

**DIALECTICAL AND HISTORICAL METHOD, CULTURAL-HISTORICAL THEORY AND EDUCATION: SOME APPROPRIATION IN RESEARCH ON EDUCATION OF TEACHERS WHO TEACH MATHEMATICS**

**MÉTODO HISTÓRICO-DIALÉTICO, TEORIA HISTÓRICO-CULTURAL E EDUCAÇÃO: ALGUMAS APROPRIAÇÕES EM PESQUISAS SOBRE FORMAÇÃO DE PROFESSORES QUE ENSINAM MATEMÁTICA**

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**ABSTRACT**

The contributions of the cultural-historical approach to the comprehension of phenomena related to learning processes and human development have been expressed in the increasing number of academic research that take such approach as theoretical reference. This work presents the main theoretical assumptions of dialectical and historical materialism method that founded the investigations of Vygotsky and his contributors and how these structuring elements have been taken as reference in the production of theses and dissertations on education of teachers who teach mathematics. In the analysis of these studies, the text highlights aspects about monitoring, apprehension and analysis of the phenomenon investigated in light of the historical-cultural theory and explains some possible theoretical and methodological ways to researches supported by this theoretical approach.

Keywords: Dialectical and historical method, cultural-historical theory, teacher education, mathematics education.

**RESUMO**

As contribuições do enfoque histórico-cultural para a compreensão de fenômenos relacionados aos processos de aprendizagem e desenvolvimento humano tem se manifestado no número crescente de pesquisas acadêmicas que tomam tal abordagem como referência teórica. Este trabalho apresenta as principais premissas teóricas do método histórico dialético que fundamentaram as investigações de Vygotsky e seus colaboradores e como esses elementos estruturantes vêm sendo tomados como referência na produção de teses e dissertações sobre formação de professores que ensinam matemática. Na análise desses estudos, o texto destaca aspectos do acompanhamento, captação e análise do fenômeno investigado à luz da teoria histórico-cultural e explicita alguns possíveis caminhos teóricos metodológicos para pesquisas apoiadas em tal referencial teórico.

Palavras-Chave: Método histórico-dialético, teoria histórico-cultural, formação de professores, ensino de matemática.

## 1. Introduction

The contributions of the cultural-historical approach to the comprehension of phenomena related to Psychology and Education fields have been expressed in the increasing number of academic research that take such approach as theoretical reference. In particular, the methodological principles based on dialectical and historical materialism have aroused the interest of researchers from different countries who have been taking on this dialectical approach in scientific investigations about learning processes and human development in its intrinsic relationship with the social and historical nature of the human psychological processes.

The cultural-historical approach in Psychology has its origins from the work of Lev Semyonovich Vygotsky (1896-1934) who, along with Alexander Romanovich Luria (1902-1977) and Alexei Nikolaevich Leontiev (1903-1979) constituted Troika, known as the first generation of the Soviet School. This group's research focused on the constitution of the psychological functions and consciousness, highlighting the role of mediation and culture on this process. Starting from substantiated criticism against Positivist Psychology and the fragmentation of Psychology in schools and approaches, Vygotsky and his contributors searched for an approach with explanatory concepts and principles that were able to overcome identified obstacles in methodological divergence of the so called "Psychologies" of his time, which were composed by distinct ontologies. To Vygotsky (1990), such theoretical perspectives found themselves polarized, because they would either follow dogmatic and reductionist principles, or be constituted by an exacerbated eclecticism, generating what he called the Crisis in Psychology. "In his view, both standpoints disregarded the dialectical and historical essence of the psychological and social phenomena" (Nunes; Fernandes; Gutierrez, 2014, p.164). Seeking to build a new "Psychology", Vygotsky and his contributors leaned on, theoretically and methodologically, the assumptions of dialectical and historical materialism, especially on Marx and Engels's philosophical ideas and the concept of dialectics.

Despite the importance of Vygotsky's methodological propositions, many of these ideas have not been much considered in the Psychology field, which, according to Veresov (2010), would be related to the fact that

In order to introduce Vygotsky's theory to world psychology the Western Vygotskians simplified and adapted the whole picture to the existing tradition. It is quite understandable when the task is to make the difficult theory recognizable. What is bad is that the price was too high and Vygotskian community keeps on doing it until now, with no attention that the world psychology is different and simplified and fragmented picture is not anymore relevant (Veresov, 2010, p.290).

As a paradigm for educational research, the dialectical and historical approach is highlighted in the academic scene as of the 1980s (Gamboa, 1989), and the appropriation of such referential by the field of research in Education does not seem to be given differently than indicated by Veresov, since it leaned on the same fragmented translations on which the

explicitness of the method was reduced to the indication of some principles on which not much is explained about the dialectical and historical basis.

In this context, we have considered relevant the analysis of some theoretical assumptions of dialectical and historical method and its correlations to the cultural-historical theory. Thus, in the first part of this article we have bent ourselves over such challenge and, after that, we have turned the attention to the Mathematics Education area presenting some possibilities of appropriation of such theoretical and methodological principles aimed in research about education of teachers who teach Mathematics. Evidently, the indication of these possibilities of appropriation and objectification of elements from dialectical and historical method has no intention to exhaust the possibilities of such appropriations, much less to cover the list of research that has been constituted from this methodological path, but to express modes of organization and treatment of research that reveal some of these possibilities.

## **2. The basis of dialectical and historical method**

By understanding the educational processes as historically situated and eminently contradictory, the dialectical and historical approach understands history as “the axis of comprehension and scientific explanation, and it has in practice its epistemological basis.” Methodologically, the analysis is anchored in dialectical pairs which seek to represent the tension between contradiction and totality, such as content/form, theory/practice, historical/logical, concrete/abstract, thesis/antithesis, etc” (Fiorentini & Lorenzato, 2009, p.67).

According to Martins (2006, p.2), the choice for this theoretical approach "dispenses the adoption of qualitative approaches in the legitimation of scientism of its methods of investigation, for it disposes of a sufficiently elaborated epistemology for scientific act". The author argues that the basic and systemized characteristics of qualitative studies (Bogdan & Bilden, 1982; Lüdge & André, 1986) differ substantially from dialectical and historical method.

Referring to his own method of investigation, Marx (2002) presents the analysis of one of the critics of his work when affirming that, in his view

only one thing matters: finding out the law of the phenomena he studies. It matters not only the law governing them, as they have defined form, and connects them to the observed relation in given historical period. The most important to him is the law of their transformation and their development, that is to say, the transition of a form to another, of an order of relations to another. As he investigates, in detail, the effects on which it manifests in social life. (...) In consequence, all of Marx's efforts aim to demonstrate, through scrupulous scientific research, the need of certain orders of social relationships and, as much as possible, to verify, in an irreproachable way, the facts that are the basis and the starting point. [...] What can be used as a starting point is, therefore, not the idea, but, exclusively, the external phenomenon. (Marx, 2002, p.27).

In conclusion, Marx indicates that what was exposed characterizes nothing more than the dialectical method. However, he makes it clear that his method differs from the Hegelian method, once

to Hegel, the process of thinking - which he transforms in autonomous subject with the name of idea -is the creator of the real, and the real is just its external manifestation. To me [Marx], on the contrary, the ideal is nothing more than the transposed material to the human mind, and by it interpreted. (Marx, 2002, p.28).

More than a method of investigation, dialectics in Marx subsidizes a conception of man and world in which man through work, understood as intentional activity, transforms the reality and produces himself. Thereby, it is the man's material activity that constitutes mediation between him and the world. As a method of investigation, dialectics implies the analysis of objective reality through its contradictory aspects in the set of its motion and in the search of making the object's essence appears. "To make it appear the essence of each process it is necessary to make it appear the specific character of both aspects of each one of the contradictions of this process [...] to verify the reciprocal action of the opposite poles of contradiction..." (Gadotti, 2003, p.30).

Since dialectics implies the analysis of the contradictory in motion, the attempt to indicate fixed and predefined categories of analysis for the dialectical method of investigation would constitute itself as a paradox. How can a philosophy of change be codified in fixed laws? According to Konder (2000, p.60) "the principles of dialectics aren't appropriate to any codification". In the same direction, Frigotto understands that "dialectics cannot constitute itself to the researcher as a 'doctrine' since in order to involve the totality, the specific, the singular and the particular, it must be considered that [...] the categories of totality, contradiction, mediation, alienation, are not aprioristic, but historically constructed" (Frigotto, 2000, p.73).

In this regard, Engels's (1979) attempt to formulate laws for dialectics from the analysis of examples from nature, has not been immune to criticism. Either way, disentangling from a positivist comprehension, many authors have been taking as a starting point some general principles or characteristics of dialectics (Gadotti, 2003). The general principles or basic laws of dialectics that were initially enunciated by Engels are three: 1) the law of the interpenetration of opposites; 2) the law of the transformation of quantity into quality and vice versa; 3) the law of the negation of the negation. Such general principles or basic laws were taken as a starting point for the study of Marxist dialectics by other authors (Cheptulin, 1982; Kosik, 1969; Kopnin, 1978; Lefebvre, 1993) so explaining its essence, in especial the principles of motion and totality. Thus, it is possible to consider indicating four principles of dialectics: the principle of totality, the principle of motion, the principle of qualitative change and the principle of contradiction (Gadotti, 2003).

The principle of totality or unity, according to Kosik (1969), refers to the comprehension of reality as a concrete totality. Only in a secondary way, that implies everything is connected to everything and that the whole is more than the parts. The essential is to comprehend

reality as structured, dialectical whole, in which or from which any fact (class of facts, set of facts) can become rationally understood. [...] The facts are knowledge of reality if understood as facts of a dialectical whole [...] if they are understood as structural parts of the whole. (Kosik, 1969, p.44).

The comprehension of reality, concrete totality in development, is related to the principle of motion, the idea that everything transforms itself. The dialectics sees this motion as a result of the internal conflicts that do not immobilize themselves between affirmations and negations, between thesis and antithesis, but produces itself in the synthesis, as negation of the thesis and antithesis. "The statement engenders necessarily its negation, however the

negation does not prevail as such: both affirmation and negation are surpassed and what prevails in the end is a synthesis, the negation of the negation" (Konder, 2000, p.59).

The idea of dialectical overcoming brings in itself both the negation and the motion. According to Konder (2000, p.26), the word overcoming was used by Hegel with three different meanings so that "the dialectical overcoming is simultaneously the negation of a determined reality, the conservation of something essential existing in this negated reality and its rising to a superior level."

The principle of qualitative change, or the passage of quantity to quality, considers that the motion also takes place through ruptures and leaps, in different rhythms and radical transformations. The gradual transformation of quantity may result in a sudden change in the phenomenon's quality. The example of a physical change of water, from liquid to gas, with gradual increase in heat, reflects this principle. "It is not possible, for example, to raise a question about what emerged first - the quality or the quantity, but it is licit to raise the matter of how was our knowledge about the qualitative and quantitative precision of the object developed..." (Kopnin, 1978, p.118).

The fourth principle highlights contradiction as the struggle of opposites that at the same time that they oppose each other, they also constitute the unity of the phenomena of reality. Therefore, the principle of contradiction, more than affirming the existence of contraries, seeks to comprehend the unity and motion related to them. "Contradiction is the essence or the fundamental law of dialectics" (Gadotti, 2003, p.27).

From these four principles, numerous dialectical categories that constitute themselves as units of contraries emerge. Thus, for example, there are the dialectical pairs concrete/abstract, empirical/theoretical, quantity/quality, individual/social, necessity/liberty, logical/historical, form/content etc.

As research method, dialectics takes reality as starting point and end point, comprehending concrete as "the synthesis of many determinations" since "concrete appears in thought as the synthesis process, as a result, not as starting point, although it is the actual starting point" (Marx, 1978, p.123). Thus, the rise of the abstract to the concrete aims to appropriate the concrete as "thought concrete."

Because of this motion, Kosik (1969) points out that while the immediate utilitarian praxis is essential to man's relationship with the world, it is insufficient for his comprehension of reality because that reality is the unity of the phenomenon and the essence.

The phenomenon indicates the essence and at the same time, hides it. The essence is manifested in the phenomenon, but only inadequately, partially or only under certain angles and aspects. The phenomenon indicates something that is not himself and lives only thanks to its opposite. The essence does not occur immediately; it is mediated to the phenomenon and, therefore, manifests itself in something other than what it is. The essence is manifested in the phenomenon. The fact that it manifests itself in the phenomenon reveals its movement and shows that the essence is not inert or passive. The demonstration of the essence is precisely the activity of the phenomenon. (Kosik, 1969, p.15).

The search for unveiling the essence of the phenomenon takes the researcher to trying to learn its motion and, like this, dialectical and historical approach's research "can be compared to the movies, for being concerned with the record of the motion, the evolution and dynamics of the phenomena" (Gamboa, 2000, p.105). In this process, it is manifested the unity between

theory and practice once the theory that subsidizes the investigation is continuously revisited and (re)signified in a way mediated by practice. This allows us to explicit the active role (Davidoc, 1988) that the researcher takes on this methodological approach. As Frigotto (2000) alleges:

It is important to highlight that who conducts the investigation is the investigator and not the data, whether primary or secondary. It is the researcher who structures the questions and its signification to conduct the analysis of the facts, the documents etc. Therefore, it is being alleged that the investigator goes to reality with a theoretical posture since the beginning (Frigotto, 2000, p.88).

Lastly, we retake Marx (2002) regarding the distinction between the method of investigation and the method of research exposure. The method of investigation, according to Kosik (1969), comprehends 1. appropriation of matter in its details; 2. analysis of different forms of development of matter; 3. investigation of internal relations. Meanwhile, the method of exposure, as synthesis of the research, is the process by which "the phenomenon becomes transparent, rational, understandable" (Kosik, 1969, p.37) and is constituted as product of the researcher's thought in the motion of rising from abstract to concrete. In the words of Frigotto (2000, p.89), this synthesis is "an organic exposure, coherent, concise of the 'multiple determinations' which explain the investigated problem".

From this brief exposition of elements of dialectical and historical method we can enter the analysis of the method in Vygotsky once, as we said, this theoretician takes Marx's philosophical ideas and the concept of dialectics as reference to his production.

### **3. Cultural-historical theory and method in Vygotsky**

As we highlighted in the introductory text, in the search for developing a new approach and conception for Psychology, Vygotsky leaned on, theoretically and methodologically, Marx and Engels's philosophical ideas and on the concept of dialectics. On this search he developed what he called "concrete human psychology" (Vygotsky, 1989), explaining the research method that guided this theoretical production.

Dealing with the research method in Vygotsky refers to philosophical, epistemological and necessarily ontological deepening that was sought to be explained in the first part of this article, through worldviews guided by dialectical and historical reading of reality. Once speaking of a method implies approaching the process of knowledge production from the establishment of the subject-object relation and a systematic organization of the instruments and procedures used by the researcher in his investigation (Nunes; Fernandes; Gutierrez; 2014), one of the biggest challenges in the field of research on human phenomenon is to find the appropriate method that enables getting to more assertive answers about the explored issues. Investigations of this nature require that the investigator has a clear research problem and looks for appropriate procedures to get to the explanation of the material and objective reality so that a mutual and close relationship between the method and the object of study is built.

In this regard, Vygotsky affirms that "... every fundamentally new presentation of scientific problems inevitably leads to new methods and research techniques. The object and the research method maintain a very close relationship" (Vygotsky, 1995, p.47). For this researcher, the problem formulation is directly linked with the methodological way to go, that is to say, the success of an investigation depends on the refined look of the researcher to the method he will use. Although the appreciation of the method is one of the strongest themes in his work, Vygotsky understands that the method is produced in unity with the explanation of the object of research. Accordingly, there aren't methodological steps in the investigation rigidly defined a priori, since:

The method must be adapted to the object that is being studied (...) The elaborations of the problem and method are developed jointly, although not in parallel. The search for method becomes one of the most important tasks in investigation. The method in this case is both premise and product, tool and results of the investigation. (Vygotsky, 1995, p.47).

Based on the analysis of higher mental functions, Vygotsky presented three important methodological principles which are essential to conduct research on this approach: 1. The analysis of processes and not objects; 2. Explanation versus description; 3. The problem of fossilized behavior (Vygotsky, 1994, p.81-86).

The first principle reveals the respect for the historicity of the studied phenomenon, emphasizing the idea of detailed analysis of the processes and not only of isolated, tight, stable and fixed objects. The psychological phenomenon's nature is considered as something unfinished in a motion of perennial change, so knowing it implies the watchful eye of the researcher to its past and present, a look to the becoming of the phenomenon.

(...) the historical study, I must say in passing, simply means applying the categories of development to the investigation of phenomena. To study something historically means to study it in motion in its historical development. This is the fundamental requirement of the dialectical method. When in an investigation it is included the process of the development of some phenomenon in all its phases and changes, since it arises until it disappears, it implies giving visibility to its nature, knowing its essence, for it is only in motion that the body demonstrates its existence. Thus, the historical investigation of the conduct is not something that complements or helps the theoretical study, but it is its basis. (Vygotsky, 1995, p.6).

Vygotsky assumes, therefore, the principle of motion that governs the dialectical comprehension of reality when formulating the principle of "process analysis" in his methodological approach. If we replace the object analysis by the process analysis, then, the basic task of research obviously becomes a reconstruction of each stage in the development process: it should make the process return to its early stages" (Vygotsky, 1994, p.82). The "reconstruction of each stage" to which Vygotsky refers relates this way to the historicity of the phenomenon which implies knowing it in motion and transformation. This premise justifies Vygotsky's Genetic Psychology in his quest for the genesis of the relationship between thought and language.

In the second principle "explanation versus the description" the author mentions the risk of thinking that science can only study what the direct experience shows us. In this regard, it shows that the fact that the researcher describes a particular object does not mean that he has managed to reach the comprehension of its totality, because it is impossible to unveil the real dynamic-casual relations underlying a phenomenon, with only their mere description. According to Kosik (1969), Vygotsky leans on dialectics to take on the principle of totality,

or unity, as a condition to know a phenomenon beyond its appearance, which refers to the comprehension of reality as a concrete totality and the pursuit of overcoming pseudo-concreteness. "In the world of pseudo-concreteness the phenomenal aspect of the thing, where the thing manifests and hides itself, it is considered as the very essence, and the difference between phenomenon and essence disappears" (Kosik, 1969, p.16).

Criticizing Psychology approaches of his time, the author explains that although descriptive tasks will be part of the whole investigative process, they should not be understood as an end in themselves. Thus, the analysis of a phenomenon would not be supported only from its description, it needs to be able to establish the fundamental relations of the studied phenomenon. It is therefore absolutely necessary that the investigator seeks to analytically and theoretically establish relations that make up the object that is studied in its multiple determinations (Zanela et al, 2007).

The analysis of an object, in Vygotsky's view, must overcome external or phenotypic characteristics of the phenomenon, leaning on issues related to genotype or its genesis and essence, and in its dynamic-causal bases, "through which a phenomenon is explained based on its origin, not on its external appearance" (Vygotsky, 1994, p.82). To elucidate the issue, he mentions characteristics of a whale, highlighting that from the point of view of its external appearance, such animal resembles more a fish than a mammal. According to him:

(...) the phenotypic approach categorizes processes according to their external similarities. Marx commented more generally the phenotypic approach when he said that were the essence of objects coincident with the form of their external manifestations, then all science would be superfluous – an extremely reasonable observation. Were all objects phenotypic and genotypically equivalent (that is, if the true principles of their construction and operation were expressed by their external manifestations), then the experience of day to day would be fully sufficient to replace scientific analysis. Everything we saw would have been subject of scientific knowledge. (Vygotsky, 1994, p.83).

The third basic principle of the method indicated by Vygotsky is called the problem of "fossilized behavior". Some synonyms for fossilized, such as petrified and extinct, point out that this term refers to something that is stagnant or has ceased its development. In this regard, the author explains that thinking of fossilized behavior concerns the fact research on human and psychic phenomena often come across some processes that went out over time and history, "processes that have already died away" (Vygotsky, 1979, p.63). Such processes have been modified through several very long stages in the development of mankind, becoming fossilized or automated. According to the author, we can see this principle in forms of behavior that came to be petrified or mechanized because of their very remote origins and, at the moment, they have been repeated many, many times, losing "their original appearance." In this case, when the researcher observes and tries to analyze their external appearance, or what is given by empirical observation, he cannot fully grasp their nature, inner essence or understand them in their idiosyncrasies and differences, precisely because they are constituted by such stagnant characteristics. Therefore such processes should be studied in a motion of constant change through history, in search of understanding of their true origins which again is linked to historicity and the principle of motion.

Vygotsky (1994) states that for the smooth progress of the research it is necessary for the researcher to lean on its "own process of establishment of higher forms" (p.85). For this, it is necessary, even forcibly, that the researcher alters the "automatic, mechanized and fossilized [character of] higher forms of behavior" (p.85), so that these can return to their original

forms, which is possible in planned research experiments. In this dynamical analysis, says the author, those said to be rudimentary or inactive functions are preserved not as living remnants of biological evolution, but in the historical development of certain conduct or human behavior. Thereby,

the study of rudimentary functions must be the starting point for the development of a historical perspective in psychological experiments. This is where the past and the present merge and the future is seen in light of history. Here we find ourselves simultaneously on two levels: that one who is and that one who was. The fossilized form is the end of a line connecting the present to the past, the higher stages of development to the primary stages. (Vygotsky, 1994, p.85).

The principles of the method indicated by Vygotsky were also aimed at the analysis method that sought to counter the positivist method of "decomposition of complex psychological totalities in elements" (Vygotsky, 2001, p.5) seeking to understand the phenomenon in its totality. For this, Vygotsky proposed the decomposition of the complex totality in units that have "all the properties that are inherent to all told and, concomitantly, that are alive and indecomposable parts of this unity" (Vygotsky, 2001, p.8).

The careful study of these theoretical principles of dialectical and historical method is presented as a necessity for the production of research in Education in which the researchers intend to adopt this referential as a conductor of research since, as already stated by Frigotto (2000), the researcher's way to reality assumes from the beginning a theoretical position. In this regard, we will discuss next some possibilities of theoretical and methodological appropriation of the method in research in the field of Education seeking to illustrate how these principles have been revealed in the motion of monitoring, apprehension and analysis of phenomena.

#### **4. Dialectical and historical method in research on education of teachers who teach Mathematics**

Considering the challenge of presenting some appropriation possibilities of principles of dialectical and historical method in the production of research on education of teachers who teach mathematics, a search was carried out at the CAPES's bank of theses and dissertations from the following descriptors: "mathematics teacher education", "cultural-historical theory" and "activity theory." From this search it was used as inclusion criteria for this work master and doctoral research that dealt with the mathematics teacher education, besides having as theoretical basis the cultural- historical approach, particularly with regard to the methodological approach adopted. Altogether fifteen (15) investigations were collected, being nine (9) doctoral theses and six (6) dissertations. It is noteworthy that it was not the objective of this work to stress a specific or of any other nature that could be defined as a state of the art.

Starting from a careful reading of the selected research and driven by the goal of the work, we have organized the analysis of work in three specific categories named: Following the phenomenon: the method as principle; Apprehending the phenomenon: the method as process; Revealing the phenomenon: the method in the analysis. These categories will be detailed in the following three items. In each one of them, we sought to identify a possible

methodological appropriation of the principles of dialectical and historical method, pointing out characteristics and developments from consistencies with the proposed basis.

#### **4.1. Following the phenomenon: the method as principle**

In the studies analyzed, in general, the researchers' efforts to monitor the historicity of the investigated phenomenon in motion made them resort to strategies that we understood as approaching the formative experiment notion (Davidov, 1988), although this term has not been made clear by all authors.

Such approach is justified once, even though there are significant differences in the objective form of group composition and research context (extension courses, supervised internship, education observatory, math club, etc.), there are approximations regarding the central characteristics, such as: qualitative specificity of data; the sense of learning for the participating teachers; the active involvement of the researcher in learning the subjects; the interaction between the collected observations and the planning of actions and the longitudinal nature of the work (Cedro, 2008, p. 106).

The concept of formative experiment (Davidov, 1988) relies on Vygotsky's genetic method and on the notion of experiment in the pedagogical context proposed by Zankov (1984). According to Zankov, the experiment allows "to study the relations of certain facets of the process and find the causes that affect the need for the appearance of the given phenomenon. Thus, the experiment allows us to highlight the laws of the reality's realm that is object of study" (p.21). Furthermore, Davidov (1988), referring to the formative experiment, explains the active intervention of the researcher in the processes being studied, as well as the unity between the investigated processes and teaching. In the research on teacher education, the use of formative experiment allows the researcher to propose actions in an effort to induce the emergence of the phenomenon to be investigated and step in, in order to monitor the education motion triggered in the collective space. In addition, by following the education motion in formative experiments through intentional interventions the researcher acts in the fossilized character of certain behaviors (Vygotsky, 1981) creating conditions for those to return to their original forms allowing the genetic study proposed by Vygotsky.

Besides the formative experiment as a way to monitor the education motion there was also, though in much smaller numbers, the investigation in practice community (Pamplona, 2010) and collaborative group (Pinto, 2002; Fraga, 2013; Borowsky, 2013). Practice community is understood as "a set of relationships between people, activity and the world, over time and in relation to other tangential and partially overlapped practice communities" (Lave and Wenger, 1991, p.98). Meanwhile, in a collaborative group, according to Fiorentini and Lorenzato (2009, p.115) "everyone works together and supports each other in order to reach common goals negotiated by the collective group," which implies an absence of hierarchy and collective definition of the actions. Thus, the fact that a survey is developed in a collaborative group does not necessarily imply its collaborative nature. It is noteworthy that the formative experiment indication is not necessarily incompatible with the creation of a collaborative group.

During the formative experiments, the analyzed research made use of different theoretical and methodological strategies as a way to trigger an education motion in the direction of the object of investigation. Among the strategies named by the researchers, we found teaching activities (Marco, 2009), thematic discussions, Teaching-Orienteering Activity (Araújo, 2003; Moretti, 2007; Helms, 2012), investigation activities (Carreta, 2011), learning triggering situations (Ribeiro, 2011; Fraga, 2013), teaching triggering situations (Smith, 2014) etc. In some research, the researchers made use of more than one kind of strategy.

Araújo (2003), for example, says the education dynamics "had as a triggering element the [teaching] proposal for development of Mathematics Education for Early Childhood Education" (Araújo, 2003, p.72). Marco (2009) followed "the experience of educational activities" and the "production of computer teaching activities" (Marco, 2009, p.78). In Ribeiro (2011), the proposition of the study of a text is constituted as a learning triggering situation with pedagogical intent to mobilize beliefs and knowledge of teachers in initial education about what teaching and learning mathematics is. Therefore, the researcher held a teaching triggering situation from the preface of Caraça's (1989) work in order to counter math conceptions, its teaching and learning.

Cedro (2008), when investigating "actions that reveal the transformations or changes of quality in the individuals' motives" (p.98) in the teaching learning process of future graduates in Mathematics, made use of dialogued exhibitions, texts study, group debates and thematic seminars (Cedro, 2008). Meanwhile Moretti (2007), when monitoring how math teachers, in teaching activities, reorganize their practice, review motives and assign new senses to the action elected "problem situations as instruments of education", selected from the needs indicated by the teachers at the beginning of the continued education. In both surveys, the purpose of investigation and the way to monitor the phenomenon's motion relate to the principle of qualitative change aforementioned.

Some research suggest the learning triggering situation as a structuring component of teaching-Orienteering Activity, as it can be seen, for example, in Araújo (2003), Moretti (2007), Ribeiro (2011), Lemes (2012) and Fraga (2013). The Teaching-Orienteering Activity developed by Moura (1992; 2002), in light of the concept of activity in Leontiev, has as its structure "the very genesis of the concept: the triggering problem, the search for intellectual tools to solve it, the appearance of the first solutions and the search for optimization of these solutions" (Moura, 1992, p.68). When investigating the attribution of senses in the production of didactic proposal in algebra by 6th to 9th grades mathematics teachers, Lemes (2012), for example, proposes the resolution of Teaching-Orienteering Activity in a historical and logical perspective anchored on the assumptions of the cultural-historical theory. The emphasis on collective actions revealed in many of these studies is based on the comprehension of inter-social motion to intra-social (Vygotsky, 1981; 2001) when understanding that "significations are phenomena of social consciousness, but when appropriated by individuals they become part of individual consciousness" (Asbahr, 2005, p.111).

#### **4.2. Apprehending the phenomenon: the method as process**

The development of research, in which the monitoring of the phenomenon and the preposition of situations of intervention are enablers of change, implies the need for a broad

and systematic process of data collection that allows the apprehension of the investigated phenomenon in a profound way and towards its 'totality'. In this direction, it is necessary the simultaneous use of several data capture and record instruments, as well as the incorporation of strategies for one's permanence for extended time in the research field.

In the set of instruments that intend to meet these data capture needs, it has been highlighted in the studies: field journals (Ribeiro, 2011; Milani, 2016) portfolios (Carreta, 2011; Araújo, 2003; Marco, 2009; Palma 2010), reflexive sessions (Borowski, 2013), audio and/or video recordings (Pinto, 2002; Araújo, 2003; Marco, 2009; 2007; Silva, 2014, and others) oral and written records, as well as questionnaires and interviews. In general, the use of field or board journals has been linked to data capture through observation and as a way of recording the observed phenomenon.

The portfolio was used by Palma (2010) in order to "follow the motion of the education" serving as a mediator instrument in this education process. Meanwhile Marco (2009), in his research, by proposing the use of portfolios, guides undergraduates in mathematics to register evidence of their educational processes such as "thoughts, perceptions, sensations, longings about the issues discussed in each class, educational mathematics experiences, possible (re)signification of mathematical concepts" (Marco, 2009, p.81), surpassing the idea of merely descriptive reports with pre-established structure and linearly arranged. Carreta (2011) uses portfolio as data collection instrument and understands it as "an organized collection of all the work in progress, which allows the evolutionary resumption of the individual or group's ideas" (p.66).

Another instrument adopted in research on education of teachers who teach mathematics concerns the reflective sessions, proposed by Ibiapina (2008) in light of Luria's theoretical assumptions. The research developed by Borowski (2013) adopted the reflective sessions as a data capture instrument of the movement of formation while the researched teachers shared teaching activities. Reflection allows the apprehension of the phenomenon through interviews in small groups, being these interviews guided by a common problem to the group, through which it is intended to reveal evidence of change in the individuals, from collective to individual. This instrument is close to what Bellotti (2010) calls "reflective focal group".

Other possibilities are the questionnaires and individual interviews. In general, the interviews are semi-structured and the questionnaires are open, allowing greater flexibility and involvement of the participants. Cedro (2008) interviewed all the investigated participants, at the beginning of the formative experiment and in order to know the most relevant aspects of the live contexts that could contribute to the comprehension of certain ways of thinking and acting (p.99).

The adoption of interviews, more than open questionnaires, tends to favor the expression of the subjects' ways of thinking, understanding them imbued with beliefs, values, knowledge and experience produced historically. The research developed by Pamplona (2010), reveals that when interviewing the subjects, it has not been sought evidence of alleged truths confronting narratives with the individuals' practices in order to assess consistencies. The mechanisms that engendered the narratives, the social practices which prompted their production, as well as the marks and experiences that they could have generated have been considered (p.44). In view of the intentions mentioned by researchers in the use of interviews, it is extremely necessary to reflect on the importance of planning a good interview script.

Most research analyzed seeks to overcome tight data collection, limited to questionnaires, interviews or narratives collected in punctual moments without the involvement of the researcher in situations of intervention. Each of the instruments selected by the researchers should enable the collected data to promote the disclosure of the changing motion of the investigated phenomenon (Ribeiro, 2011). It should be noted, finally, the role of oral and written records as an important source of data capture research that may be combined with the use of field journals and other instruments.

### **4.3. Revealing the phenomenon: the analysis method**

The process of data analysis, consistent with the principles of dialectical and historical method, has the challenge of searching for revealing evidence of qualitative change of the investigated object's motion and explaining its transformation, which means, according to Vygotsky, not only to describe the phenomena, but explain them in their totality. In the analyzed research, some ways of analysis have been highlighted, including the following concepts: isolated (Araújo, 2003; Ribeiro, 2011; Fraga, 2013), units of analysis (Cedar, 2008; Smith, 2013), episodes and scenes (Moretti, 2007; Smith, 2014), activity systems (Palm, 2010) and centers of signification (Voigt, 2012).

This simultaneous search for representing, in the analysis the investigated phenomenon's motion and its relation with concrete totality, has been revealed in strategies that, in different ways, can be compared to the movies (Gamboa, 1989). For this reason, many researchers have built units of analysis, or isolated, that are revealed through laying emphasis on the collected data that allowed explaining the internal and external relations between different units, or isolated. The isolated, according to Caraça (1989) can be understood as a "(...) section of reality, on its highlighted arbitrarily [...] in order to comprehend in it all the dominant factors, that is to say, those whose action [sic] of interdependence influences sensibly the phenomenon to be studied" (Caraça, 1989, p.112).

In this regard, the notion of isolated seems to approach the idea of the unit of analysis proposed by Vygotsky (2001) and already discussed in item 3 of this article. Each isolated is configured as a component unit of the whole at the same time each new isolated is associated with a new revealing quality of the transformation process of the object.

After the isolated or the units of analysis have been defined, the researcher sets forth the need to present the analysis process in motion: the contexts, processes, different revealing manifestations of new senses and new qualities linked to the investigated phenomenon. Given this necessity, the construction of episodes, in which they are made up of scenes, has revealed itself as pertinent. According to Moura:

the episodes of education are the attempt to build a way to analyze the interdependencies in isolated (...) they may be written or spoken phrases, gestures and actions that may reveal interdependence between the elements of a formative action. Thus, the episodes are not defined from a set of linear actions (Moura, 2004, p.276).

Thus, for example, Araujo (2003), when investigating the process of teacher learning in the dimension of professional development, proposed the configuration of four isolated, named

as: biographical, organizational, reflective and conceptual. Each one of these isolated is presented in the analysis through episodes. Ribeiro (2011), when investigating the evidence of teaching and learning in the context of teaching practice and internship with students who are in the initial phase of getting their degree in Mathematics, proposes three isolated through the development of these students' theoretical thinking for teaching: reflective, analytical and planning of actions that are justified by the possibility of understanding the development of thought in light of the elements that compose it, as stated by Davydov (1982). Meanwhile, Borowsky (2013, p.79) takes three isolated which are understood as "constitutive of the education of teachers who teach Mathematics in the context of Math Club".

Similarly, some researchers who rely on dialectical and historical method in their research, have used the idea of units of analysis (Vygostki, 2001) as a way of explaining the categories of analysis that are interdependent, allowing us to comprehend the totality of the investigated problem. Lemes (2012), seeking to reveal new qualities in the act of the investigated teachers, establishes two units of analysis: a new direction for the education organization; historical and logical the concept in teaching-Orienteering Activity. Such units are subsequently analyzed through episodes. Likewise, Silva (2013), when investigating the transformations in the organization's process of education of the investigated teachers explain that "each unit was divided into episodes that, in turn, were divided into scenes, as a key strategy for the composition of the arguments" that seek to demonstrate the solution to the investigated problem (Smith, 2013, p.133). The analysis by episodes and scenes has also been proposed by Moretti (2007) and Silva (2014), among others.

Another analysis strategy identified was developed through the concept of Activities System, based in Engestrom (1999) that understands such system as a unit of analysis that allows contemplating the principles of multivocality, historicity, contradictions and expansive transformations. Relying on this author, Palma (2010) proposes the education activity system in order to "understand the inserted education process of teachers in an activity system, in which individual or group actions are embedded in a wider structure, the collective activity system" (Palma, 2010, p.42).

Finally, we have identified the structured analysis from centers of signification, a proposal for speech analysis guided by the understanding that the relation between thought and language goes through the dialectical relations between sense and meaning (Aguiar and Ozella, 2006). When investigating the senses and meanings constituted by a group of graduates in Mathematics on their initial education, Voigt (2012) organized centers of signification to "contain and explain the changes and contradictions that occur in the construction process of the senses and meanings of the research subjects" (Voigt, 2012, p.64). According to Aguiar and Ozella (2006), "this interpretive analytic motion should not be restricted to the informant's speech, it must be articulated (and here the researcher's interpretative process is expanded) with the social, political and economic context, allowing access to the comprehension of the subject in its totality" (p.311).

As we observed in the different identified analysis of strategies, the elaboration of the unit of analysis, isolated or centers of signification, is given by the researcher's dialectical motion on the relation between theory that supports the research and the reality of the data, so that this process of analysis "is crossed by critical understanding of the researcher in relation to reality" (Aguiar and Ozella, 2006, p.310).

## **5. Final considerations**

Given the complexity of the research activity that involves Education issues, the choice of the method used requires from the researcher moments of reflections and decisions that will compose both the process and the final product of his/her investigations. In this direction, we understand that the cultural-historical approach is presented as a promising path for scientific research, given the expressed coherence between theoretical assumptions and the deriving method of research.

Starting from this theoretical context, we tried to explain the central basis of the dialectical and historical method in Marx and Engels and the resulting principles of the cultural-historical theory, based on Vygotsky. In sequence, we sought to map out possible research paths in the field of education of teachers who teach mathematics that, by adopting the cultural-historical approach as a theoretical referential, aimed at some of their guiding principles in the process of monitoring, apprehension and analytical comprehension of the investigated phenomenon.

One of these principles refers to the monitoring of investigative processes in motion. In this perspective, the options for formative experiments, practice communities and collaborative groups have been presented as possible ways of monitoring the teacher education phenomenon. As a triggering strategy of this education motion in research situation, the proposition of teaching activities, thematic discussions, teaching-Orienteering Activity, investigation activities, teaching triggering situations etc., reveal the intentional action of the researcher towards the transformation of the object's qualities.

Seeking to “document” this motion, the analyzed research resorted to various data capture tools – journals, portfolios, reflective sessions, interviews, open questionnaires, written, audio and video records – always with the aim at capturing “scenes” constituting “episodes” that allow them to produce a good “movie”. The production of this movie, to be set in the analysis motion, can be done through the isolated, units of analysis or centers of signification that are interdependent and, at the same time, allow us to comprehend the phenomenon in its totality by means of an analysis of explicative nature, in which the researcher seeks to understand the phenomenon’s motion and mediations, contradictions and overcoming which trigger new qualities.

Finally, we emphasize that the nominative indication of this research theoretical referential does not necessarily imply that the fundamental principles of dialectical and historical method are aimed at methodological research strategies, which requires the researcher continuous theoretical effort to make a profound study of these elements. Given the complexity of this course, the discussion of key aspects about the theoretical and methodological approaches of the research work here portrayed sought to explain some concepts and methodological strategies that have been adopted in research, which are organized within this reference in order to subsidize the discussion, analysis and production of new ways to overcome, in the dialectical sense, the ones that have already been drawn.

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