

Conceptual development in secondary education: thoughts on electromagnetism**Pensamento teórico na educação básica: reflexões acerca do eletromagnetismo**

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ABSTRACT

It is well known that electromagnetism is not completely understood by students. This paper presents a brief review of different resources found in the research literature to promote students' conceptual development in electromagnetism. Then it discusses a fundamental concern for planning of teaching approaches to this topic. This theoretical research goes towards enhancing our understanding for planning concrete works in teaching electromagnetism. The hypothesis is that in order to promote students' theoretical understanding, teachers should let pupils to active engage in the learning process. We use Davydov (1998) as a theoretical basis for motivating this hypothesis.

Key words: Conceptual understanding, Science education, Electromagnetism**RESUMO**

Sabe-se que o eletromagnetismo não é completamente compreendido pelos estudantes. Este artigo apresenta uma breve revisão de diferentes recursos encontrados na literatura para promover o desenvolvimento conceitual dos alunos em eletromagnetismo. Em seguida, discute uma preocupação fundamental para o planejamento de abordagens de ensino para esse tópico. Esta pesquisa teórica visa aprimorar nossa compreensão para o planejamento de trabalhos no ensino de eletromagnetismo. A hipótese é que, para promover a compreensão teórica dos alunos, os professores devem permitir que os alunos participem ativamente no processo de aprendizagem. Utilizamos Davydov (1998) como uma base teórica para motivar essa hipótese.

Palavras-chave: Aprendizagem conceitual, Ensino de ciências, Eletromagnetismo.**1 INTRODUCTION**

The focus in this paper is learning and teaching electromagnetism in high school. It is common knowledge that electromagnetism is a complicated topic for students to comprehend. One main difficulty is developing an ability to apply the concepts to new situations (SAĞLAM e MILLAR, 2006). Aside from the algebra involved, the abstract ideas make electromagnetism

difficult for students (LYNA e LEONG, 2012). One reason for this difficulty is that learners are unable to visualize the forces, fields, current, and other electromagnetism features related to this topic (ANDERSON e BARNETT, 2013).

A literature review shows that various interventions have been proposed to overcome this adversity. In the literature there seems to be two main approaches by which teachers and researchers execute their teaching activity. Some of them have chosen to build and use experiments (BENDER, SBARDELOTTO e MAGNO, 2004; CHAIB e ASSIS, 2007; PATHARE, HULI, LAHANE, e SAWANT, 1993; SABA e ROSA, 2005; SARAIVA, 2006; WILLIAMS, 2014) while others have used a technological approach, using resources from internet, digital games, virtual simulations or smartphones (ANDERSON e BARNETT, 2013; HARGUNANI, 2010; MENGISTU e KAHSAY, 2015; MICHELINI e VERCELATTI, 2012; OGAWARA, BHARI, e MAHRLEY, 2017). There are also a few approaches in which the teacher chooses to use history and philosophy of science with intentions to highlight important aspects of the nature of science as well as looking at electromagnetism's development throughout the nineteenth century (KIPNIS, 2005, 2009; ROMÁN, 2012).

Our main interest is to suggest that researchers and teachers keep the objectives of science teaching in focus during the pedagogical process, especially at the primary and secondary level. We highlight, among other things, that the purpose of primary education is to bring personal development and acquisition of intellectual abilities that would help students to learn to think independently and appropriately in relation to life problems (Davydov, 1990).

2 METHODOLOGY

We chose the qualitative methodology of analysis (BOGDAN e BIKLEN, 1992). Unlike quantitative research that seeks causal determination in data, qualitative research seeks extrapolation to similar situations (HOEPFL, 1997). In general, Strauss and Corbin (1990) define qualitative research as any kind of research that produces results that were not the result of statistical processes or other quantitative means.

Thus, in dedicating ourselves to this methodological practice, we ultimately aim to understand the process by which learners construct meanings. The theoretical option taken in our analysis seeks parameters that allow assimilating the phenomena from the human, cultural and historical dimension of intellectual formation.

However, we emphasize that the term qualitative methodology has been generalized, in a certain sense homogenized, since its first conceptions, being sometimes used without due criticism in many researches in the area of Education. Cedro and Nascimento (2017) show

us that qualitative methodology is more than an arsenal of techniques and methods of analysis, it also has its own research methods and that is why this methodological approach is also a theoretical approach. Thus, the qualitative methodology should not be used negligently as a synonym or as an integral basis for research based on cultural-historical theory. Hence, the simple qualitative methodology that aims to describe reality becomes a Herculean task from the Marxist point of view, since for Marx reality is something that presents itself in a chaotic way (COVER, 2010). It is necessary that researchers be aware and grasp the essence of the object of analysis, which we capture its structure in its historical movement, in its entirety. Cedro and Nascimento (2017) state to be based on the concepts elaborated by the Cultural-Historical Theory means to be based on all dimensions of these concepts: epistemological, logical/philosophical and ontological.

Therefore we see that the Marxist methodology, involving the reflection, analysis and mobility of concepts in social history, justifies our choice of methodological treatment due to the theme itself discussed in this paper: reflection on the teaching of physics based on aspects of cultural-historical theory.

3 PERSPECTIVE OF DEVELOPMENTAL LEARNING IN SCIENCE

We understand that there are different types of concepts each having different characteristics and particularities. Vigotski (2007) differentiates in scientific concepts that are produced under the conditions of school education, and provide the formation of processes of generalization and abstraction; and the daily or empirical concepts that are formed based on the concrete actions of the child in his daily life, outside the school context. Moreover, the Vygotskyian thesis indicates that the development of higher psychological functions is the result of an active phenomenon of internalization and appropriation of the outside world, mediated by language and culture through a dialectical process. That is, knowledge occurs first in the social world, stuffed and flooded with signs and then transformed into individual knowledge with the help of a more capable partner, such as the teacher.

Engeness and Lund (2018, p.7) state that the concept of developmental learning introduced by Davydov and Elkonin – based on Vygotsky – came as an option for formal education, since the traditional education did not ensure the development of students as learners, “but only trained and reinforced those mental functions that were already developed in preschool children: sensory observation, empirical thinking and utilitarian memory”. In this sense, it is chosen a teaching system in which prioritize the learning of students as active and creative beings, and expected as a function of the school, considering that the school is the

fundamental component of the educational system of Marxist tradition and cultural-historical theory. Longarezi and Puentes (2013) also highlight the visceral role of the construction of theoretical thinking as the focus of school teaching that aims the psychological development of children.

Thus, we understand that the role of the school is no longer traditional teaching with the focus on learning the empirical characteristics of objects, it should focus on the creation of a pertinent pedagogical instruction capable of working on the development and appropriation of objects through theoretical thinking. Theoretical thinking admits the task of elaborating the data of contemplation and representation in the form of concepts, and revealing the movement, the essence of the phenomenon, through the ascension procedure from abstract to concrete (RIGON, ASBAHR e MORETTI, 2016).

Davydov's theory of developmental teaching focuses on the development and construction of students' theoretical thinking through the historical and dialectical materialist method. Because this process is an active phenomenon, which implies activity of the student whose object is the content to be learned, Davydov believed that it would drive the sophistication of mental abilities that make us human. Therefore, we realize the objective of organizing and systematizing teaching in such a way as to favor the learning of scientific concepts with potential for the development of children's theoretical thinking. Davydov's theory seeks to develop the ability to think in a way that reflects the essential relationships present in phenomena. The ascent to the concrete is understood as theoretical thinking, which in turn is grounded in the presence and manipulation of theoretical concepts.

Mastery of theoretical concepts allows the student to work with a multitude of concrete cases, that is, allow students to act independently in relation to objects. This observation was somewhat expected since a central assumption of the dialectical materialist method is that phenomena cannot be understood in their immediacy, in their appearance. The apprehension of the real is not given to us by direct contact with the phenomenon (RIGON; ASBAHR, e MORETTI, 2016) but rather through analysis of its possibilities of existence.

4 DISCUSSION

All the interventions we found at the research were reported as successful, regardless of the approach utilized by the teacher – use of experiments or use of technology to teach topics of electromagnetism. One reason for this success was that, whether the teacher is demonstrating an example through material experiments or digital video, students can often see changing on phenomena' parameters – like distance, resistance and current – which is fundamental for

understanding the conceptual relations of the theory. However, we still concern about whether the students would be able to generalize the experiment or the simulation shown into other life related problems. In that sense, Gaspar (1997) also presents concerns about teaching activities that reduces the process of learning to showing off experiments and expecting students will understand relations like the exchange of electrons between bodies.

To address the question of generalization, a common argument throughout the literature is that learning physics would be more relevant if teaching activities were presented in contextualized manner, in reference to students' daily life and previous experiences with objects. In other words, it is not enough for teachers to bring experiments or to find a useful computer simulation; they would still need to relate the content to the students' life outside from school (AZEVEDO, 2013). Students need to bring the contextualized questions, not the teacher. Davydov (1998) emphasizes that the teachers' responsibility is to create a propitious environment so that meaningful learning activity could happen in the classroom. Pupils should formulate questions, which they then use to direct their learning process. In other words, students must have an internal need and motivation to assimilate the content.

Davydov's model refers to instruction and learning as sources of psychological development, where instruction should prepare and motivate the child for active and creative participation in existing social practices (LOMPSCHER, 1999). However, the focus of the schooling process should be that students have full and authentic control over the meaning of the information they are able to reproduce (DUARTE, 2016).

We expect that contents that are important in a societal practice are going to be interesting to students. It requires that the teacher understand enough of the content to points out what is a problematic issue that should be addressed. For instance, production of electricity is a common content in many curricula. Why is it sometimes required to students to learn about it? One reason is because production of removable and clean energy is a societal issue nowadays. We often think that teachers are the ones responsible to bring news to students, but most of the times students already have some awareness about the topic they are studying (CAO & BRIZUELA, 2016; MALONEY, O'KUMA, HIEGGELKE, & VAN HEUVELEN, 2001).

In that particular case, Chaiklin (2019) gives an example stating the teacher needs to help students understand why electricity production is a problem, not by stating it, but by bringing different pieces of everyday life, such as, a speech from a politician related to production of energy, an article in a newspaper, ask students to tell some experiences. Then the teacher should construct the pieces in a way that students start to realize that there is a problem. Through a dialogue with the class, it may be concluded that electricity production is indeed a

problem, so how can we investigate it? Then, with students seeing themselves as part of the problem, there are several different ways about how to carry on the investigation which are extensively described in many articles in the literature.

From a developmental learning point of view, we do not have to worry about the direction the lecture is going to, because since we defined our goal for developing theoretical thinking, any problem that is chosen to be work with, if it is a theoretical concept, than it is universal and should be present in any concrete case. In other words, students could come with any situation they find interesting – in relation to the particular topic, in this case the electricity production – that with teacher's guidance, the students would end up working with the theoretical concept. Hence, examples brought to investigate electricity production will also lead, through teachers guidance, to discussion of other phenomena and concepts in electromagnetism like electromagnetic waves.

In summary, we suggest that instead of investigating the world directly, we might think of a model of relationships as explanations of phenomena, once we have the belief that knowledge about things resulted from the relationships of their actions. A concrete teaching activity on the topic of electromagnetism is still under development on author's master thesis.

5 CONCLUSIONS

Overall it is evident that engaging secondary school students in the process of learning and accounting for electromagnetism's phenomena in their daily lives is challenging. Nevertheless, some technological instruments such as virtual simulations, animations, computer games and cellphones, and hands-on experiments can provide useful mechanisms to immerse students in the study and the joy behind this subject matter.

However, positive changes in the way we conceptualize teaching and learning relies on whether teachers and researchers are able to restructure the role of each participant in the learning process. The educational process in the school should start with students and teachers constantly recreating the need for learning. Knowing that, the teachers' role in the classroom is to create conditions to instigate students to act in relation to the subject-matter. Afterwards, the teacher should evaluate to see whether what students are doing is a good learning task and how it should be further develop. We claim that organizing the learning process in this manner is helpful for students to develop their ability to think independently.

We understand that the process of learning scientific concepts in schools should be close to the use of experiments, for example. However, based on Davydov (1990), we warn of the limitations of this perspective and advocate for an analytical study of the phenomena. It is

through theoretical generalization that the essence of phenomena is discovered. Rosa, Moraes and Cedro (2016) contribute to this discussion by pointing out that students who work in teaching activities based on empirical thinking in general have great difficulty in differentiating the essential attributes of superfluous from an object or phenomenon.

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