

Interdisciplinarity and Scientific Literacy: an essay about two sides of the same coin¹

Nuria Pons Vilardell Camas²

Marcelo Lambach³

Fernando Roberto Amorim Souza⁴

RESUMO

O presente trabalho visa buscar nos fundamentos teóricos elementos para um diálogo entre a interdisciplinaridade e a alfabetização científica. Parte do pressuposto de que o ensino fragmentado em um currículo compartimentado em disciplinas se constitui como uma barreira para a construção do conhecimento, tendo em vista que, por via de regra, as disciplinas são fechadas em si, sem diálogo umas com as outras. O texto segue balizado por um questionamento: é possível a alfabetização científica sem a perspectiva interdisciplinar? Em face da natureza proposta para este trabalho, tenta-se um convite, sem convergência ao fim, a nos colocar em um estado dialético sobre nossa própria prática docente diante dos desafios na promoção da alfabetização científica. Conclui-se que, em virtude da compartimentação do currículo escolar, a alfabetização científica não logrará êxitos sem a perspectiva da interdisciplinaridade no ensino de ciências.

PALAVRAS-CHAVE: Interdisciplinaridade; Alfabetização científica; Ensino de ciências.

*Interdisciplinarity and Scientific Literacy: an essay about two sides
of the same coin*

¹ English version by Matheus Segalla Frare. Email: matheusfrare@gmail.com.

² Doutora em Educação. Universidade Federal do Paraná, Curitiba, Paraná, Brasil. Orcid.: <https://orcid.org/0000-0003-3992-7914>. E-mail: nuriapons@gmail.com.

³ Doutor em Educação Científica e Tecnológica. Universidade Tecnológica Federal do Paraná, Curitiba, Paraná, Brasil. Orcid.: <https://orcid.org/0000-0001-7168-5498>. E-mail: marcelolambach@utfpr.edu.br.

⁴ Doutorando em Formação Científica, Educacional e Tecnológica. Universidade Tecnológica Federal do Paraná, Curitiba, Paraná, Brasil. Orcid.: <https://orcid.org/0000-0003-2969-5371>. E-mail: fernandoamorim.ifpr@gmail.com.

ABSTRACT

The present work seeks to find elements in the theoretical foundations to spur a dialogue on interdisciplinarity and scientific alphabetization. It is based on the assumption that when teaching is fragmented in a curriculum compartmentalized into disciplines, it constitutes a barrier to the construction of knowledge—moreover when disciplines are, as a rule, closed in on themselves and bereft of mutual dialogue. The text is guided by the question: is scientific literacy possible without an interdisciplinary perspective? Due to the nature of this proposal, we attempt an invitation towards a dialectical state of our own teaching practice in face of the challenges posed by scientific literacy promotion. In virtue of the compartmentalization of school curricula, we conclude that science literacy will not succeed without the premise of interdisciplinarity in the teaching of science.

KEYWORDS: Interdisciplinarity; Scientific literacy; Science teaching.

Interdisciplinarietà e Alfabetizzazione Scientifica: un ensayo sobre las dos caras de la misma moneda

RESUMEN

El presente trabajo tiene por objeto buscar en los fundamentos teóricos elementos para un diálogo sobre la interdisciplinarietà y la alfabetización científica. Se basa en el supuesto de que la enseñanza fragmentada en un plan de estudios compartimentado en disciplinas constituye una barrera para la construcción del conocimiento, teniendo en cuenta que, por regla general, las disciplinas están cerradas en sí mismas, sin diálogo entre sí. El texto se guía por una pregunta: ¿es posible la alfabetización científica sin una perspectiva interdisciplinaria? Debido a la naturaleza de la propuesta de este trabajo, estamos tratando de invitar, sin convergencia al final, a situarnos en un estado dialéctico sobre nuestra propia práctica docente frente a los desafíos de la promoción del alfabetismo científico. Se concluye que debido a la compartimentación del currículo escolar, la alfabetización científica no tendrá éxito sin la perspectiva de la interdisciplinarietà en la educación científica.

PALABRAS CLAVE: Interdisciplinarietà; Alfabetización científica; Enseñanza de las Ciencias.

Introduction

The conceptual debate about interdisciplinarity and scientific literacy, although relatively recent, has figured extensively in academic environments. This work seeks to comprehend its divergences and convergences. Undoubtedly, it is not intended to bring the analytical results of research, but to contribute to an emerging reflection upon the teaching of the sciences. The objective is to instigate a question so that it may spawn reflection, dialogue, and possible means of establishing the differences and agreements between the two fields: scientific literacy and interdisciplinarity in the teaching of science.

For conventional researchers, the difference is merely one of stylistics, in accordance with Adorno (2003, p. 20): “[...] bad essays are just as conformist as bad dissertations”. It suffices to remember that the philosophers have left behind their thoughts in their essays such as: *Water and Dreams: An Essay on the Imagination of Matter*, by Bachelard (2018); Habermas’s *The Postnational Constellation: Political Essays* (2001), among others.

In an attempt to bring about reflections on the topic of this essay, we intend to deepen and radicalize an analysis. Here, “radicalize” is used in allusion to its etymology in the Latin *radix*, or root, to mean going after the roots of the matter, seeking epistemic elements that contribute to this debate without dogmatism. It is understood that both object and thought are in movement. The probability of getting it right only happens in something static. In the universe, everything walks, runs and leaps in space and time.

No scientific method will be capable of establishing the truth. It is not an intrinsic property, nor does it materialize by mere dogmatic assertion, even if strict procedures are followed (ADORNO, 2003). In

explaining how the essay appropriates other concepts, the author makes an analogy, comparing it to:

[...] the behavior of a man who is obliged, in a foreign country, to speak that country's language instead of patching it together from its elements. He will read without a dictionary. When he has seen the same word thirty times in different contexts, he will be better acquainted with it than if he had looked up its listed meanings, which are usually too narrow, considering they change depending on the context, and too vague in relation to the nuances that context provides in each individual case (ADORNO, 2003, p. 30).

Adorno (2003, p. 30) also reflects that this is a type of learning guided by trial and error, and that the same happens in education:

[...] so does it happen in the essay as form; the price for its affinity with open intellectual experience is that lack of security which the norm of established thought fears like death. The essay not only neglects indisputable certainty, it also renounces its ideal. The essay becomes true in its progress, which drives it beyond itself, and not in an obsession with finding its foundations as if they were buried treasure [...]. (ADORNO, 2003, p. 30).

No more important than the product of the reflection this essay intends to bring, is the audacity of rupturing with traditional reason. It would be paradoxical for something new to emerge attached to formalities and methods. Thus, the invitation is made, and the motivation may be for its agreement or for the disagreement with the elements here offered in relation to interdisciplinarity and scientific literacy. What matters will be the analysis of reality before the arguments.

Modern society has clamored for a solid foundation that would support its yearnings and perspectives for the future in an orderly and standardized fashion, but over the years it has failed to respond to society's clamor, and it all aged so quickly that an ambivalent crisis erupted. If there was, in fact, a foundation that supported this structure, time has eaten away at it. Now,

everything seems so fleeting and volatile that Bauman (2011) calls it liquid modernity, “we are as modern as ever, obsessively ‘modernizing’ everything we touch. A quandary, therefore: the same but different, discontinuity in continuity.” (BAUMAN, 2011, p. 83). This transient posture of things has significantly impacted social relations, culture, art, politics, economics, and everything in which humans are involved.

School, as part of this context, lives a paradigm. Thought out and organized to sort the system, as it was designed in the past, it has not fulfilled its role before the characteristics of this new social reality, considered post-modern. It has become, in consequence, neither attractive nor seductive (JOBIM E SOUZA; CAMPOS, 2002). The school, living its obsolescence, still resists the changes and constitutes a framework that thinks of the future but is guided by the past, as Contreras (2012) says making use of the concept of Schön (1883), a teaching of technical rationality and positivist conception that feeds on traditionalism and whose materialization can be seen outlined in the school curriculum—more temporal than social and compartmentalized into disciplines with well-defined boundaries.

In spite of this clear tension, the world will not stop spinning so that the school can catch up with the changes; it will continue to provide transformations at an unprecedented speed. Weil *et al.* (1993) say that, after Kuhn’s thesis, we are living a scientific revolution and paradigm shift. Although there is still little clarification of what this is all about, there is an urgent need for intellectual appropriation for the construction of a holistic comprehension, as a new consciousness for a new age. This intellectual appropriation is in the conceptual bulge that Fourez (2016) attributes to scientific literacy.

Scientific literacy, in the conceptual sense brought by Sasseron and Carvalho (2011), emerges as a way to enable subjects to read the world as a whole, not fragmented, but it begs the question: how to make it work in the context of a school still rooted in its traditional structure, with an immobilized

curriculum, compartmentalized into disciplines that don't communicate? How to talk about interdisciplinarity in such a context?

Finding the right answer for these two questions (and many others of similar nature), pointing out the solution for something being discussed for centuries, is no easy task. We do not intend to do so here for two reasons: firstly, considering the rationality of the phenomena that have proven non-static and not synonymous with concrete events, causing the curriculum more harm than good; secondly, as everything moves, the very answers as a product of thought also move and transform at every moment, so that no answer is ever finished. Thus, this essay is outlined from the question: Is it possible to make a citizen scientifically literate without an interdisciplinary perspective? Whether the answer is yes or no, this is what is intended as a discussion in this important issue for the contemporary social context, and in this aspect, it will also lead to a reflection upon the role of the school in these times of science denial.

The main objective presented here is to reflect on the main concepts of scientific literacy and interdisciplinarity, if they intertwine and, above all, if scientific literacy can be institutionalized, in the sense of promoting knowledge in the subject regardless of interdisciplinarity, since both are connected to science. Speaking of scientific education, we attribute importance to the clarification given by Chassot (CACHAPUZ *et al.*, 2004) in this regard. According to the author, it should “[...] prioritize the formation of scientifically literate citizens capable of participating actively and responsibly in societies that wish to be open and democratic”. In this sense, in talking about science literacy and interdisciplinarity, aren't we dealing with the same thing?

What is, however, the relevance of this discussion? The dissociation of what the school preaches and the students' daily experience is already, by itself, fundamental, “[...] the school practices and rapid spatial and temporal changes that are happening in the today's world” can bring the feeling of “what is usually called a school crisis” (VEIGA-NETO, 2007, p. 102). How to

talk about scientific literacy if the school lives in dissociation with reality?
How to talk about interdisciplinarity in the context of school crisis?

What is wrong cannot be ignored; to close our eyes to this debate is to ignore the objectives of interdisciplinarity and of scientific literacy itself. To turn one's back on all of this is to persist in science illiteracy, and what we intend is precisely to highlight the importance of such a debate, all the while making it clear that the core of this matter is to seek elements that help reflect on scientific literacy and interdisciplinarity, opening doors to new dialogues.

Heads or tails: the side of scientific literacy

Initially, it is good to remember that we are dealing here with the teaching of school science, responsible for leading students towards the process of scientific literacy, in an attempt to achieve the development of students capable of acting consciously and critically in society (SASSERON; CARVALHO, 2011). Fourez (2003) draws attention to the necessary distinction between scientific literacy and scientific prowess. For the author, regarding the development and insertion of critical citizens in society, scientific and technical literacy are responsible. There is, however, in science education which cannot be confused with scientific literacy, the formation of specialists. This, the author relates to scientific prowess, responsible for developing the ability to solve complex problems starting from a discipline, as he explains:

The science courses that seek to train scientists branch out into physics, chemistry, and biology. Those that seek to train citizens (and perhaps most young people) talk about the environment, pollution, technology, medicine, space exploration, the history of the universe and living things, etc. Those are two different orientations (FOUREZ, 2003, p. 113).

It is interesting, at this moment of terminological discussion, to observe Sasseron and Carvalho (2011), who sustain that there is a variation of terminologies in science didactics used equally to designate the concept of a conscious and critical formation in society, called by them citizen formation. They further argue that some authors, such as Santos and Mortimer (2001), use the term scientific literacy; others adopt the term scientific enculturation, as is the case of Carvalho and Tinoco (2006); others still, prefer the term scientific alphabetization, in the example of Auler and Delizoicov (2001) and Chassot (2000). However, the semantic concern lies in the same idea related to science teaching, that is, “reasons that guide the planning of this teaching for the development of practical benefits for people, society and the environment” (SASSERON; CARVALHO, 2011, p. 60). However, the authors claim difficulty in the conceptual interpretation and consistency of these terminologies from languages other than Portuguese. Thus, they favor the term scientific alphabetization (from the Portuguese *alfabetização*) defined by Freire (2011) as a process that goes beyond technique and wordplay. It is the awakening to a critical awareness of culture and reading of the world, the opening of new horizons. Along these lines, the authors assert:

It is more than just a psychological and mechanical mastery of the techniques of writing and reading. It is the mastery of these techniques in conscious terms. [...] It implies a self-training that can reference an interfering posture of man upon his context (SASSERON; CARVALHO, 2011, p. 61).

It is agreed that literacy transcends the ability to read and write and should lead the subject to organize thought logically and consciously (SASSERON; CARVALHO, 2011), in order to contribute with the construction of the society in which one is inserted. However, it complements what Cachapuz *et al.* (2004) presents, in the sense that scientific literacy happens from an early age, stemming from the natural

curiosity of students for the new, in the events of science and technology, exploring their everyday knowledge.

It can be inferred, therefore, that scientific literacy is able to humanize science and contextualize its teaching, sparking the interest of learners. Nonetheless, this requires teachers prepared both in science and didactics, which is crucial for the didactic transposition and for captivating students. It is important to mention the opinion of these authors about the curriculum, for which those tasked with its elaboration in basic education do not take into consideration:

[...] that the eventual enthusiasm of students by the study of science does not arise naturally or inevitable, as if by contagion, from scientific/technological successes. The academic and non-experimental character that marks, to a variable degree, the science curricula and its teaching (in primary and secondary education) is perhaps the main responsible for the lack of interest of young students in science studies. The science which finds legitimacy in curricula is disconnected from the world that it necessarily concerns (CACHAPUZ *et al.*, 2004, p. 364).

Complementing Cachapuz *et al.* (2004), Fourez (2003, p. 45) clarifies that “the goal of scientific and technological literacy is not a series of particular knowledge, but a global set that allows us to recognize ourselves in the universe”. For this reason, it is necessary to develop a critical sense towards the events of everyday life. For the author, there is a contradiction between teaching and the goals of scientific literacy, and the school continues to be strongly focused on the individual, without taking into account that he or she is part of a social context. The classroom would be the appropriate place to elicit associations between the individual and his own social context. In the classroom, although it has its own identity, is where a collective culture is built. The author states:

[...] the subject of scientific literacy is no longer the isolated individual, but the group. In the same way, a local collectivity can be “made literate” about the building of a polluting

industry, or in relation to a drug policy. This means that a culture (made up of knowledge, know-how and knowing how to be) has been established in this community, allowing a pertinent discussion of the situation. Under these conditions, a democratic debate is made possible (FOUREZ, 2003, p. 114).

Continuing with the exploration of the author's idea, scientific literacy, by itself, is given as unable to meet its own goals without detaching itself from the reductionist, Cartesian-Newtonian and mechanistic culture responsible for the compartmentalization of science. The insistence on this disciplinary fragmentation will contribute nothing to the global perception of the wider context, and students will continue to look out at the universe through their own window, with well-delineated knowledge.

Involved by a materialistic culture, which isolates the subject from the object, each one, in his individual circle, will understand the universe as if it worked in uncorrelated fractions, and individually does his part without knowledge of the whole, as exemplified by Weil *et al.* (1993), as if thought belonged only to philosophers; calculation to mathematicians; hammering to carpenters; bread to bakers; feeling to poets; delirium to mysticists; evidence to scientists; and teaching to teachers. This situation, according to the authors, is one of the most perverse consequences of epistemological fragmentation.

In this perspective of collective knowledge construction, it is important to bring forth the claim of Fourez (2003, p. 115):

There is, therefore, in relation to scientific and technical literacy, a polarization between two educational attitudes: one that promotes the formation of the individual and reinforces his power, and one that aims to strengthen the citizen culture of collectivities. Both go hand in hand, but one can wonder if a teaching is often thought out with the goal of creating a group culture that enables a collectivity to deliberate on social and political mechanisms of scientific and technical decisions (or other types of decisions involving science or technology).

Considering this assumption, it is not possible to think up scientific literacy from the standpoint of isolated disciplines. Everything is co-dependent. Moreover, the production of collective knowledge does not occur in the mere transmission from one individual to another, but from the interaction of a whole interdependent system, formed by an inseparable triad: matter-life-consciousness (WEIL *et al.*, 1993). For these authors, “the divorce between science and consciousness lies at the base of the institutional decadence of the West” (WEIL *et al.*, 1993, p. 139).

In this perspective, Fourez (2003) elaborates on the appreciation of the citizen culture of collectivities. Moraes (1997) recalls the knowledge networks, which imply an open system capable of creating, recreating, and transforming knowledge itself without hierarchization, and no science is more important than another, nor does any discipline overlap it. Its creation presupposes flexibility, cooperation, and interactivity, among other attributes. In this same sense, when Fazenda (2011) reflects on interdisciplinarity, she points out the need for reciprocity and mutuality and that all knowledge is hierarchized in the same importance. Thus, scientific literacy and interdisciplinarity are intimately linked in this concept of network, because they feed on the same elements that constitute the construction of knowledge beyond the borders that delimit the subjects of study. Scientific literacy is to science teaching what interdisciplinarity is to education, so they are intertwined.

Heads or tails: the side of interdisciplinarity

Since the industrial revolutions, the world has undergone increasingly accelerated transformations, not necessarily for the better. For Santomé (1998), starting with the implementation of Fordism and Taylorism, the exclusion of male and female workers from the decision-making processes has intensified, preventing the democratization of the production processes. A concept of valorization of the capital’s interests is established, considering a

discourse of disqualification of education. For the workers, a shallow technical education was enough, but for the minority who became responsible for thinking up the general production after the exclusion of the workers, a good schooling was needed. This reinforced the pyramidal and hierarchical social system in which, at the top, a minority controls the base of this pyramid formed by the vast majority of the working class, left without having a say in the decisions concentrated on the top,

[...] these strategies are also destined to deprive the working class of its ability to decide about the productive process of labor, about the product, and about the work environment and its condition. [...] It has been denied the responsibility to intervene in matters as important and human as what should be produced, why, what for, how, when, etc. (SANTOMÉ, 1998, p. 12).

Santomé (1998) reminds us that this historical process linked to the economy had a strong impact on the educational systems. Schools started to reproduce all the distortions of the productive system. The school contents were worked in an isolated and disconnected way, rendering reflection and criticism of reality a difficult task. Consequently, the school “betrayed its authentic reason for being: to prepare citizens to understand, judge and intervene in their community in a responsible, fair, solidary and democratic way” (SANTOMÉ, 1998, p. 14). Thus, the school, because of the persistence of this culture throughout the years, is unable to respond in the same time required by the contemporary social context, being plunged into a crisis about which we commented earlier in this text.

Another situation still reflecting this historical process was the reinforcement of technical procedures and scientific specialization, fruit of the fragmentation of the unity of scientific knowledge (WEIL *et al.*, 1993). This same situation justifies the difficulty in developing scientifically literate students, confirmed by their lack of interest in science teaching, especially in the mnemonic approach employed in these classes, “making it so that students don’t realize the contributions of the content to their

daily lives, in face of the need to solve problems in their community” (SANTOS *et al.*, 2013, p. 15395).

According to these authors, science classes in their current format do little to pique the interest of students towards the acquisition of scientific knowledge. Along the same lines, the authors relate another unpromising condition for science teaching: teacher training. Regarding the initial training, it is said to be insufficient, and continuing education is not encouraged among them, contributing to such failure. The consequences in the classroom are the superficial contents that do not lead students to an association with their daily lives (SANTOS *et al.*, 2013).

Performing scientific literacy without thinking of interdisciplinarity repeats the mistake of trying to define the spatial and insurmountable boundaries of teaching in disciplines such as physics, biology or chemistry, closed in on themselves, in which the teachers’ deontological postures lead them to believe that their subject is as a locked chest, without need for correlation with all the other subjects and with the historical, social, economic, and even spiritual context of the students.

Faced with this situation and the school's inability to reverse it, teachers, concerned about the failure of the educational system, almost always, by their own efforts, resort to countless educational resources in order to make their classes more dynamic. Among them, they seek in interdisciplinarity a way to respond to their anguish and correct this educational anomaly. However, teachers interpret it erroneously and without understanding its true nature. This occurs because of the complexity of understanding the polysemic concepts and many dimensions that touch upon the professional, scientific, and school level. On these grounds, such a misunderstanding and its application are natural (FAZENDA, 2011).

One of the great problems of interdisciplinarity at school is the fad for correcting the evils caused by the dissociation of knowledge. (FAZENDA, 2011). In its name, a pedagogical panacea is promoted, with

intuitive practices but without adequately observed fundamentals. Fazenda (2012, p. 13) states that it is impossible to build a single theory, but “[...] the search or the unveiling of the personal theoretical path of each researcher who ventured to address the issues of this theme is necessary”. Interdisciplinarity cannot be observed from the viewpoint of disciplinarity. Disciplinarity refers to the specificities of knowledge, while interdisciplinarity is concerned with the integration of these specificities. It is worth remembering that, from this interaction that is interdisciplinarity, new fields of knowledge emerged, such as biochemistry, neurophysiology, quantum physics, among others (D’AMBROSIO, 2016).

Regarding pedagogical, curricular, didactic, or school interdisciplinarity, Fazenda (2008) warns about the need for an extensive knowledge of the concepts of school, curriculum or didactics. Understanding the historical path of these aspects “requires profound research into the potentialities and talents of the knowledge required of or requested from those who are practicing or researching them” (FAZENDA, 2008, p. 21).

Although interdisciplinarity is born from the Piagetian perspective of cooperation between disciplines, in this sense Lenoir (2008) not only agrees, but also builds upon the discussion, stating that the reason for the existence of interdisciplinarity itself lies in the interactionist need between disciplines in a reciprocal action. Fazenda (2011) shares the same statement, but warns that this interaction goes beyond the shallow thinking within the scope of integration of content and methods, and should project itself basically at the level of integration of partial and specific knowledge for a more global vision of knowledge. He understands interaction as “a condition for the effectiveness of interdisciplinarity. It presupposes an integration of knowledge aimed at new questionings, new pursuits, in short, the transformation of reality itself” (FAZENDA, 2011, p. 12).

According to Lenoir (2008), interdisciplinarity can be characterized as to its purpose in: scientific, school, professional, or practical

interdisciplinarity, organized by the modalities of research, teaching and application. For the author, whatever the intentionality of operationalization, it can be investigated (research), taught (teaching) or practiced (application), but it is important not to confuse the scientific and school characters. Broadly speaking, one leads to the production of new disciplines from various processes and technical-scientific achievements; the other leads to the establishment of complementary links between school subjects, and, “in the school's domain, school interdisciplinarity can be the object of research, just as it can be taught and practiced” (LENOIR, 2008, p. 50).

Two sides of the same coin

We return to the definition of scientific literacy brought by Sasseron and Carvalho (2011) as the viable way to empower and develop the subject for a critical attitude in its social context and its emancipation as citizen, including to conceptualize citizen emancipation. They take the concept as Freirian, establishing in consciousness a self-training capable of modifying itself and its surroundings. Chassot (2003, p. 94) further extends this clarification:

Just as it is required that those who are literate in their mother tongue be critical citizens, as opposed, for example, to those whom Bertolt Brecht classifies as politically illiterate, it would be desirable that those who are scientifically literate not only have an easier reading of the world in which they live, but have an understanding of the needs to transform it—and, preferably, to transform it into something better. I have repeatedly defended the demand that, with science, we can improve life on the planet, and not make it more dangerous, as sometimes happens with bad uses of certain technologies.

As mentioned by Morin (2013), Fazenda (2011) and Lenoir (2008), it is necessary to overcome the compartmentalization and fragmentation of knowledge to be able to think “the body of knowledge that would facilitate men and women to make a reading of the world where they live” (CHASSOT,

2000, p. 19). However, the author's statement highlighted *ipsis litteris* refers to the concept he determines for scientific literacy, while the others, cited at the beginning of this paragraph, are relating to interdisciplinarity.

This combination was purposely made to call attention to the tenuous difference between meanings. Interdisciplinarity is the paving of a path (not to be confused with methodologies) that can foster scientific education without disciplinary delimitations, which can promote, in turn, scientific literacy. Thus, scientific literacy is in charge of leading the subject towards an understanding of what science is and its applicability regarding the improvement of his own life, as well as the negative impacts (for example, a bad technology employed, no less a fruit of science) on the environment, providing him with a perception of the world that will assist in his decision-making (CHASSOT, 2003).

Fourez (1995) conceptualizes interdisciplinarity with a clear example concerning the examination of health problems. The author argues that biology does not manage the existing health demands, requiring the broadening of the focus to psychology, sociology, ecology, etc. To study health problems in everyday life, multiple approaches are required, which have a bifurcation.

From this concept of interdisciplinarity established by Fourez (1995) and Lenoir (2008), its two attitudes are explained: one has the research perspective of a conceptual synthesis (academic), whose goal is the construction of a concept in the horizon of the unity of knowledge, to unite all scientific knowledge, guided by philosophical and epistemological concerns; the second, in turn, relates to the instrumental perspective, i.e., to solve everyday problems based on individual practices, making use of the functional knowledge capable of responding to social problems of contemporary society. The excerpt from Fourez's (1995, pp. 136 – 137) own explanation about the difference between the two perspectives is relevant:

[...] the first, by pretending to relate different disciplines in a supposedly neutral process, masks all the “political” issues inherent to interdisciplinarity: which disciplines will be given greater importance? Which specialists will be consulted the most? How will a concrete decision be made? And so on. On the other hand, from the second perspective, interdisciplinarity is seen as an essentially “political” practice, that is, with a negotiation between different points of view, to finally decide on the representation that is considered adequate. It is evident, then, that one can no longer use external and purely “rational” criteria to “merge” the various disciplines that will interact. It is necessary to accept the confrontations between different points of view and to make a decision that, ultimately, will not result from knowledge, but from a risk that is taken, an ultimately ethical and political choice.

As described, scientific literacy is only possible if science teaching contemplates the complexity of knowledge as a whole, letting go of the disciplinary narrowing in benefit of a practice that is, as Fourez (1995) said, multifaceted. Thus, expressing concern, the author published an article titled *Un modèle pour un travail interdisciplinaire*, in the journal ASTER, no. 17, in 1998, which was translated by Paulo Ricardo da Silva Rosa in 2016. It addresses the methodology contemplating interdisciplinarity for basic education, on the pretext that the approximation of disciplines alone is not able to bring out the complex reality. To this end, the construction of an interdisciplinary island of rationality is presented (FOUREZ *et al.*, 2016).

As can be understood, scientific literacy and interdisciplinarity are two sides of the same coin, each with its own conceptualization and objectives. However, when taking into account the fragmentation and compartmentalization of knowledge, scientific literacy without interdisciplinarity would achieve few or none of its objectives. On a humanistic side, there is the objective of leading students to a holistic understanding of the world in technical and scientific aspects, building an autonomous posture in their contemporary social context. On the social side, that of democratizing the techno-scientific debate through the

students' acquisition of sufficiently critical knowledge. Finally, there is the objective linked to economy and politics—the conscious participation in the production of wealth and of technological and economic potential (FOUREZ, 2003).

Conclusion

The head is full, the mind is empty. This popular jargon, not attributed to any one author, portrays our schools well. Stuck in the past behavior-wise and ignoring modernity, our curriculum is fragmented and content-centered. There are many subjects, each with its own objectives, but the relation between them is missing. They are mismatched, organized according to a linear pattern whose main objective is to meet the demands of the current curriculum, passing on the contents it determines. As a result, students assimilate information using only the scales of time as a parameter, in order to keep up with everything in a specific grade, year, quarter, or cycle. As Santomé (1998, p. 103) states, “this brings about the end of education meant as knowledge, as an understanding of the world and the ability to actively live in it.”

The fact is that the school curriculum responds to an economic order, organized to fulfill the discourse of business groups complainant of an educational system that does not prepare people to meet the needs of the market (SANTOMÉ, 1998). This axiom is used to keep school and curriculum paralyzed, focusing on preparing more productive men and women for the economic system, with no liberty for choice. Consequently, the isolated subjects and knowledge areas play an important role, each following a path oriented by their aptitudes as requested by the market, while learning happens unconsciously.

In order to overcome this problem of fragmentation in the hope of responding to society's yearnings and the students' own emotional needs, many teachers resort to didactic and pedagogical resources that help them

break with this discrepancy and seek in interdisciplinarity a path they find viable to minimize the effects of the compartmentalization of curriculum. However, this has tainted interdisciplinarity with a misunderstanding of its true meaning, being understood as a mere merging of content or methods—a reductionist view related to the integration of disciplines.

Fazenda (2011) clarifies that interdisciplinarity is, above all, a bold attitude towards habit change, but recognizes that there is not much in the way of research geared towards its implementation, because content is considered more important. Additionally, the author explains that while disciplinary integration is a step in interdisciplinarity, the latter is a factor of transformation and social change, something that is missing in integration alone, whose main concern “would still be in knowing and relating content, methods, theories, or other aspects of knowledge.” In this sense, “[...] to remain in it alone would be to keep things as they are, but in an orderly fashion” (FAZENDA, 2011, p. 83). Therefore, interdisciplinarity escapes this concept, and its integrative aspect goes far beyond the disciplines.

Interdisciplinarity is not directly concerned with content, but with the effectiveness of teaching and the reasons for education which, in turn, is connected to the record, production, acquisition and diffusion of knowledge. Regarding school contents and the acquisition of knowledge, in the scope of this essay, the concern lies in science literacy, because the criticism to the classroom resides in the partial content approaches, often irrelevant and disconnected from the setting students are inserted in, hindering the formation of critical citizens capable of transforming themselves and interfering in their social context.

According to Chassot (2000, p. 19), scientific literacy means “the set of knowledge that would make it easier for men and women to read the world they live in.” It is, for Fourez (1995, p. 11), “a type of knowledge, ability, or expertise and know-how that, in our techno-scientific world, would be a counterpart to what literacy was in the last century”. Sasseron

and Carvalho (2011) seek to define scientific literacy, adapting it to the context of Brazilian literature, by first elucidating the concept of literacy and associating it to the understanding of Paulo Freire that literacy is more than the simple acquisition of knowing how to read and write, it is the cognitive capacity for the logical reasoning of ideas, turning one into a critical subject.

The term has different definitions depending on the author, but all relate to interest, interaction, and understanding of science. As far as school education is concerned, the goal of science education is to lead students to be scientifically literate. As noted, the disciplinary fragmentation becomes an obstacle to both scientific literacy and interdisciplinarity, because it does not allow for a holistic construction of knowledge and both require a unity of knowledge to develop citizens capable of changing their own reality and that of their surroundings.

Interdisciplinarity is an attitude, above all, of breaking with the old ideology that constitutes pedagogy, in order to allow students to achieve a critical autonomy in face of the world and of science literacy. The understanding that guides logical reasoning, associated with the students' daily lives to permit the building of knowledge necessary for making them into active subjects within society. Could, then, scientific literacy fulfill its role in isolation from interdisciplinarity? In our understanding, in the case of science teaching, they complement one another, considering the compartmentalization of school curricula. This being the case, scientific literacy would hardly be successful without the perspective of interdisciplinarity.

References

ADORNO, T. W. O ensaio como forma. *In: ADORNO, T. W. Notas de literatura I*. Tradução Jorge M. B. de Almeida. São Paulo: Duas Cidades: Editora 34, 2003.

AULER, D.; DELIZOICOV, D. Alfabetização científico-tecnológica para quê? *Ensaio Pesquisa em Educação em Ciências*, Belo Horizonte, v. 3, n. 1, p. 105-115, 2001.

BACHELARD, G. *A água e os sonhos: ensaio sobre a imaginação da matéria*. São Paulo: WMF Martins Fontes, 2018.

BAUMAN, S. *Bauman sobre Bauman*. Rio de Janeiro: Zahar, 2011.

CACHAPUZ, A.; PRAIA, J.; JORGE, M. Da educação em ciências às orientações para o ensino de ciências: um repensar epistemológico. *Revista Ciência e Educação*, Bauru, v. 10, n. 3, p. 363-381, 2004. Disponível em: <https://doi.org/10.1590/S1516-73132004000300005>. Acessado em 05 jun. 2020

CARVALHO, A. M. P.; TINOCO, S. C. O ensino de ciências como “enculturação”. In: CATANI, D. B.; VICENTINI, P. P. (org.). *Formação e autoformação: saberes e práticas nas experiências dos professores*. São Paulo: Escrituras, 2006.

CHASSOT, A. *Alfabetização científica: questões e desafios para a educação*. Ijuí: Editora Unijuí, 2000.

CHASSOT, A. Alfabetização científica: uma possibilidade para a inclusão social. *Revista Brasileira de Educação em Ciências*, Rio de Janeiro, n. 22, p. 89-100, jan./abr. 2003. Disponível em: <https://doi.org/10.1590/S1413-24782003000100009>. Acessado em fev. 2020.

CONTRERAS, J. *A autonomia de professores*. 2. ed. São Paulo: Cortez, 2012.

D’AMBROSIO, U. A Metáfora das gaiolas epistemológicas e uma proposta educacional. *Revista Perspectivas da Educação Matemática*, v. 9, n. 20, p. 222-234, 2016. Disponível em: <https://periodicos.ufms.br/index.php/pedmat/article/view/2872/2234>. Acesso em 1.º dez. 2019.

FAZENDA, I. C. A. *O que é interdisciplinaridade?* São Paulo: Cortez, 2008.

FAZENDA, I. C. A. *Interação e interdisciplinaridade no ensino brasileiro: efetividade ou ideologia*. São Paulo: Loyola, 2011.

FAZENDA, I. C. A. *Interdisciplinaridade: história, teoria e pesquisa*. 18. ed. Campinas: Papirus, 2012.

FOUREZ, G. *A construção das ciências: introdução à filosofia e à ética das ciências*. Tradução Luiz Paulo Rouanet. São Paulo: Editora UNESP, 1995.

FOUREZ, G. Crise no ensino de ciências. *Investigações em Ensino de Ciências*, Porto Alegre, v. 8, n. 2, p. 109-123, ago. 2003. Disponível em: <https://www.if.ufrgs.br/cref/ojs/index.php/ienci/article/view/542/337>. Acesso em 1.º nov. 2019.

FOUREZ, G.; MATHY, P.; ENGLEBERT-LECOMTE, V. Um modelo para um trabalho interdisciplinar. Tradução Paulo Ricardo da Silva Rosa. *Revista Labore em Ensino de Ciências*, v. 1, n. 3, p. 42-67, 2016. Disponível em: <https://periodicos.ufms.br/index.php/labore/article/view/3993>. Acesso em 22 nov. 2019.

FREIRE, P. *Pedagogia do oprimido*. 50. ed. São Paulo: Paz e Terra, 2011.

HABERMAS, J. A. *Constelação pós-nacional: ensaios políticos*. Tradução Márcio Seligmann-Silva. São Paulo: Littera Mundi, 2001.

JOBIM E SOUZA, S.; CAMPOS, C. C. G. Infância, mídia e cultura de consumo. In: GONDRA, J. G. (org.). *História, infância e escolarização*. Rio de Janeiro: 7 Letras, 2002.

LENOIR, Y. Didática e interdisciplinaridade: uma complementaridade necessária e incontornável. In: FAZENDA, I. C. A. (org.). *Didática e interdisciplinaridade*. Campinas: Papirus, 2008. p. 45-75.

MORAES, M. C. *O paradigma educacional emergente*. 16. ed. Campinas: Papirus, 1997.

MORIN, E. *Ciência com consciência*. Rio de Janeiro: Bertrand Brasil, 2013.

SANTOMÉ, J. T. *Globalização e interdisciplinaridade: o currículo integrado*. Porto Alegre: Artes Médicas, 1998.

SANTOS, A. H.; SANTOS, H. M. N.; SANTOS JUNIOR, B.; SOUZA, I. S.; FARIA, T. L. As dificuldades encontradas para o ensino de ciências naturais em escolas municipais do sul de Sergipe e o processo de formação continuada. In: CONGRESSO NACIONAL DE EDUCAÇÃO, EDUCERE, 11, 2013, Curitiba, PR. *Anais...* Curitiba, PR: PUCPR, 2013, p. 15393-15405. Disponível em: https://educere.bruc.com.br/arquivo/pdf2013/9474_6573.pdf. Acesso em 14 dez. 2019.

SANTOS, W. L. P.; MORTIMER, E. F. Tomada de decisão para ação social responsável no ensino de ciências. *Ciência & Educação*, v. 7, n. 1, p. 95-111, 2001. Disponível em: <https://doi.org/10.1590/S1516-73132001000100007>. Acessado em 14 dez. 2019.

SASSERON, L. H.; CARVALHO, A. M. P. de. Alfabetização científica: uma revisão bibliográfica. *Revista Investigações em Ensino de Ciências*, v. 16, n. 1, p. 59-77, 2011. Disponível em: https://edisciplinas.usp.br/pluginfile.php/844768/mod_resource/content/1/SASSERON_CARVALHO_AC_uma_revis%C3%A3o_bibliogr%C3%A1fica.pdf. Acesso em: 18 nov. 2019.

VEIGA-NETO, A. Pensar a escola como uma instituição que pelo menos garanta a manutenção das conquistas fundamentais da modernidade. In: COSTA, M. V. (org.). *A escola tem futuro?* 2. ed. Rio de Janeiro: Lamparina, 2007. p. 97-118.

WEIL, P.; D'AMBROSIO, U.; CREMA, R. *Rumo à nova transdisciplinaridade: sistemas abertos de conhecimento*. 5. ed. São Paulo: Summus, 1993.

Received in April 2020.

Approved in December 2020.