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Review article

Understanding and solving verbal arithmetic problems. A holistic look from a sociocultural perspective

Comprensión y solución de problemas aritméticos verbales. Una mirada holística desde una perspectiva sociocultural

Compreender e resolver problemas de aritmética verbal. Uma visão holística de uma perspectiva sociocultural

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ABSTRACT
The article socializes the results of a doctoral thesis, which started from the recognition of deficient comprehension as the main cause of the difficulties presented by students in solving arithmetic problems. In line with this, the objective of reflecting on the links and correspondences between the processes of comprehension and solution of verbal arithmetic problems was pursued, from a sociocultural perspective. In the investigation, documentary analysis was used as an empirical method and, as theoretical methods: analysis-synthesis, induction-deduction. The main result obtained resides in the systematization of those epistemological postulates that allowed resignifying arithmetic problems as texts and problem solving as a process of textual comprehension.

Keywords: comprehension; word arithmetic problem; solution of verbal arithmetic problems; Didactics of Mathematics.

RESUMEN
El artículo socializa resultados de una tesis doctoral, que partió del reconocimiento de la deficiente comprensión como la principal causa de las dificultades que presentan los estudiantes en la solución de problemas aritméticos. A tono con ello, se persiguió el objetivo de reflexionar en torno a los nexos y correspondencias entre los procesos de comprensión y solución de problemas aritméticos verbales, desde una perspectiva sociocultural. En la investigación, se empleó el análisis documental como método empírico y, como métodos teóricos: el análisis-síntesis, la inducción-deducción. El principal resultado obtenido reside en la sistematización de aquellos postulados epistemológicos que permitieron resignificar a los problemas aritméticos como textos y a la solución de problemas, como un proceso de comprensión textual.

Palabras clave: comprensión; problema aritmético verbal; solución de problemas aritméticos verbales; Didáctica de la Matemática.

RESUMO
O artigo socializa os resultados de uma tese de doutorado, que partiu do reconhecimento da má compreensão como a principal causa das dificuldades que os alunos apresentam na resolução de problemas aritméticos. Em consonância com isso, perseguiu-se o objetivo de refletir sobre as ligações e correspondências entre os processos de compreensão e resolução de problemas de aritmética verbal, numa perspectiva sociocultural. Na pesquisa, utilizou-se a análise documental como método empírico e, como métodos teóricos: análise-síntese, indução-dedução. O principal resultado obtido está na sistematização daqueles postulados epistemológicos que permitiram ressignificar problemas aritméticos como textos e resolução de problemas como processo de compreensão textual.

Palavras-chave: compreensão; problema de aritmética de palavras; solução de problemas de aritmética verbal; Didática da Matemática.

INTRODUCTION

The solution of mathematical and arithmetic problems, in particular, constitutes an essential objective and content of the teaching of Mathematics, at all educational levels, internationally (Pérez, 2020a). Based on this, the present investigation is attached to the problem-solving teaching approach, which has been gaining momentum in the research field since the 1980s (Pérez, 2020b).

The review of the specialized literature: Pérez & Hernández (2020); Montero & Mahecha 2020; Pérez (2021), allows to identify the recognition of comprehension as an essential element in the solution of verbal arithmetic problems. This is consistent with the generalized criterion of recognizing the deficiencies, in that one, as the main cause of the low performance of the students, in this one. In this sense, it must be added that empirical studies (Canales, 2018) confirm a significant relationship between student performance in both areas of knowledge.

According to Pérez (2020b), the theoretical models of solving arithmetic problems conceive comprehension as a previous phase of that; position strongly influenced by the model of the Hungarian mathematician George Polya. According to Pérez himself (2020b), the aforementioned phase is attributed a merely guiding function, which is even reflected in the name: orientation stage, used by some authors. This reveals a psychologizing and, therefore, reductionist conception of comprehension in solving arithmetic problems.

Based on the above and the existence of significant contributions, in recent decades, around textual understanding, the author of this research identified the need to deepen the links and correspondences between it and the solution of arithmetic problems. The analysis of a large number of bibliographical sources, from a dialectical-materialist position, revealed as the main epistemological "gap": the lack of theoretical support to explain the multidetermination and multifunctionality of understanding in solving arithmetic problems.

The complexity of both processes and the intention to address their most internal and essential relationships, led to the need to adhere to the position that defends interdisciplinarity as a way of thinking (González, Padilla & Zúñiga, 2020). From this epistemic position, the procedural nature of

comprehension and the role of the cognitive and affective aspects were approached in an integrating way, fundamentally from philosophical, semiotic, hermeneutic, linguistic, psychological, socio-pedagogical and didactic postulates; as well as the internal and external in both processes.

In keeping with the dialectical-materialist support of the research, the reflection carried out on the basis of the assumed epistemological assumptions, from a sociocultural perspective, allowed its systematization at a qualitatively higher level. In turn, the latter revealed the transversal nature of comprehension in solving verbal arithmetic problems, an essential premise of the new theoretical construction provided by the author in his doctoral thesis.

Consequently, the objective of the article resided in reflecting on the links and correspondences between the processes of comprehension and solution of verbal arithmetic problems, from a sociocultural perspective.

DEVELOPING

The intention to deepen the links and correspondences between the processes of solving verbal arithmetic problems and textual comprehension, from a sociocultural perspective, conditioned the search for bibliographic sources of a philosophical, hermeneutic, semiotic, linguistic, psychological, socio-pedagogical and didactic nature. In some cases, the reference categories were addressed separately; in others, fully.

The selection of the sources was made according to the following criteria: that they contribute elements regarding the theoretical conceptions about the processes of comprehension or solution of arithmetic problems, from a sociocultural perspective; that reveal links and/or correspondences between both processes or significant relationships between the performance of subjects in both activities. The period of its publication extends from the 1960s to the present, due to the growing number and significance of research aimed at solving arithmetic problems and textual comprehension, in that time frame.

Studies around understanding and solving verbal arithmetic problems are characterized by their prolixity. Hence, in the following lines, emphasis is placed on those epistemological referents that allow a redimensioning of the first in the second, from a sociocultural perspective. For this, it was significant the identification of the limitations of the acting conception of comprehension as a previous phase of the solution of verbal arithmetic problems, from the assumed epistemological position.

The assumption of dialectical materialism as a methodological basis is vital, since its principle of the universal concatenation of phenomena constitutes a methodological guide for the integrated approach of different and apparently distant processes, in a way that is qualitatively superior to the preceding ones. If the complexity of both processes is taken into account, then the need for an integrated and holistic approach would be reaffirmed, assuming interdisciplinarity as a way of thinking (González, Padilla & Zúñiga, 2020). All this makes it possible to reveal the links and correspondences between them and, therefore, their didactic approach in a more effective way.

Lenin's theory of knowledge (1970) and, in particular, his postulates on the knowability of the world are essential referents to explain the objectivity of understanding and, in particular, in the solution of verbal arithmetic problems. In this line of thought, the criterion of Mariann (2020) is also assumed, regarding the need for the reader to focus on

the text, during the comprehension process, because it is the object of the latter.

The recognition of the role of the text in the comprehension process is reinforced by the linguistic conception, which assumes it as the basic unit of communication (Roméu, 2018). This justifies the need to conceive verbal arithmetic problems as texts, based on their study, from the textuality models proposed from Textual Linguistics (Roméu, 2018). In turn, this would lead to the need to resignify the solution of verbal arithmetic problems as a process of textual comprehension.

From the Marxist-Leninist philosophy, the dialectical character of the cognitive process is also recognized as an important referent (Lenin, 1970). This is coherent with the circular conception of comprehension, formulated by hermeneutics, which explains the dialectical movement that energizes the aforementioned process, based on the following links or components: comprehension, explanation and valuation-application (Gadamer, 1988).

The assumption of the application by Hermeneutics (Gadamer, 1988), as a component of comprehension, has a close relationship with the pedagogical and didactic conceptions that explain comprehension as performance or competence (Gardner, 1993). The foregoing, in turn, is consistent with the theoretical-methodological positions of Marxist-Leninist philosophy, around the assumption of practice as a basis, criterion of truth and final objective of knowledge.

From the sociocultural model of comprehension, assumed in the article, it is explained as the process and product of the interaction between the data provided by the text, the reader's knowledge and the activities carried out during reading (Pérez, Hernández & Francés, 2018). From this perspective, the school group constitutes the context in which meaning is elaborated; for which the treatment of logical relationships and the semantic organization of the text is valuable (Roméu, 2018), as well as the preparation of questions to activate and measure cognitive performance (Pérez, Hernández & Francés, 2018).

The connotation, from a sociocultural perspective, of the role of practice in understanding, leads to the need to consider the role of internalization, execution and expression, in it, according to Fariñas (2019), as a concretion of unity. dialectic between interiorization and exteriorization. This, in turn, becomes an epistemological support to overcome the acting atomistic conception, around the understanding in the solution of verbal arithmetic problems, of separating the processes: understanding of the statement-choice of the operation of calculation-operational execution.

The assumption of the category levels of cognitive performance (Cruz, Romero & Marrero, 2020) would make it possible to specify the correspondence between the development achieved by students in the understanding of verbal arithmetic problems and the curricular objectives of their educational level or grade. This would become a key element for the didactic instrumentation of the solution of arithmetic problems as a process of textual comprehension and, in turn, a more integrating approach to the processes: understanding of the statement-choice of the calculation operation-operational execution.

The dialectic of the internal and the external, from the historical-cultural conception of psychic development, allows explaining the social nature of the psyche (Vigotski, 1987), which, in turn, has as epistemic support the considerations of philosophy. Marxist-Leninist, around the social character of the human being and the historical-social conditioning of its development (Guadarrama, 2017). All of this is consistent with the socio-pedagogical position that

explains individual development, from the dialectical unity between the objectification and subjectification of social content (Chávez & Pérez, 2015).

The assumption of the historical-cultural conception of psychic development addresses the need to consider the role of psychological categories: activity and communication; since, from various social sciences they are conceived as forms of human interaction and from Psychology and Didactics, as methodological instruments for the exploration/diagnosis of student development (Pérez, Hernández & Francés, 2018). From this perspective, the role of the relationships that occur in the teaching-learning process of understanding verbal arithmetic problems between: teacher-group, teacher-school, school-school, school-group and of these with the problem is connoted. verbal arithmetic.

Lotman's (2003) conception of understanding as an interactive process of unlimited meanings constitutes valuable epistemological support, which is consistent with the unlimited nature of understanding, from hermeneutical (Gadamer, 1988; Mariann, 2020) and pedagogical perspectives. (Gardner, 1993). This is consistent with the covert nature of the polysemy of words (Ricoeur, 1998).

The variability of the textual content, in correspondence with the context and the reader's experience, justifies the need to recognize the situational and cultural determination of meaning and the connotative and denotative, as its components (Pérez, Hernández & Francés, 2018). All this supports the assumption of the context as an essential element in understanding, and allows explaining the implication that it has in the didactic instrumentation of a deep and comprehensive understanding of the textual content of verbal arithmetic problems, in which treatment occupies an essential place. to their semantic structures and the practical meanings of the calculation operations, which intervene in their solution (Pérez, 2021).

The logic of the exposed ideas presupposes the assumption of understanding as a co-creation, by assigning meaning to the text; after knowing the facts or events that appear in it (Ricoeur, 1998). In addition, the mediating character of the interpretant and the dialectic between question-answer as an exegetical mechanism are recognized (Gadamer, 1988). This makes it possible to base the active, significant and mediated nature of comprehension in the solution of verbal arithmetic problems.

From the epistemological perspective assumed, in the present study, student development is guided and driven by teaching. In this sense, in addition to the references indicated, the Law of the mediation of psychic development (Vigotski, 1987) is essential; which is coherently articulated with the postulate of Marxist-Leninist philosophy, around the correlation between language, consciousness and reality (Konstantinov, 1984). In turn, all this is consistent with the circular conception of understanding (Mariann, 2020) that Hermeneutics wields, since it explains the dialectical movement that occurs, from the factual, for the holistic apprehension of the object of the exegetical process, through of the dialogue between the reader and the text, from the limits of the context.

The category zone of proximal development (Vigotski, 1987) becomes another epistemological support, from the assumed perspective. Its assumption implies the need to specify the levels: real and potential, of the development of the students, with the objective of using forms and levels of help that make effective the didactic instrumentation of understanding in the solution of verbal arithmetic problems.

The aforementioned postulates, belonging to the assumed conception of psychic development, find their concretion in the explanation and didactic instrumentation of comprehension as a process that allows the student to internalize the textual content (logical-mathematical and socio-referential) of verbal arithmetic problems. In the same way, it is reflected in the different mediations that are conceived in the analyzed process, in correspondence with the individual development of the schoolchildren; namely: social (subjects), instrumental (proposed didactic procedures) and semiotic (verbal language and different types of semiotic representations used).

The structure of consciousness and the systemic conception of personality (Leontiev, 1981) constitute other assumed psychological referents, since they make it possible to explain how the elaboration of personal meanings is instrumented, didactically, from the integration of logical-mathematical meanings. and socioreferential that contain verbal arithmetic problems. This evidences the referent-meaning-sense transit that implies the understanding of verbal arithmetic problems, a process in which the internal functioning of consciousness and the principle of unity between the cognitive and the affective materialize (Pérez, Coaguila & Hernández, 2019).

The cognitive dimension of the solution of arithmetic problems has been approached, fundamentally, from Psychology. From a Marxist-Leninist orientation, the works of Rubinstein (1966) stand out, who developed theoretical and empirical studies on its analytic-synthetic character, revealing analysis through synthesis as its essential mechanism. The contributions made around the links between thought and language (Vigotski, 1987), from a dialectical-materialist position, are also essential.

From the sociocultural perspective, assumed in the article, there are significant contributions about the thought-language relationship, widely extended, in the field of Mathematics Didactics. Such concretion is reflected in the postulates of theories such as Semiotic Representation (Báez, Pérez & Blanco, 2018) and the Theory of Objectification (D'Amore, 2018). All this makes it possible to explain the role of the correlation between thought and language in the understanding of verbal arithmetic problems, from a sociocultural perspective.

The contributions from Cognitive Psychology, although they do not always have a dialectical-materialist support, in their entirety, are valuable to explain the cognitive dimension of arithmetic problem solving and understanding. This is confirmed by the contributions of De Vega (2005) regarding the role of cognitive processes in both activities and the methodological value of the think-aloud technique for diagnosis/exploration. On the other hand, the contributions on the role of schemes, mental models and scenarios in the comprehension process stand out (Manzano, 2013), which have had a wide impact on the contributions of Mathematics Didactics and Didactics. of Language and Literature.

The contributions of Fariñas (2019), regarding the recognition of reading as one of the fundamental capacities for human development, connote that the value judgment is the vehicle to make sense of knowledge. The latter is a position shared by educators (Pérez & González, 2021) and philosophers (Fabelo, 2011) from a Marxist-Leninist orientation; from this is inferred the necessary unity between the cognitive and the affective, in the comprehension process.

From this perspective, it is considered that understanding is possible after a process of explanation (starting from the statement to dismember it) or interpretation (starting from experiences to arrive at the statement).

This epistemologically supports the need to take into account the unity between the cognitive and the affective in the conception and instrumentation of understanding in the solution of verbal arithmetic problems. In this way, the hermeneutic postulate is assumed, which maintains that understanding is not only knowing but behaving, knowing how to be in the world (Gadamer, 1988).

The recognition of the unity of the cognitive and the affective in the understanding of verbal arithmetic problems leads to the need to assume the experience category (Vigotski, 1987). This is consistent with the intention of the present study, to resignify the process under analysis as the process of elaboration of logical-mathematical and socio-referential meanings, based on the conceptual knowledge and experiences of the student. For its part, the integration between the logical-mathematical and the socioreferential favors attention to the experiential, from the process of understanding verbal arithmetic problems.

The conception of learning as appropriation of culture in the developer learning model (Rico, 2006) constitutes another essential epistemological support, since from a dialectical-materialist orientation, culture integrates the material and the spiritual (Guadarrama, 2017). If, in addition to connoting the active, reflective and significant nature of learning, the semiotic position of assuming the text as a sign system and cultural unit, in charge of conserving, transmitting and recreating culture (Lotman, 2003), is taken into account, this allows us to base the role of the social and the cultural in understanding and solving verbal arithmetic problems, as independent processes and in their interconnections.

The contributions of Roméu (2018) on textuality also epistemologically support the research, since the conception and implementation of the solution of arithmetic problems as a process of textual comprehension requires the resignification of the latter, as texts. For its part, the study of the particularities of its textuality would make it possible to deepen the characteristics that influence its understanding, such as: the logical-semantic organization, the mathematical and social information it covers, as well as the role of the context and the link with others. texts (arithmetic problems, mathematical content in general or another type of text).

The effective realization of the unity between the cognitive and the affective, in the understanding of verbal arithmetic problems, requires the precision of the socio-pedagogical and didactic postulates, which are assumed from a Marxist-Leninist orientation. In this sense, the historical and class nature of education is pointed out, assuming the latter as a fundamental means for the socialization of individuals (Chávez & Pérez, 2015). In this line of thought, education is defended as a function of society; recognizing, in addition, the influence it exerts on social development (Chávez & Pérez, 2015). Likewise, it is important to consider the link between education and society as a pedagogical law (Pla, Ramos, Arnaiz, García, Castillo, Soto, Rey, Moreno, González, Faba, Rodríguez, Fonseca, Ferrer, Yera, Companioni, Rodríguez & Cruz, 2012).

It is also essential, from the perspective of this research, the assumption of pedagogical principles that postulate the unity between scientific character and ideological intentionality (Pla, Ramos, Arnaiz, García, Castillo, Soto, Rey, Moreno, González, Faba, Rodríguez, Fonseca, Ferrer, Yera, Companioni, Rodríguez & Cruz, 2012); as well as the didactic ones, which postulate the link of the content of the subject with the daily life and the unity of the instructive, the educational and the developer (Fariñas & Santos, 2022). They are articulated with ideas such as those of Perkins (1995) on the

links between the subjects and of the subjects with life, to promote understanding.

The considerations of Chávez & Pérez (2015), from a materialist-dialectical basis, around the category's instruction, education, teaching and learning, are also assumed. In the same way, the author of the article adheres to the didactic position around the systemic and dynamic relationship between the components of the teaching-learning process, assuming its conscious, organized and institutionalized/schooled character and the class as its fundamental organizational form. , which has specific functions and requirements for its planning, execution and control (Pla, Ramos, Arnaiz, García, Castillo, Soto, Rey, Moreno, González, Faba, Rodríguez, Fonseca, Ferrer, Yera, Companioni, Rodríguez & Cruz, 2012).

The assumed socio-pedagogical and didactic assumptions make it possible to explain the teaching and learning of comprehension in the solution of arithmetic problems as a consciously organized, directed and controlled process in the school institution. In addition, they make it possible to implement, in the process under analysis, the unity of instruction and education as a concretion of the existing link between education-society and science-ideology. In this way, its teaching-learning process is projected and directed, in correspondence with the historical-social context.

CONCLUSIONS

The most relevant models and theories, around textual comprehension and the solution of verbal arithmetic problems, connote the sociocultural as an essential dimension of both processes. In addition, they coincide in recognizing its complex, dialectical and multifunctional character, by highlighting the value of the links between the cognitive and the affective; as well as internal and external, to explain them theoretically and implement their teaching-learning process.

The theoretical models that explain the solution of verbal arithmetic problems conceive comprehension as a previous phase; which reflects a psychologizing conception of the latter, by reducing it to a merely guiding function in the former. This reveals the limited theoretical support of existing models, to explain the complexity, multidetermination and multifunctionality of understanding in solving arithmetic problems.

The systematization, from a dialectical-materialist position, of philosophical, hermeneutic, psychological, semiotic, linguistic, socio-pedagogical and didactic postulates around the understanding and solution of arithmetic problems, reveals the textual nature of the latter and the comprehensive nature of their solution. This constitutes the epistemological support of the mainstreaming of understanding in the solution of verbal arithmetic problems, understood as the circular transit (unfolding) of the first through the different stages or phases of the second, allowing the transit from the reproductive to the creative in the holistic apprehension of the semantic content (meanings: logical-mathematical and socio-referential) of the latter.

The interrelationships between the basic functions of the textual comprehension process (analytical, explanatory and evaluative-applicative) and the cognitive processes (with emphasis: thought and language), conditions, from a structural-functional systemic approach, that the transversal conception of comprehension in the solution of verbal arithmetic problems it has the following components: circular-problem processing, logical-semantic integration and concentric comprehensive-problem acting.

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