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HOW MATHEMATICS TEACHERS DEVELOP THEIR PUPILS' SELF-REGULATED LEARNING SKILLS

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Abstract. Self-regulated learning skills are important in mathematical problem solving. The aim of the paper is to present a research on how mathematics teachers guide their pupils' mathematical problem-solving activities in order to increase self-regulation. 62 teachers have filled in a questionnaire developed for this research. The results are show that more than two third of the teachers promote the methods of understanding the problem; develop pupils' self-efficacy and self-control. But only one third of the teachers ask pupils to use different strategies for solving a problem; ask students to explain the solution to their colleagues. In case of unsuccessful problem solving only one third of the respondents ask pupils to present previous knowledge about the problem or/and recall and try different methods.

Keywords: self-regulated learning, mathematics education, mathematics teacher, developing self-regulated learning skills, mathematical problem solving.

1. Introduction

Self-regulated learning (SRL) is an academically effective form of learning, through which the learner sets goals and makes plans before starting to learn; monitors and regulates his/her cognition, motivation and behaviour during the learning process; and reflects on his/her learning process [9, 10, 16]. Self-regulated learners analyze the task (understand the problem; identify the given data, the unknown data and the relations between these data, recall prior knowledge related with the problem), solve the problem (select, apply, and evaluate plans and strategies, check outcomes and results, revise and abandon unproductive plans and strategies), and evaluate their performance. Motivational goal-orientation, self-efficacy, perception of task difficulty, self-control, self-monitoring, self-judgment, and self-reaction are important skills of a self-regulated learner. These skills are also important for a successful mathematics problem solving.

Romanian pupils' self-regulated learning skills are around average [6,7]. Secondary school pupils' (10-15 years old, 5th-8th grades) have low interest for studying mathematics, low self-efficacy and high level of anxiety [7]. High-school pupils (14-19 years old, 9th-12th grades) also have low interest for mathematics, low goal-orientation, self-efficacy and self-control, but a high self-judgment [6]. Pupils' mathematical results are in strong correlation with their interest to study mathematics, their task analysis and self-control skills, and their task difficulty perception.

There is a need to motivate pupils for learning mathematics and to develop their self-regulated learning skills. The mathematics teacher has an important role in this process.

The aim of this research is to study how mathematics teachers guide their pupils' mathematical problem-solving activities in order to develop self-regulation.

2. Developing students' self-regulated learning skills

In traditional mathematics education the teacher proposes a problem to be solved; shows a method which should be used; and gives exercises to practice solving this type of problem [15]. Thus the student learns and uses an algorithm for a certain type of problem. This method of teaching mathematics doesn't promote the development of mathematical thinking, problem solving skills, and self-regulation learning.

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Teachers should be aware that they should use teaching methods and strategies which develop pupils' problem solving and self-regulation learning skills.

Lester t al. [3] during a 12 week intervention in a seventh grade class used a chart with problem-solving tips to be used by the teacher and the students. Some of the tips contained in this chart are related with SRL, for example "be sure to check your work along the way" instruct to self-control. In this research no substantial differences were observed between pupils' activities before and after instruction because of the intervention's short time and the alternative use of problem-solving instruction with regular mathematics teaching.

Pape, Bell & Yetkin [8] reported the results of a one year long intervention of developing pupils' SRL skills in a seventh grade class. During the classes students were encouraged to make their solutions public, to name and describe their strategies, to use multiple representations while solving the problems. After the intervention period students were more able than previously to communicate mathematical understanding and justify their mathematical reasoning. A small proportion of students recognized the relationship between the strategies they used and the grades they got.

Samuelsson [13] has studied the impact of three different teaching method, traditional (with mostly frontal activities at the blackboard), independent work, and problem-solving on seventh grade pupils' arithmetic and self-regulated learning skills. The results show that students' self-conception is affected more with traditional or problem-solving method. This is because with these methods they get feedback from the teacher and from their colleagues. The interest of the pupils towards mathematics was the best developed by the problem-solving method.

Gandhi & Varma [2] have showed that the strategic content learning (SCL) approach promotes self-regulated learning in mathematics of class eight. Students taking part in the experiment gain in task performance, perception of task specific self-efficacy, and metacognitive awareness about mathematical tasks and strategies.

3. Research

3.1. Design of the research

The aim of the research is to study how mathematics teachers guide their pupils in problem solving. The focus is on that type of guidance which contributes to the development of self-regulated learning skills.

The research was conducted during May-June 2011 in Romania.

A questionnaire was developed as the main tool for collecting the data. The first 4 items are demographic questions, the next 16 items are related with the topic of the research and they are affirmations which have to be evaluated by the teachers on a 5-point Likert scale: from 1- not at all typical for me to 5 – totally describes me. The affirmations were formulated based on the theory of SRL and on the previous researches about teaching methods which develop students' SRL skills. Cronbach's alpha reliability for the test is .0.892.

The questionnaire was anonymously filled in by the respondents. 62 mathematics teachers have completed the questionnaire, 16.1% of them are male, 83.9% female. As regarding their age, almost half of the respondents (48.4%) have between 31 and 40 years old, 19.4% between 41 and 50 years old, 17.7% between 25 and 30 years old (see Figure 1).

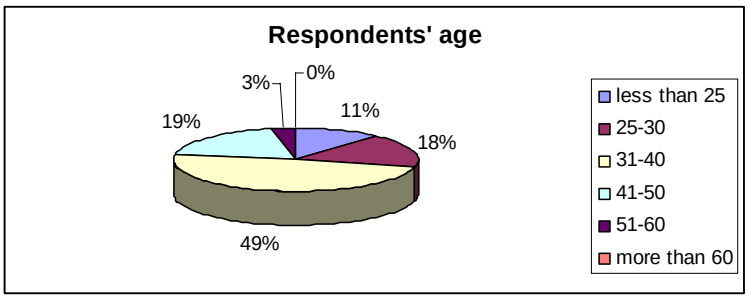

Figure 1. Respondents' age

One third of the teachers (32.3%) have between 11 and 15 years of teaching experience, 19.4%-19.4% between 2 and 6 respectively between 7 and 10 years of experience (for more details see Figure 2).

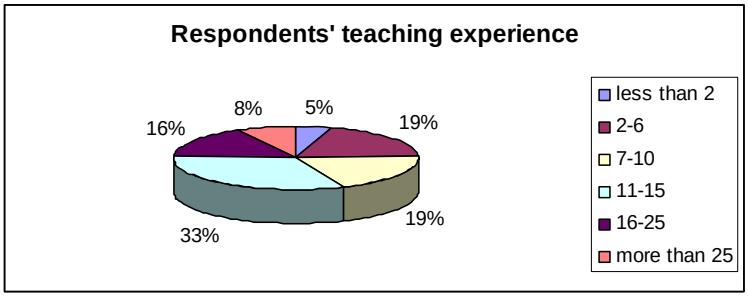

Figure 2. Respondents' teaching experience

50% of the respondents are teaching in primary school (grades 1-4, pupils' age between 6 and 11), 25.8% in secondary school (grades 5-8, pupils' age between 10 and 15), 4.8% in high-school (grades 9-12(13), pupils' age between 14 and 19), and 19.4% both in secondary and high-school.

3.2. Results

The responses are recorded in Table 1 and Table 2.

Table 1. How teachers' guide their pupils' during problem solving (the header is from 1- not at all typical for me to 5 – totally describes me, the numbers in the table are representing percentages)

Affirmation	1	2	3	4	5
I ask pupils to read carefully the text of the problem.	0.0	1.6	12.9	14.5	71.0
I ask pupils to reformulate the text of the problem with their own words.	0.0	11.3	27.4	32.3	29.0
I ask pupils to write down data of the problem and the relations between these data.	0.0	1.6	21.0	21.0	56.5
I ask pupils to check if all the data are used during the problem solving.	0.0	3.2	29.0	27.4	40.3
I ask pupils to check, if the solution is correct.	0.0	1.6	19.4	30.6	48.4
I ask pupils to solve the problem using different strategies.	1.6	32.3	30.6	29.0	6.5
I ask pupils to choose the more efficient strategy if the problem can be solved in different ways.	0.0	8.1	38.7	29.0	24.2
I ask pupils to write down the detailed solution.	0.0	3.2	40.3	32.3	24.2
I ask pupils to explain the used strategy to their colleagues.	0.0	18.1	47.5	27.8	6.6
I ask pupils to explain their strategy while solving the problem	0.0	14.5	35.5	33.9	16.1

Table 2. How teacher reacts if a pupil can't solve the problem (the header is from 1- not at all typical for me to 5 – totally describes me, the numbers in the table are representing percentages)

Affirmation	1	2	3	4	5
I ask him/her to read again the text of the problem.	0.0	1.6	16.1	22.6	59.7
I ask him/her to tell what is his/her difficulty..	1.6	3.2	27.4	35.5	32.3
I give him/her ideas, but I don't give the necessary strategy.	0.0	3.2	17.7	37.1	41.9
I write the solution on the blackboard.	35.5	46.8	11.3	0.0	6.5
I encourage him/her to try more methods.	3.2	11.3	46.8	29.0	9.7
I ask him/her to present previous knowledge about the problem.	1.6	12.9	46.4	24.8	14.3

In the following we add the percentages from column 1 and 2 to obtain the percentage of those teachers who don't assume the given affirmation, and we add column 4 and 5 to get the percentage of those teachers whom typical.

3.3. Discussion

Understanding the problem is one of the most important steps of the problem solving. Pupils should read the text of the problem, identify the context of the problem, rephrase the problem in their own words, write down the given and unknown data, draw diagrams and figures to help themselves to understand better the problem and see the relations between these data. Most of the teachers (85.5%) ask the pupils to read carefully the text of the problem, 77.5% of them guide pupils to write down the data of the problem and the relations between these data, but only 61.3% ask the pupils to reword the problem (Table 1).

Self-efficacy is student's judgments about their ability to successfully complete a task, as well as students' confidence in his/her skills to perform the task [12]. The questions related with this skill is about explaining their difficulties in case of an unsuccessful problem solving and evaluating the correctness of a solution. 79% of the teachers are aware about the importance of checking the correctness of the solution (Table 1). 67.8% of the teachers are asking their pupils to explain the difficulties what they have encountered in case of an unsuccessful problem solving (Table 2).

Self-control and self-monitoring are important skills of a self-regulated learner. While solving mathematical problems "control has to do with the decisions and actions undertaken in analyzing and exploring problem conditions, planning courses of action, selecting and organizing strategies, monitoring actions and progress, checking outcomes and results, evaluating plans and strategies, revising and abandoning unproductive plans and strategies, and reflecting upon all decisions made and actions taken during the course of working on a problem." ([3], p. 4) From Table 1 we conclude that the percentage of those teachers who ask pupils to check data and outcomes is high: 67.7% of the teachers ask pupils to check if they have used all the data of the problem, 79% ask to check if the solution is correct. The percentage of those teachers who ask pupils to use more strategies for solving a problem is much lower, only 35.5%. A higher percentage, 53.2% of the teachers ask their pupils to choose the more efficient strategy if a problem can be solved using different strategies. These low percentages can be explained with the fact that traditional mathematics teaching is still widely used in Romania: the teacher presents a method that gives problems to practice that method. This is encouraged by the national tests, where problems are not challenging; they need only to apply formulas or algorithms [4, 5].

Asking pupils to explain how they solve a problem is important for developing their SRL skills. Questions as "What (exactly) are you doing? Why are you doing it? How does it help you?" ([14], p. 206) help students to reflect on their strategies and to verbalize their reasoning. "When thinking is articulated regularly, patterns of thinking develop that are iterative. Thinking cannot be articulated unless students reflect on the problem and the strategies they use to solve it; articulation, in turn, increase reflection, which leads to understanding." ([1], p. 188) The collaborative learning helps students to develop their self-regulation competencies [11] and gives the opportunity for the pupils to verbalize their thinking, to explain their reasoning. 50% of the teachers ask pupils to tell how they

solve the problem and only 34.4% of the teachers guide students to explain the used strategy to their colleagues (Table 1).

In case of unsuccessful problem solving there are some steps one can make: reread the problem, recall previous knowledge, try different methods, search for similar worked examples, seek for help, etc. Only 39.1% of the teachers ask pupils to present previous knowledge about the problem and 38.7% to recall and try different methods.

4. Conclusions, recommendations, future directions of investigations

The results are shown that more than two third of the teachers promote the methods of understanding the problem; develop pupils' self-efficacy and self-control. But only one third of the teachers ask pupils to use different strategies for solving a problem; ask students to explain the solution to their colleagues. In case of unsuccessful problem solving only one third of the respondents ask pupils to present previous knowledge about the problem; recall and try different methods.

The research limitation is the size of the sample. To get stronger conclusions the research should be extended to a wider sample. As a future research, it would be interested to study the correlation between teachers' problem solving guidance in the classroom and their pupils' self-regulation level.

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