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METACOGNITION-INTERNAL CONDITION OF LEARNING SCHOOL MATHEMATICS

Daniela Căprioară Ovidius University of Constanta, Romania,

ABSTRACT Learning mathematics in school takes place in a field of factors both external and internal for the subject, which determine the success of the process. Among internal conditions, metacognition (self-knowledge, self-organization, self-regulation and self-control of cognitive processes and mechanisms involved in learning mathematics) is a necessary condition, but obviously not sufficient. Mobilizing and exploiting these resources is part of the knowledge gained in school and forms the basis of long life learning for every field of knowledge. School practices and specialized studies prove that relatively few middle school students, after eight years of studying mathematics in school, use metacognitive strategies in this process. This has negative repercussions both on the level of understanding, and the status of motivation in the learning of mathematics.

KEYWORDS : metacognitive strategies, mathematics learning, problem-solving

INTRODUCTION

Socio-cognitive paradigm in which didactics of mathematics has been developed in the past years emphasizes cognitive, metacognitive, motivational and affective-emotional resources of the subject involved in a learning process, in which the key role is played by the student, because the student is the learner. Without will, commitment, mobilization, effort, involvement and responsability from the student, learning will not occur at all or possibly only to a minimal extent and totally inefficient. Authentic mathematics learning involves a greater effort of understanding and structuring of knowledge and therefore requires the student to be „active agent of his own development *by being able* to control *what he is, what he does* and *what he becomes"* (Crahay&Dutrévis, 2010, p. 36). The condition to achieve this goal is the real, accurate knowledge of cognitive and affective-motivational resources available to him. Research has shown that certain weaknesses of intellectual skills involved in learning can be compensated by metacognitive skills, which form and enrich along student's metacognitive experiences (conscious, affective and cognitive experiences).

Metacognition is based on „cognitive educability" (Taba, *apud* Raynal & Rieunier, 2005), a concept developed on three postulates: 1. Thinking can be learned; 2. Thinking is an active transaction between individuals and data; 3. Specific strategies should be used to develop specific mental operations. For Lafortune &St. Pierre (1994), the components of metacognition are m*etacognitive knowledge* (declarative aspect of metacognition); *management* of *mental activity* (control and management of mental activity) and *metacognition awareness.* Metacognitive control requires mon itoring, verification and evaluation and is generally followed by a decision of regulating mental processes involved. Adjustment refers to interventions decided upon by examination results: the introduction of corrections, change of strategy, stopping a procedure or rather continuing a process.

Fayoll (*apud* Crahay&Dutrévis, 2010, p. 35) states that "the learning of control and of metacognitive strategies is not spontaneously done, without, perhaps for a minority of individuals; an explicit instruction and application of devices to ensure their acquisition, transfer and maintainance in time have proved to be necessary for most". These statements are very important for the learning of mathematics, due to complex cognitive mechanisms involved, of which the most complex being problem- solving. Math teacher's responsability is not only to teach students mathematics, but expecially to teach them *how* to learn mathematics.

The teacher who helps students develop self-monitoring habits after treir problem-solving activity is over creates opportunities to reflect on the metacognitive questions: *what, why* and *how.* (Van de Walle, 2011).

Research carried out in didactics of mathematics shows how important it is to teach students to monitore and control their progress in learning, because „students who learn to monitor and regulate their own problem-solving behaviours do show improvement in problem-solving" (Van de Walle, *source cit.,* p. 42). The same source shows the THINK framework (proposed by Thomas) for the exercise of metacognition: Talk about the problem; How can it be solved?; Identify a strategy to solve the problem; Notice how your strategy helped you solve the problem; Keep thinking about the problem. Does it make sense? It there another way to solve it?

Also, mental management provides the math teacher didactic tools which are useful in teaching and learning mathematics.

Schoenfeld (apud Lafortune&St-Pierre, 1994, pp. 39-40) showed that there are links between *affectivity* (emotions and causal attribution) and *metacognition,* and also that the ideas entertained about mathematics influence our way of doing mathematics (this is about *self-knowledge*, according to Flavell and Brown).A perception of lack of utility of mathematics in everyday life (Viau, 1999), or a belief that all efforts in learning mathematics (as a result of inadequate assessment) will fail, will definetely lead to rejecting and abandoning mathematics. In school learning, in general, *regulating* emotions (ability definde by Goleman as *emotional intelligence)* is, according to some studies, a predictor of school success. „To be a successful student and a productive citizen, one must know how to use emotions intelligently"(Sousa, 2017, p.51).

If negative emotions prevent the students in learning mathematics, positive ones are valuable resources in the process. We note, for example, *self-confidence,* „a sense by which the individual shows bravery and confidence in terms of achieving an experience" (Sillamy, *apud* Lafortune&St-Pierre, 1994, p. 45). School practice must create as many mathematics learning experiences as possible to generate such positive emotions. Also,„it is natural to focus on the positive side of mathematical thinking […]that can come from the involvement of learners in their own learning. This concentrates on gaining confidence in solving problems, communicating ideas, learning to reason, developing flexibility in problem solving, willingness to persevere and so on." (Tall, 2013, p. 124)

A commonly met phenomenon in learning is the difficulty encountered by students to apply specific strategies to solve a task (solving an exercise, a problem etc.) and for this there are three assumptions: 1. The students have not mastered the relevant strategies for the task *(availability deficiencies);* 2. Deficient use of strategies *(production deficiency)*; 3. Student's motivational beliefs, namely developing a sense of learned incompetence (helplessness) (Crahay&Dutrévis, 2010, pp. 34-35). In support of the latter hypothesis, we argue the *control* the student may have on the causes of school failure. Thus, Viau (1999) distinguishes *controllable* *causes*, avoidable by the student, which imply student's accountability in this matter (eg, effort paid or learning strategy applied) and *uncontrollable causes,* on which the student has no control (mostly being about luck). An important significance for teaching mathematics has *„learned helplessness"* (caused by the *causes* perceived by the student as *external, stable* and uncontrollable), as well as a variant of this phenomenon, *„acquired resignation"* (Viau, 1999, p.68). This situation does not occur spontaneously, but is the result of a series of effort paid by the student, followed by failures in assessments. It follows, hence, the need for teachers' long-term awareness of the effects that repeated failures can have on students.

RESEARCH METHODOLOGY

Each student has their own way of relating to school mathematics. Learning strategies include a varied spectrum, from the strategy of „not learning" to the most complex and effective strategies centered on *knowing, training and adjusting metacognitive abilities (introspection, self-analysis, self-control and self-assessment of mental activity)*. The current study is part of a wider research on the obstacles faced by middle school students in learning mathematics (Căprioară, 2011). The research sample included 350 students aged 14-15 from the south-eastern Romania, having eight years of experience in learning mathematics, enough to build a style of learning mathematics.

The hypothesis behind this study is that students do not have a strategy to apply in learning mathematics, which could mean that no one has taught them how to learn math.

For the present study were selected two items, the first of them targeting the extent in which middle school students *apply a specific strategy for learning mathematics, based on introspection, self-analysis, self-control and self-assessment of mental activity. The table below* (Table 1) shows the frequency distribution of the answers to this item.

TABLE – 1
FREQUENCY DISTRIBUTION ON USING A STRATEGY FOR LEARNING MATHEMATICS

never	quite rarely	rarely	often	quite often	always
12.61%	15.76%	20.92%	22.06%	12.89%	15.76%

Analyzing the data, it appears that only 15,76% of respondents are prepared by applying a specific learning strategy and about half of them say that their preparation in mathematics is based on a strategy rather that study, while for 12,61% of them this never happens.

The second item concerns *students' ability to carry out the mathematical task without external support* (help of a teacher, a parent etc.). This is an indicator of control and autonomy the student has on learning mathematics.

As shown in Figure 1, over 36% of students of eighth grade sampled can not carry out a task without external help. Most students (23%) admit that this happens very rarely and little over 17% of students say they are independent of another person's assistance in solving math problems or exercises.

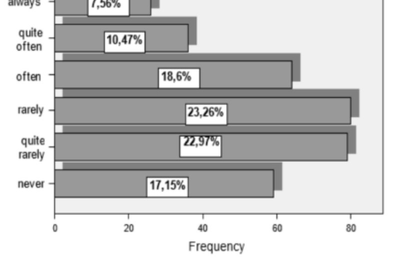

Figure 1: Frequency distribution for *insecurity in solving independently mathematical tasks*

CONCLUSIONS

The results show the lack of a personal approach to learning matematics, which negatively affects the quality of learning. First of all, teachers who accompanied the students for eight years are responsible for this issue. Learning mathematics is a complex process for which the student must be prepaired. Then, any student concerned/interested to perform at a certain activity, can develop their own strategies to approach those activities. Absence of mathematics learning strategies can be interpreted as a lack of interest from students, though, the responses show that students *have control* over possibilities to fulfill specific tasks of learning mathematics.

In general, we consider it necessary to increase the autonomy of students in solving learning activities specific to mathematics, both within math classes, by reducing frontal activities fully monitored by the teacher, and replacing them with students' individual work (or group work), where the level of monitoring by the teacher is significantly reduced. These are instances in which the student *practices self-organizing and self-controlling activities, fundamental strategies for a conscious learning.* Thus, the student takes a significant share of responsability for learning mathematics.

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