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CONSTRUCTIVIST PARADIGM IN THE LEARNING OF SCHOOL MATHEMATICS

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Abstract: *Mathematics is, for most students, a challenge which requires for its learning a considerable effort. As a dimension of the scholar curriculum, it is based on the internal logic of the science of reference, but mathematical knowledge must be built in relation to the student's psychic life specific features. In the teaching process, this statement is the main actor, the role of the teacher being that of a facilitator, guide, coach, organizer, stimulator, support, and coordinator. From the constructivist theory's view, learning as an active, direct and experiential process is a personal frame, initiated, managed, assessed and regulated by the one who is learning.*

Key words: *constructivism, school mathematics, learning process, didactic strategies.*

1. Introduction

Constructivism is a movement in the field of Educational sciences, which, regardless of the perspective from which it is analyzed, has as defining mark the achievement of access to knowledge through its building process, by actively involving the subject in the mental elaboration of the object of knowledge. For Astolfi, Darot, Ginsburger-Vogel, & Toussaint, (1998) the perspective in which constructivism is analyzed in learning is tridimensional: *psychological*, *epistemological* and *didactic*.

a. From a *psychological* point of view, constructivism represents a model of understanding the intelectual activity of the subject engaged in solving a problem. Opposed to the behaviorism, costructivist paradigm shows common elements with the piagetian model of genetic psychology (regarding the construction of general invariable operators over individual development) and with the model of approaching the information (focused on local mechanisms involved in solving each type of problem). Walon, quoted by Astolfi, thinks of knowledge as the result of subject's constructive activity and that it does not exist and cannot develop outside social life, by this outlining the *socio-constructivism*[3].

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[3] Concept initiated and promoted by important researches in the field of psychology of learning, realised by L. S. Vîgotski, J. Bruner and others. Their contributions are synthesized by Moal (as cited in Astolfi *et al.*, 1998, pp. 55-56) "Bruner tries to outline an original path between Vîgotski and Piaget, insisting on the construction of knowledge in a social context, in which *la mediation de tutelle* (support mediation*, our tr.*) is privileged. Starting with Vîgotski's theory, he insists on the decisive role of the social transmission and on the mediation between partners. Regarding the influence of Piaget, it manifests at Bruner through a cognitivist approach on development through the experimental method and the statement of construction of knowledge through person's action.

b. *Epistemologically*, costructivism represents a new outlook on the object of knowledge. The empirist or positivist perspective considers scientific knowledge a way of "removing the curtain" through more and more performant methods and means, in order to reach natural laws, hidden until now. Opposed to this, the constructivist perspective considers that the object of a science is not a given, but the result of an intelectual construction. Bachelard (aa cited in Astolfi et al., 1998, p. 54) synthesizes the constructivist paradigm in epistemology by the quote "Nothing comes naturally. Nothing is given. Everything is built."

c. The *didactic* point of view, which is of great interest for the current study, opposes the constructivism to the transmissive model, promoting strategies focused on student. In Astolfi's view (1985) "knowledge can neither be transmitted, nor can it be communicated in fact; knowledge must always be built and re-built by the student, the student being the one who learns". Moreover, he gives a variety of meanings to this change of paradigm in didactics, defining the constructivist conception as "being transposed in a didactic plan, it appears amended to the extent in which, if it opposes a transmission-reception pedagogy, which is focused on the object, it also opposes a pedagogy exclusively focused on student, who would build himself his own knowledge, according to his needs and interests (…) in a nonlinear way, through differentiations, generalizations, breaks… This trait the knowledge owns is based on very individualized constructions, but also on classroom-situations, collective situations, where cognitive conflicts can arise, susceptible of impelling the construction of knowledge." (Astolfi et al., 1998., pp. 196-197). By this, it is emphasized the role of contextual variables that characterize the learning situation and influence the learning act. It is also touched the issue of obstacles (especially epistemological obstacles) and errors in the learning of mathematics (Căprioară, 2012), main theme in modern didactics, but which, for reasons of space, we will not develop here.

Introduced in the didactics of mathematics, constructivist paradigm redefines each dimension of the learning process (learning, teaching, assessment).

On learning mathematics, De Corte and Verschaffel (as cited in Crahay, Verschaffel, De Corte, & Grégoire, 2005, p. 33), considers this a „social construction of meanings and understandings", which is achieved through „a constructive process aimed at developing *disposition à mathématiser le réel*". From these authors' point of view, the learning of mathematics must be *dinamic*, which involves three characteristics: self-controlled, contextualized and collaborative. Self-control, an essential component of constructive learning, „refers to the degree to which individuals involve in an active, metacognitive, motivational and comportamental way in their personal learning process" (Zimmerman, as cited in Crahay et *al*., 2005, p. 36). The contextualization of learning mathematics involves making it „in context: in relation to the social, contextual and cultural environment and to the factors in which these processes are inserted and influencial" (Crahay *et al*., 2005, p. 36), as a mean of achieving the sense of mathematics. The collaborative character of learning mathematics results from the nature of the socio-constructivist current's vision on learning, according to which: „social interactions are essential for learning mathematics, individual construction of knowledge being a result of the processes of interaction, negotiation and cooperation" (Crahay *et al*., 2005, p. 38).

These traits of learning, briefly described above, come to complete the list of requirements for an efficient learning, that has to be participative, active and creative (Neacşu, 1999).

So the key elements of the learning process are: to explore, to search, to ask, to combine, to recombine, to process the information, to give meaning to the information. The *conditions* that provide learning's durability are the direct experience in the learning environment and the active involvement of the learner.

Regarding the *teaching* act, Siebert (2001, pp. 53-54) considers that "teaching is more than knowledge transmission and discussion moulding. Teaching is elaborating a learning-favourable environment, change of perspective, preparing materials for different learning channels, creating social situations in which it is learned from others and together with them, but is, at the same time, second-grade observation, which means observing the way in which students build their own reality, the way they define the learning content."

From a constructivist point of view, *assessment* regards moulding competences, by capitalizing knowledge, developing abilities, moulding abilities, values, and attitudes. Mathematical competence aims at the individual's ability of mathematically shaping different aspects from the surrounding reality and mobilizing acquisitions of mathematical nature in order to solve potential problem-situations.

Constructivist paradigm operates with a series of characteristics essential for mathematics' learning process, detached from specialty literature, which are reference points in the conception of a teaching model, experienced within this study:

Mathematical knowledge is built based on previous acquisitions (cognitive, operational, conditional structures, beliefs and so on) which are gathered in „structures of receival" (Giordan & De Vecchi, 1987), their role being that of facilitating the uptake and the integration of new knowledge (declarative, procedural, conditional). During this approach, the student must play an active role (puts questions and tests in order to build his own understanding) and become coparticipant at his own teaching, as emphasizes Meirieu (1988, p. 134): „We can only teach by relying on the subject, on its previous acquisitions, on familiar strategies. Teaching is barren unless it creates learning situations, in which the student can engage in an elaboration activity, in other words situations of integrating new knowledge in his cognitive structure. Nothing can be assimilated without having the student link it with what he already knows." The mathematics teacher should be able to have an overview of school mathematics curriculum, not only for the stage he teaches at, but also for what happens before and after it, from where student's mathematical knowledge comes and where it aims to go. Following the development of main mathematical concepts in school curriculum, it comes out that they are organized after some guiding lines that direct the winding evolution of concepts, which are formed on gradient levels of conceptualization and through capitalizing previous studied contents. Thus, the process of learning mathematics has also an evolutionary character, which requires comebacks on previous knowledge (reorganization, alteration, ignoration and so on).

In his role as mediator and facilitator of learning, the teacher should create learning situations that challenge the student to show a reflexive attitude on his own learning experiences, that provide cooperation relationships between classmates and that facilitate the development of thematic investigations based on available resources (cognitive, material, informational and so on).

2. Objectives

The current study belongs to present-day researches in the field of Didactics of mathematics. The synthetic conclusion of the experiments realized during this research is that „by substantially modifying the learning context, especially combining a series of real-life problems (qualified by us as being complexe), (shown in different ways – text, various mass-media articles, tables, charts, and so on – n.n.), with instruction methods which involve a high degree of interaction, as well as with introducing other socio-mathematical rules, it is possible to significantly improve the reflexive and conscious approach students have regarding the solving of mathematical problems" (Crahay *et al*., 2005, p. 45).

The empiric research has had the following main objective: streamline the process of formation of numeration in primary school through a teaching model developed in the spirit of constructivism.

The hypotesis from which we have started in the conduct of this research is the use of a teaching model developed on the principles of constructivism, focusing on the student's own experience (explores, searches, asks, combines, recombines, processes information through direct exploration) leads to a superior quality level in the moulding of mathematical competences (to know, to do, to do together with others, to be).

3. Material and Methods

To verify the hypothesis, the didactic experiment has been applied, developed on a design with unique group, focused on the analysis of learning progress as an indicator of the efficiency degree of the implemented teaching model.

To this it was associated the method of direct observation, used in order to catch some behaviours that show students' motivation degree for the learning activity. We used the indicators of motivation, showed by Barth (2002, p. 148-149*)*:

- Existence of a high focus level (maximal use of available time and fulfillment of tasks undertaken, continuing chats with classmates during the breaks or after classes and so on);
- Existence of spontaneous initiatives (by helping the classmate find the solution, by organizing and carrying out activities and so on);
- Existence of energic attitudes (by taking part in debates);
- Existence of a free-change and listen-to-the-other climate (by creating a state of emulation which allows exchanges between students or between students and teachers);
- Expression of shared enjoyment (expressed by the joy of contributing to the group's achievements);
- Expression of confidence (self-confidence).

The research has been conducted on a group of 21 students (12 boys and 9 girls) aged between 6 and 7 years old.

The experimental design consisted of three stages: initial assessment; the stage of formative activities (experimental activities); final assessment.

4. Results

The didactic efficiency of the model used is proven by the results obtained at the assessment tasks within the experiment, shown as follows.

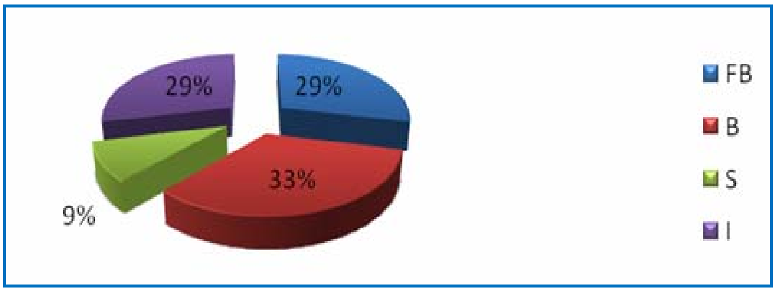

Fig. 1. *Initial assessment results*

Using the chart with the results obtained in the initial assessment (Fig. 1), it is to be observed that the weights corresponding to the extreme cases are equal: 29% of students achieved the mark FB (very good) and as many achieved the mark I (insufficient), which means that they do not possess minimum acquisitions on natural numbers.

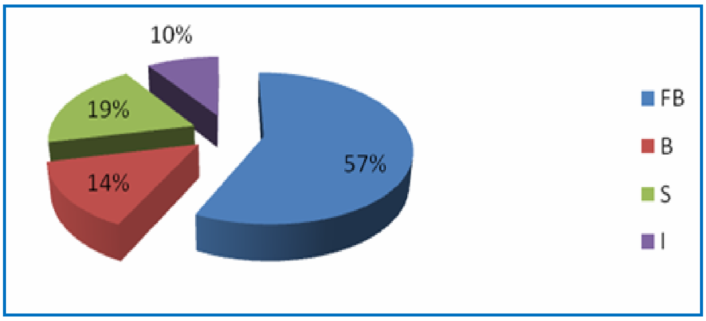

Fig. 2. *Final assessment results*

After crossing the experimental stage (Fig. 2), the distribution of marks has altered, so that more than half of the students in the class, respectively 57% of these have achieved a FB, which means they operationalize on a high level of performance with specific concepts of numeracy (the concept of natural number and operations of representation, writing, recognition, comparison and ordering of natural numbers). About 14% of students taking part in the experiment can operate with natural numbers at a medium level (grade B), 19% of students are at a satisfactory level (S) and a 10% still find it difficult to operate with natural numbers (grade I). Most of the students have proven autonomy in the realization and have correctly assimilated the notion of natural number. Students who achieved a low score, under 60 points (of a maximum of 100) and have received a grade S (satisfactory) or I (insufficient) have registered gaps in learning, being able to fulfill their tasks only helped by a classmate or by the teacher. Although they are not at a cognitive level that allows them autonomy in the fulfillment of their tasks, these students have registered a progress on a personal level, being able to fulfill, with help and on a minimal level, basic operations with natural numbers.

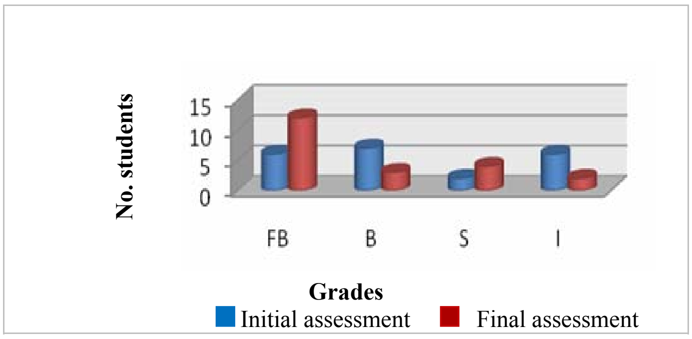

Fig. 3. *Comparative chart: initial assessment – final assessment*

Comparing results from the two assessments recorded (fig. 3) it comes out that students have made progress in learning mathematics. Among students who have achieved a grade FB, 5 students have obtained the maximum score (100 points), while the others had scores over 90 points. Among the 21 students, 15 of them had scores over 60 points, converted into marks B (good) and FB. It is proved this way the fact that by actively involving in the learning process, students have managed to better assimilate mathematical knowledge and operate more easily with it.

5. Conclusions and Discussion

Building a didactic situation requires an „a priori" analysis of each variable involved, analysis necessary for an accurate projection, as well as an „a posteriori" analysis, in order to assess the activity and to determine the level of knowledge reached, a mandatory stage in ensuring continuity in knowledge's building process. From a constructivist perspective, teaching does not confine itself to the transmission of information from teacher to student, but the teaching-learning activity is emphasized as a whole centered on the student, where the teacher plays different roles: partner of student, moderator, „coach" of student.

Among the essential attributes that should define a constructive learning situation is to be found its motivating-stimulating character. In this regard, the results of conjugated efforts, made by other researchers in the field of educational sciences (Crahay et al., 2005), in order to create a model of teaching-learning of mathematics, have been materialized through five basic principles for building a stimulating teching-learning environment:

a. Learning environments must arouse the process of active and constructive acquisition of knowledge.
b. Learning environments must encourage students' development of self-regulation strategies.
c. Starting from the importance of context and collaboration in learning, stimulating environments must insert knowledge-building activities in authentic situations from real life, with personal meaning to the student.

d. Learning environments must create opportunities for the student to gain learning and thinking habits, inserted into specific disciplinary field.
e. Learning environments must create, in classroom, a climate and a culture that can induce to students an explanation and a meditation on the learning activity and on the problem solving strategies.

In order to build a mental state of activism, we appealed to what Raynal and Rieunier (2005, p. 15) declared: „*The activity degree of a student depends on his motivation degree for some kind of learning. To make a student active means to create a motivational learning situation, able to stimulate some intellectual, emotional and/or psychomotor involvement from his part. This activity is always practised on real objects or on symbols.”*. Therefore, mental activism is based on „*emphasizing the importance of contents in different contexts of use* and *acknowledging students on the fact that the learning activity inevitably requires agreeing to make exquisite efforts”* (Beaute, 1994, p. 56-57).

To form mathematical notions, respectively the concept of natural number, we conceived worksheets and we gave them to the students in different moments of the lesson. The worksheets have been built so that students could discover themselves new knowledge and anchor in their own knowledge experience in order to build new knowledge.

To elaborate the didactic strategy we began with the fact that students were familiarized with the notion of set and we switched to the concept of natural number, going over the mandatory stages in building mathematical notions: from direct action with real objects, which students have mostly realized in preparatory class, to operating with semiabstract objects (various substitute representations of real objects) and finally with abstract objects (symbols). We followed the moulding of natural number concept and the development of competences of use of natural numbers (tasks focused on forming, writing, reading, comparing, ordering natural numbers). Abilities formed in the experimental activity have proven to last in time, when students have learned about mathematical operations, addition and substraction, with and without trading. They were more responsive, they understood quicker, they assimilated easily the calculus method.

Approaching the didactic act from a constructivist point of view imposes the teacher a good knowledge of the mathematical curriculum, especially of the manner in which contents are structured and their continuity over different school levels, as well as the didactic strategies. Then, it is required a good knowledge of students' age particularities and class particularities, as a social group, of each student's cognitive, emotional and volitive potential, as well as a good understanding of teacher's role in this kind of approach.

Results obtained from the experiment confirm the hypothesis that initiated this study: active and conscious participation of the student, mobilization of resources the student owns, under teacher's careful guidance is the key to success in learning mathematics and through formative effect, even the key to school success, overall. Process and system level, constructivist approach of learning process requires rethinking the entire educational field (curriculum, educational strategies, and above all, resources: human, material, procedural, time). It is opened thus an optimistic outlook on learning school mathematics.

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References

Astolfi, J.-P. (coord.) (1985). *Procédures d'apprentissage en sciences expérimentales* [Learning procedures in experimental sciences]. Paris: INRP.

Astolfi, J.-P., Darot, E., Ginsburger-Vogel, Y., & Toussaint, J. (1998). *Mots-clés de la didactique des sciences. Repères, définitions, bibliographies* [Key-words in the didactics of sciences. Marks, definitions, bibliographies]. Paris: De Boeck Université.

Barth, B.-M. (2002). *Le savoir en construction* [Knowledge in building]. Paris: Ed. Retz.

Beaute, J. (1994). *Les courants de la pedagogie contemporaine* [Les courants de la pedagogie contemporaine]. Lyon: Chronique sociale.

Căprioară, D. (2012). *Predarea şi învăţarea matematicii. Studiul obstacolelor şi al erorilor* [Teaching and learning mathematics. Study of obstacles and errors]. Bucureşti: Ed. Universitară.

Crahay, M., Verschaffel, L., De Corte, E., & Grégoire, J. (Eds.) (2005). *Enseignement et apprentissage des mathématiques* [Teaching and learning of mathematics]. Bruxelles: De Boeck Université.

Giordan, A., & de Vecchi, G. (1987). *Les origines du savoir* [Orings of knowledge]. Paris: Neuchàtel.

Meirieu, Ph. (1988). *Apprendre…oui, mais comment?* [Learn… yes, but how ?]. Paris: ESF.

Neacşu, I. (1999, ed. a II-a). *Instruire şi învăţare. Teorii. Modele. Strategii* [Teaching and learning. Theories. Patterns. Strategies]. Bucureşti: EDP.

Piaget, J. (1975). *Psihologia copilului* [Psychology of child]. Bucureşti: E.D.P.

Raynal, F., & Rieunier, A. (2005). *Pedagogie: dictionnaire des concepts cles. Apprentissage,formation, psychologie cognitive*, 5e Edition [Pedagogy: dictionary of key concepts. Learning, trening, cognitive psychology]. Paris: SF editeur.

Siebert, H. (2001*). Pedagogie constructivistă* [Constructivist pedagogy]. Iaşi: Institutul European.