very state apparatuses resulting from incomplete bourgeois revolutions (Fernandes, 2014). The subsequent neoliberalization process and its commercial opening only accentuated the role of international capital in the generation of new technological knowledge, making it difficult to solve both the basic demands of the population and the historical problem of competitive insertion in the world market, "Which caused the already fragile relationship of the installed capacity of research and training of human resources in S&T [science and technology] with the economic-productive activity to diminish." (Dagnino, 2010, p. 28-29, our translation).

Auler and Bazzo (2001) discuss these issues when they analyze the Brazilian case and reflect on the place of the STS perspective in education studies. They write in the year 2001 — therefore about 15 years after the beginning of the implementation of neoliberalism in Brazil — and list three essential elements: the absence of a project for the nation, which is preponderant in the design of the correlations

of forces that have existed throughout Brazilian history; the absence of a dynamic articulation between science, technology, and society; and the dominance of an authoritarian State with no history of social participation in more general decisions. They conclude, therefore, that this context determines Brazilian educational practices, making it difficult to break away from a technocratic school model and the students' contact with science and technology.

A complement to Auler and Bazzo's (2001) finding emerges from our discussion. The technocratic model has its roots precisely in the duality of Brazilian education, deepened by a liberal democracy permanently suspended and artificially introduced in school relations. With neoliberalism, the fundamental actors called upon to solve educational problems have changed, but the structural root has remained. The entry into the scene of multilateral organizations introduced, for example, the demands of evaluation and quality control, the subordination of school knowledge to the needs of the flexible technological market (Gentili, 1996) and, more recently, the proposals of privatization via school vouchers. Not surprisingly, Von Linsigen (2007) identifies the strong revival of the ideology of the two cultures, a movement that ends up ratifying technocracy in the school environment.

The STS perspective, in the sense that we defend here, is affirmed with the ethical-political commitment to analyze this split and its repercussions in the field of education. It gains, moreover, specificity when discussed in the light of Brazilian and Latin American capitalism. Duality and polytechnic education, on the other hand, have a universal dimension as a concept, at a broader level of abstraction. However, it is important that we analyze them in the more concrete determinations and delimitations of each social formation. Next, we will discuss possible connections between these elements, highlighting, as a synthesis, the concept of polytechnics.

## THE ETHICAL-POLITICAL COMMITMENT OF THE SCIENCE, TECHNOLOGY AND SOCIETY PERSPECTIVE: THE CONCEPT OF POLYTECHNICS

In conclusion, the aim of this section is to defend the idea that the concept of polytechnics is one of the possibilities of translation of the STS perspective into the educational field. More than that, the conception that emerges from polytechnic education highlights the ethical-political commitment of this perspective, qualifying the expression "technological education" present in the Brazilian legal frameworks. We, thus, present a conception that can guide the construction of curricula, methodological choices, and the understanding of the role of school knowledge.

Based on the previous sections, three pillars support our assertion. First, the starting point for the insertion of the STS perspective in the field of education should be a critique of the conceptions of the neutrality of science. As we have seen, such conceptions have produced an artificial division between humanism and scientism, criticized by Von Linsigen (2007, p. 9, our translation), for whom "The main purpose of STS is to try to close the gap between two cultures, since this gap is fertile ground for the development of dangerous technophobic (or technophilic) attitudes.".

But it is also in the conceptions of neutrality that resides the worldview unable to see science from its political, economic, and social purposes. For Saviani (1989), the look of polytechnic education is directed to these dimensions, which made possible the generalization of knowledge systematized by modern science. The following excerpt is worth highlighting:

> In capitalist society, science is incorporated into productive labor, becoming material power. Knowledge becomes a productive force and, therefore, a means of production. But the contradiction of capitalism also runs through the question concerning knowledge: if this society is based on the private ownership of the means of production, and if science, if knowledge is a means of production, a productive force, it should be the private property of the ruling class. However, workers cannot be absolutely expropriated from knowledge, because without knowledge they cannot also produce and, consequently, if they do not work, they do not add value to capital. In this way, capitalist society has developed mechanisms through which it seeks to expropriate the knowledge of workers and systematize, elaborate this knowledge, and return it in parceled form. (Saviani, 1989, p. 13, our translation)

Fragmentation is thus constitutive of this model and has repercussions in the school domain, also fragmenting the process of human formation. The dynamism of the relations between science, technology, and society in the STS perspective, incorporated into the curriculum and teaching methodologies, enhances the critical understanding of this fragmentation. The material forces, industrialization, and the multiple techniques that make up modern productive work are, in this way, included in the polytechnic school from, for example, a historical, geographical, sociological, or philosophical contextualization.

The second pillar that allows us to see polytechnics as a possible manifestation of the STS perspective in the educational field is directly linked to the first. We discussed earlier the split between manual and intellectual labor, conceptualizing the structural duality of the school system. The issue is not new in the educational debate, as well as the formulations about polytechnic education. Already at the beginning of the last century, the socialist experiments built in the context of the Russian Revolution made use of the idea of a polytechnic school of labor, aimed precisely at breaking this split.

More than a pedagogical maxim, labor gains a dominant role among Russian revolutionary principles. This is due to the fact that it develops in the worker's education the dialectic between human power that transforms nature (abstract labor) and the specific skill employed in the creation of use values (concrete labor). In other words, the polytechnic school articulates, in the same educational path, the social relations of production and the technical aspects of the productive forces, leading the pedagogical process to an ever more rigorous understanding of the contradiction between these two elements.

One of the main syntheses of these ideas is in Pistrak's (2018) book *Foundations of the labor school*, organized in 1924. In discussing the pedagogical meaning

of the proposal, the author compares the Russian school experience with those of the West, showing that both clash precisely in the essence of their goals. For them, what is at stake is the mere learning of a profession, the subsequent deepening of the logic of exploitation, and the ideological inculcation of the operating principles of the bourgeois liberal state. For the former, the materialist and dialectical view on work allows resolving the contradiction between the individual and society; in Pistrak (2018), work in school is an activity that provokes a social need and, therefore, is directed to scientific knowledge about reality.[4]

In this sense, it is possible to affirm that the critique of technology was already present in the Russian educator's reflections, for whom the instrument-machines and the motor-machines of big industry would be syntheses of the most varied scientific processes. The author advocates the active role of youth in the processes that involve practice in learning: "In order for them to understand the essence of the division of labor, they must take part in it. To understand the work of a machine, one must feel the essence of the problems of mechanized production." (Pistrak, 2018, p. 83, our translation).

In that case, Pitstrak was dealing with the so-called school workshops. In today's pedagogical practices, we can analyze laboratory activities and their non-restriction to adaptation to market models — even though this is a dimension of the reality of wage labor and from which the school cannot simply detach itself. On the contrary, these activities can be syntheses between different views of the same object: the phenomenon of thermal expansion explains the laws of Thermology, allows the learning of chemical properties of metallic alloys, and provides an opportunity for discussion about the role of Brazil in the exportation of iron ore. In this example, with work as the articulating element, it is possible to theorize about the activity of transforming nature and to understand the practice of knowledge production as the result of intervention in reality. The scientific method, itself, can thus be understood from various investigative applications and technology gains social meaning beyond reification.

Also in Pistrak (2018) is the third argument of our thesis. In this case, the emphasis is on the political dimension of the problem. For the author, the polytechnic school of work should be focused on the self-organization of the school community, being a possible answer to the question of democratic participation.

Let us remember the elaborations presented by LATSTS and its genuinely Latin American intellectual contribution. A fundamental point is that popular control of public policies energizes the National Project capable of breaking with the authoritarian logic that has structured the region's social formations and its

4 Pistrak (2018, p. 42-43, emphasis added) works with the concept of actuality to address the issue: "The fundamental task of the school is to *study actuality, to master it, to penetrate it*. [...] But one must not only *study* current events. This, the reader will say, almost every school does. The school must educate in the ideals of the present time, the present time must be a wide river that *flows* into the school, but it flows in an *organized* way. The school must penetrate the actuality and become familiar with it, actively transforming it.".

scientific and technological matrixes. The perspective that highlights the imbrications between science, technology, and society and between these and school content inserts the democratic ambition of LATSTS in educational policies. The issue, however, was already present many years earlier in Pistrak's (2018) reflections on the polytechnic school.

The author shows that the ideological function of the Western school is based on a type of self-organization and a form of democracy limited to the logic of state power that organizes the dominant classes. Such are, in his reading, the democratic obligations of the citizen disseminated by the hegemonic school of modernity: "First of all, he must respect the law; secondly, from time to time, on certain dates, he must go to a polling station and give his vote to this or that candidate in one or another municipal or state body, and that is all." (Pistrak, 2018, p. 223-224, our translation).

The polytechnic school, on the contrary, involves the participation of the masses in the construction of the State, in the policies it assumes, and in the directions of national development. Therefore, the very definition of the curricula must rely on the students' self-organization, which is not restricted to the physical environment of the school but is linked to the territoriality in which it is immersed. Articulated with a distrustful perception of the neutrality of science and socially useful work, self-organized experiences consolidate the student's ability to situate himself critically in the world, reaching gradually higher levels of political and intellectual autonomy. This involvement in participating in the directions of the school can occur, according to Pistrak (2018) proposes, in the most diverse forms: self-organized groups, children's collectives, justice system exercised and simulated among students, models of work organization in practical-pedagogical activities, etc. In any assumed methodology, self-organization is based on the active involvement of the masses in building an effectively democratic state.

Finally, it is worth pointing out that the conclusive indications of this essay should not be transposed without mediation from the Russian reality of the 1920s to Brazil or Latin America today. Our school, its structural duality, and the very conformation of social classes in the region have specificities different from revolutionary Russia. However, the features of dependency and inequality and the way they impose limits on the fulfillment of the universal right to schooling are quite similar in both realities. This allows us to articulate contemporary ideas, formulated as demarcations against the conservative principles of positivism, to proposals that emerged in a political and cultural broth as rich as humanity has rarely been able to witness. The Russian Revolution, by the way, developed, theoretically, what had already appeared in a practical state in the work of Marx and Engels, opening the way for a whole process of conceptual elaboration of critical pedagogies, to which, as we have seen, important Brazilian authors are tributaries.

## CONCLUDING REMARKS

Our reflections are preliminary answers to the problem presented by Von Linsigen (2007), Auler and Bazzo (2001) and, indirectly, several other studies in

the STS area: how to enrich educational research with the critique of reductionist conceptions of science and technology? This is not a problem that will be solved with activist practicalism or dogmatic theorizing. The history of humanity after the industrial revolution was able to produce intensely human and philosophically potent practices from the organization of educational experiences that questioned the paradigm of neutrality. Therefore, we present contributions that are still unfinished and that need deeper looks, both to critical pedagogies and to the triad science, technology, and society.

In this complexity, the importance of seeing educational problems in the light of the concrete realities of each social formation is emphasized. Not for nothing, we highlight the characteristics of Latin America that have produced the traits of economic, cultural, and technological dependence and autocratic bourgeois states (Fernandes, 2014) that limit democratic participation. Producing, systematizing, and transmitting scientific knowledge in this region of the globe are tasks that impose specific demands. More than that, they put on the agenda the urgency of the conquests achievements already made more than two hundred years ago in countries at the center of capitalism and, to this day, still unachieved in Latin America.

It is interesting to observe, for example, the recent setbacks suffered by the policies for high school and professional education in Brazil. Research (Ferretti and Silva, 2017; Silva, 2018; Araújo, 2019) has shown that Law No. 13,415/2017 imposed a training model that deepens the structural duality and resumes the "professionalizing" visions of the period of the military dictatorship. Araújo (2019) has evidenced that the fragmentation of the curriculum into socially different portions becomes the rule, creating what he called the "curriculum itinerary of the poor". In addition to a restricted curriculum base common to all students, pathways may be chosen by young people from arrangements defined "at the discretion of the education systems" (Araújo, 2019, p. 67). The author's hypothesis is that the predominantly technical and manual knowledge will be pre-directed to young workers.

This is one more chapter in a story made up of ruptures, continuities, and contradictions. To return to the discussion that begins this article, therein lies the lack of identity of Brazilian and Latin American high schools. We hope to contribute to a view on the problem that allows establishing links between the school and the new perspectives of analysis of the relations between science, technology, and society. The search for political, cultural, and economic autonomy in our region is the key to thinking about the issue, deepening the study of experiences already built in countries with similar histories. In this sense, assuming the STS principles in a critical prism requires that we dialogue them with currents of thought that already implicitly pointed them out decades before their emergence.

Thus, the practical dimension of our proposal seeks in the conception of the polytechnic school the educational content of the STS perspective. The critique of the neutrality of science and the kind of political participation associated with this conception can contribute to curriculum design, didactic options and epistemological constructions within technological education.

The theoretical point of view of the proposal lies in the dialectic of labor — human force transforming nature and a specific skill that creates use values. From there, the understanding of the dynamics of the capitalist mode of production and the projection of productive models that subordinate capital to labor allow us to interpret the conception as a critical pedagogy of science and technology.

In these terms, based on historical-dialectical materialism, we argue that the concept of polytechnics can be a mediation for the articulation between the STS perspective and the field of education. The thesis takes contributions from Soviet pedagogical thought but should not be limited to it. The experiences in science, technology, and education built by the Russian Revolution at the beginning of the last century are starting points for reflections, opening new perspectives, and critical reviews. It is necessary to broaden this view, consolidating the ethical-political commitment revealed by the STS perspective.

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