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MECHANISMS OF THE RESOLUTIVE PROCESS IN PRIMARY EDUCATION FOR MATHEMATICS AND SCIENCE

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Abstract

The resolutive process evolves due to the development of sensory psychological processes (sensation, perception, representation), cognitive processes (thinking, memory, attention, language, imagination) as well as emotional processes (affectivity, will, motivation), which compete to build mathematical abilities (identification, pairing, grouping, sorting, global appreciation of quantity, notification of changes in quantity, elaboration of value judgments and expression of informational or operational logical units). In the primary schooling phase, the teaching-learning process of mathematics and sciences involves first performing concrete actions with objects which then, through structuring and internalization processes, build the ability to perform logical, abstract operations in which a major role is played by language, by his referential function (contextual information), aesthetic/poetic (auto-reflection), emotive (self-expression), conative (vocative or imperative addressing of receiver), phatic (checking channel working). In this regard, curriculum for mathematics and science discipline for primary education mentions as a framework objective the *formation and development of the ability to communicate using mathematical language*; in addition, there are presented as performance standards: correct use in various contexts of learned mathematical terminology; the oral and written expression, in a concise and clear manner, of how to work in solving exercises and problems. In this communication, we propose to present some methods of optimizing problem solving in mathematics and science for primary education.

Keywords: Resolutive process, optimization methods, primary education, mathematics and science.

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1. Introduction

Starting from the reason that "intelligence is learned as any other type of behaviour" (Feuerstein, Rand, Hoffman, & Miller, 1980), meaning that the student can be transformed from a *passive receiver of information* into an *information generator*, recent studies reveal the crucial importance of educating the intelligence, because only through convergence of bio-psycho-socio-educational factors, the potential can be transformed into manifest performance, at the level of problems identification, problems solving, and problems composition.

1.1. The resolutive process

The resolutive process evolves due to the development of sensory psychological processes (sensation, perception, representation), cognitive processes (thinking, memory, attention, language, imagination) as well as emotional processes (affectivity, will, motivation), which compete to build mathematical abilities (identification, pairing, grouping, sorting, global appreciation of quantity, notification of changes in quantity, elaboration of value judgments and expression of informational or operational logical units) .

Kant (1783) has demonstrated that the resolutive process is influenced both by spatial topographical structures - the "association law" (Hume, 2001), and by the dynamics of an experiential causality that can be explained only by mathematical configurations and not by associations. The mechanisms of causal dynamics are related to the application of operational systems in reality research, application that generates predictions on complex relationships between events, which are then verified by observations. Operational systems, together with concepts, comprehension, memory and problem solving, represent the psychic deeds through which the fundamental thinking and operations (analysis/ synthesis, realization/abstraction, particularization/generalization) or instrumental (algorithmic/ heuristic, productive/reproductive, convergent/divergent). Thought operations are internalized actions that have become reversible and connected to one another, in a system capable of inferring, organized into structures. The general structures in which the concrete operations are coordinated were named groups by J. Piaget, by analogy with Klein's mathematical structures, the groups having the role of balancing the assimilation of notions with the child's action and accommodating the subjective schemes to changing the contexts.

1.2. Problematic situation

A problematic situation implies the existence of an internal "dissonance" through the gap between resources and requirements, the solving of which requires the construction of consecutive sequences of inferences, thus a conative effort. It is obvious that in the resolution process there are three types of intellectual structures: behavioural schemes, symbolic schemes and operational schemes, each with a specific difficulty for each child. Piaget (1971) suggested that abstract schemes can be accomplished physically, due to a biological entity acting as a learning agent, namely the ribonucleic acid, which interferes with coding, decoding, regulating, and expressing genes.

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2. Problem Statement

In the primary schooling phase, the teaching-learning process of mathematics involves first performing concrete actions with objects which then, through structuring and internalization processes, build the ability to perform logical, abstract operations in which a major role is played by language, by his referential function (contextual information), aesthetic/poetic (auto-reflection), emotive (self-expression), conative (vocative or imperative addressing of receiver), phatic (checking channel working). In this regard, curriculum for mathematics discipline for primary education mentions as a framework objective *the formation and development of the ability to communicate using mathematical language*; in addition, there are presented as performance standards: correct use in various contexts of learned mathematical terminology; the oral and written expression, in a concise and clear manner, of how to work in solving exercises and problems.

2.1. Intuitive thinking and operative thinking

It should be noted that in primary classes, intuitive thinking is diminishing its share, while the operative thinking acquires a greater share. The intuitive, empirical methods of pre-school are replaced by logical constructs, reversible, which leads to the anticipation of the result and default to mental corrections. The internalization of action is accomplished by two mechanisms. The semiotic mechanism involves the shift from actions with objects to operations on symbols. The operative mechanism involves the shift from actions with objects to reversible, internalized actions, which function in a system of schemes that structure the inference. In addition, resolutive style, cognitive background, self-efficiency in mathematics and metacognitions, manipulated by didactic approaches, modelled on modern mathematical teaching methodologies, play a role in educating thinking.

2.2. Modelling reality using mathematics and science

The child has to learn the resolutive mechanisms in order to discover or build problems or to predict new ones as well as to design different ways of solving problems and to discover the optimal resolution. The stages of mathematical learning are hierarchically structured, as in the spiral of Leibniz's knowledge, as follows: a rudimentary heuristic (try and error); applying the rule in similar contexts, applying the rule in analogous contexts, modelling reality using mathematics, symbolizing and formalizing (Piaget, 1965).

3. Research Questions

The questions we have tried to answer are: what are the methods of investigating the resolutive process and which presupposes that the student expresses the approach of thinking in order to reconstitute the mechanisms of elaborating the judgments of value and the expression of the logical units?

4. Purpose of the Study

As a method of investigating the resolutive process, the technique of "thinking with loud voice" is used, which presupposes that the student verbally expresses the approach of thinking in order to reconstitute the mechanisms of elaborating the judgments of value, and the expression of the logical units, therefore the entire resolution process, even if the inner language is faster or if the child does not realize all the stages of

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the resolution. A particular role in learning mathematics is the composition of problems that create intrinsic motivation (by experimenting with success in mathematics classes), assimilating computational algorithms (by exercising them in various contexts), developing apprehension, but also profound judgment, attention, the spirit of observation (through involvement in the didactic task developed by the teacher) and the critical thinking (through the two essential dimensions: the social one is the consequence of cooperative learning, and the pragmatic one is the consequence of the active involvement of students in solving the daily problems). Critical thinking (of analyzing or evaluating pertinent information from the hypothesis of the problem, of arguing the optimal resolution and of the conclusion) is a condition and an effective way of achieving mathematics learning. The correlation between the content of the stimulus and the response provides information on the stage of information processing by the child in his / her resolutive design (Reitman, 1965, p 312).

Involvement of students in various didactic tasks, built in various contexts, results in the development of thinking, the encouragement of metacognition as a source of self-regulation of learning processes, but also the development of working, identification, and verification of algorithms. Thus, children who have developed working algorithms have consistent results in solving exercises, those who have mastered identifying algorithms manage to build a valid resolving action, as they easily identify the operative structures involved in solving, and those who have verification algorithms, do not make calculations or judgments because they permanently verify reasoning (be it inductive, deductive, transductive, analogous) and the calculations made. The practice of all these algorithms involves the student in practical activities related to the current reality, leading to the development of mathematical models of reality in various contexts.

Modern, authentic learning implies the existence of the following components: positive interdependence (teamwork, where each member contributes to common efforts to solve the task and benefits from the right to use the contributions of all teammates), positive interaction (open interpersonal exchanges, immediate responsibility for teamwork), interpersonal and small group skills (effective communication, self-confidence and self-esteem), individual responsibility (to carry out group responsibilities), interpersonal and group skills decisions, crisis management, optimal group processing (assessment of group efficiency) .

Educational activity must be designed and deployed to generate a climate of confidence, provide immediate feedback and positive reinforcement of the right responses, all of which work to increase students' self-sufficiency in solving problems. Thus, the elaboration of a problematic situation becomes an essential professional competence which implies not only a good knowledge of the general mechanisms of development and learning or erotetic semantics, but also of the Mathematical Methodology. Studies have shown that solving well-structured problems involves algorithmic thinking patterns and logic sequences. Solving weakly defined situations involves heuristic strategies, and sets of probabilistic operations. This demonstrates that all of the teacher's knowledge of mathematical didactics is circumscribed in several spheres, such as mathematics, psychology, pedagogy, and mathematical methodology.

Strategic training is currently based on building an effective didactic approach that exploits the stimulating valences of communicative-explanatory, interrogative-conversational methodologies, problem-solving, heuristic approach, learning by discovery, involvement in independent activities. These didactic

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approaches make the student's thinking complex and prepare him/her for a creative lifestyle, because defining creativity is the task of discovering problems rather than solving them (Dillon, 1998).

Parnes (1997) believe that the creative approach (spontaneous associative, combinatorial type) is superior to the resolutive (activity based on the collaboration between critical and creative thinking). That is why the student should be trained in didactic tasks built in various contexts, which involve solving various types of problems (reproductive-non-creative, demonstrative-explanatory, heuristic-creative, inventive-creative, optimization, problems-questions or problematic exercises).

Problem solving cannot be conceived beyond mathematical correctness. However, Roback (1952) believes that the future is reserved for psychology (psychology of error), as strategic error management, which is related to metacognitive control and the ergonomic sphere of cognition, contributes to achieving problem solving performance. In addition, error management leads to performance, because instead of error-avoidance strategy, a strategy is based on the observation of errors, the understanding of the causes of their production and the restructuring of the resolution process. The way the teacher manages the errors influences pupils' performance either by inhibiting them or by demotivating them. Van Dyck, Frese, Baer and Sonnentag (2005) believe that error plays a positive role in learning, as information is deeply processed, assimilated, transformed into operative knowledge when trying to understand the causality of errors, mental models become effective when potential traps that predispose to errors are detected and the error is corrected, and resolving strategies are optimally restructured when the causes of repetition of errors are realized. In today's education, teachers have to "change the vocabulary of their profession so that they focus be more on competencies and less on content" (Albrecht, 2008, p.253) and it is therefore important for the student's cognitive background to contain strategies related to heuristic problem-solving (significant end-point analysis, planned or planned simplification strategy, reverse search) or creative problem-solving techniques (techniques that maintain paradigms, techniques that extend paradigms, techniques that destroy paradigms and produce truly innovative ideas) , all of which are practiced in contexts similar to those of the current life.

5. Research Methods

For developing an effective resolutive process, as well as error management, is the optimization of the cognitive background. It has been shown that the cognitively developed background develops a high level of self-sufficiency. It was noticed that students who are trained and educated in elite schools, who receive extensive knowledge and metacognitive education, develop self-efficient behaviour (71.43%) superior to those in schools with average level of education and training (only 28 %), even if the latter were specifically trained in the formation and promotion of behaviour that generates self-sufficiency (Havârneanu (2013).

Problem solvers filter the information through a cognitive network, including self-beliefs, available, and useful fundamental knowledge, task approach strategies, and engagement in task (Butler & Winne, 1995; Schoenfeld, 1987). That is why the building of the learning tasks involves the composition of exercises through which different resolving methods can be practiced, depending on the specifics of the problem, such as the logical methods of approaching problems such as definition and formulation (establishing the aetiology of the problem, structuring the objectives and the results; generating the

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informational and strategic background necessary for the resolutive process; redefining the initial problem); of the type of deep analysis of the problem (morphological analysis by decomposition in subproblems, functional analysis by capturing the functions of elements in the text of the problem and the connections between elements or graphic analysis, by graphical rendering of the functions of the elements of the problem and the relations between them) representation of data, ideas under the most varied schemes and codes (graphical representation, constructive schemas, diagrams, material or ideal models), the type of decision-making evaluation or selection ("decision tree", " decision tables").

6. Findings

By synthesizing, some methods of optimizing the resolutive process of children in primary education are based on the observation, that any problematic situation implies the existence of a "dissonance", the solving of which requires the construction of consecutive sequences of deductions, built by the co-operation of symbolic, and operational behavioral schemes.

Because the resolving process is influenced both by spatial topographical structures and by the dynamics of experiential causality, in the primary schooling stage, the mathematical teaching-learning process is based initially on the practice of intuitive thinking that, through structuring and internalization, leads to the development of the thinking of the operator, in which language has a determinant role, by its functions: referential, emotional, conative and facial. In this respect, curriculum for mathematics for primary education postulates "the formation and development of the ability to communicate using mathematical language" is a major objective with performance standards: the correct use of mathematical terminology and the correct oral and written expression of the resolutive approach.

A special role in the modeling of reasoning (inductive, deductive, transductive, analogous) has the resolutive style, the cognitive background, self-efficiency and metacognitions, manipulated by didactic approaches, configured on modern teaching methodologies, and as a method of investigating the resolutive process the "loud thinking" technique is used.

Since teachers have to "change the vocabulary of their profession so that they focus more on competencies and less on content," educational activities must be designed and deployed so as to generate a climate that increases student self-sufficiency, which means that the preparation of a problem situations become an essential professional competence which presupposes a good mastery of the mechanisms of learning, the erotetic semantics and the knowledge of didactics of mathematics that are circumscribed to mathematics, psychology, pedagogy and mathematical methodology.

7. Conclusion

Problem solving cannot be conceived beyond mathematical correctness. The way the teacher manages errors influences pupils' performance by either inhibiting or demoting them, therefore strategic error management, which is related to metacognitive control and the ergonomic sphere of cognition, contributes to the achievement of problem-solving performance reproductive-non-creative, demonstrative-explanatory, heuristic-creative, inventive-creative, optimization, problems-questions, problematic exercises).

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