ELEMENTARY STUDENTS' AND TEACHERS' REPORTS OF STRATEGIC BEHAVIOR IN MATHEMATICS: HOW CLOSE ARE THEY?

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Abstract

Research has shown that students and teachers need to act strategically to self-regulate their activity before, during, and after learning and teaching in order to maximize their effectiveness. The present study aimed at investigating the metacognitive and self-regulatory strategies that elementary school students and teachers report using during mathematics learning and teaching respectively. This presentation aimed to investigate the most and the least frequently used strategic behaviors during mathematics as reported separately by elementary students and teachers. There were 344 5th and 6th grade students and 292 elementary school teachers participating in the study. Students' strategic behavior during mathematics learning and problem solving was assessed with an 11-item questionnaire. Students were asked to report on a 5-point answer scale how frequently they employ the behaviors described in the sentences during mathematics learning and problem solving. Teachers' use of strategies during mathematics instruction was assessed by means of an 18-item questionnaire. Eleven out of the 18 items in the teachers' questionnaire corresponded to the 11 items of the students' questionnaire. Teachers were asked to report on a 5-point answer scale how frequently they employ the specific behaviors described in the sentences during mathematics teaching in order to activate and develop their students' metacognition and self-regulated learning. The two instruments had been previously tested for their structural validity and reliability. Descriptive statistics showed that, in general, elementary school students and teachers report similar strategies as the most and the least frequently used during mathematics. For example, the most frequently employed strategic behavior reported by the students was that, when confronted with a mathematical problem, they try to spot its key points in order to help them reach the solution. The second most frequently used strategy by the students was that, after solving a mathematical exercise, they consider if the solution produced does make sense, if it is logical. Similar results were found regarding teachers. That is, the teachers reported that they ask very frequently their students to spot the key points of a mathematical exercise in order to help them reach a solution and that they ask their students to consider if the solution produced does make sense. The reports of students and teachers also were similar regarding the least frequently employed strategic behaviors. For example, both groups reported that the least frequently employed strategic activity was that of students' self-monitoring during dealing with mathematics learning and problem solving. Students' and teachers' reports presented also some minor differentiations. For example, although teachers reported that they frequently ask from their students to check for the correctness of their answers and solutions produced in mathematics (3rd on teachers' ranking), the students reported that evaluating the solution/answer produced was not so frequently used (7th on students' ranking). The results will be discussed in the frame of self-regulated learning and teaching.

Keywords - Self-regulatory strategies, students' and teachers' metacognition, mathematics learning and teaching

INTRODUCTION

Research on self-regulation has focused on the individual's capacity to monitor and modify behavior, cognition, affect and environment, in order to achieve a goal [8, 21, 28]. Basic components of self-regulatory behavior is metacognition, that is, metacognitive knowledge and metacognitive skills, the motives of an individual (i.e., goal setting, intention and will of doing something, positive self-concept) and the strategic thought and action, which means that the individual selects and applies the suitable strategies each time and organises the environment in such a way that the probability of achieving the goal is maximized [26]. Students' and teachers' reports on self-regulatory strategy use, i.e., metacognitive knowledge about strategies, are the focus of the present study. Metacognitive

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knowledge about strategies refers to what the person has learned about what means or strategies are likely to succeed in achieving a specific cognitive goal [9]. Research showed that metacognitive knowledge of strategies is reciprocally related to the actual strategy use as it facilitates the actual use of appropriate strategies [3]. It has also been found that high achievers report that they enact learning strategies more frequently in comparison to low achievers [23]. In general, it is believed that metacognitive knowledge of strategies can affect performance in the long run and mainly indirectly, through its relationship to the actual strategy use. In this study, we examined students' reports regarding the self-regulatory strategies they use within a specific learning domain, i.e., mathematics. Teachers' reports regarding the degree to which their teaching induces students to self-regulate their mathematics learning and problem solving were also examined. The main aim was to investigate the degree of agreement between the reports of students and teachers regarding the self-regulatory strategies used during mathematics learning and teaching respectively.

Self-regulated learning

In today's classrooms there is a tendency for redistribution of responsibility of learning between the teacher and the students. Nowadays, it is expected that students will progressively undertake the control of their own learning [5]. The self-regulated learning approach claims that students should become able to set their learning goals, to choose from a variety of strategies, and to monitor their progress towards the achievement goal [19, 20]. Self-regulated learners have a repertoire of strategies they appropriately apply to tackle the day-to-day challenges of academic tasks. Planning of learning and problem solving, goal setting, self-monitoring and reflection on the cognitive activity and its outcomes are examples of such skills that can be activated before, during and after learning efforts [27]. Enhancing such skills may have important benefits for the quality of learning and for academic performance. It has been reported that students who were taught the use of various strategies for self-regulation of learning were those that presented the most impressive academic results [1, 10, 22].

In most of the studies, students' strategy use was assessed by means of self-report instruments. The more clearly defined is the context regarding self-reports about strategies the less ambiguity in self-reports is observed [25]. In this study we examined students' reports regarding the self-regulatory strategies they use during mathematics learning and problem solving.

Teaching for metacognition and self-regulated learning

Self-regulation during learning and problem solving might be a spontaneous process in the classroom, but a lot of students need their teacher's support in order to endorse self-regulatory skills [11]. Students need to know what to learn, how to learn it, how to monitor their understanding of the topic, how to monitor the effectiveness of their learning strategies, how to revise their strategy use and understanding of the topic if needed [2]. Thus, the teacher undertakes the responsibility to provide students with the appropriate environment as well as with opportunities for self-regulation and self-management [17].

Teaching for metacognition and self-regulation means that teachers provide instruction on effective strategies in order to get the students able to plan their learning activities, to monitor the learning process, and to evaluate themselves after dealing with a task [12]. Among others, teaching for self-regulation means that teachers involve students into metacognitive practices during learning, such as to think about how they remember information, and use strategies that promote active and independent learning, such as scaffolding [12]. Self-regulatory strategies instruction is important because it empowers students to take control of their own learning, allowing their performance to match their potential. Moreover, instruction of metacognitive strategy enables the learners to reach a high-level cognitive process by allowing them to discover appropriate problem solving processes and use these processes under different conditions [24]. Self-regulated learning and self-regulated teaching are thought to be active, thoughtful and interactive processes [4] that are in the long run connected with the academic results of teachers and students.

Agreement between students' and teachers' reports

Many studies have shown that students and teachers do intentionally adapt to each other's intellectual styles. For example, it has been shown that there is an agreement between students and teachers in terms of preferred learning/teaching styles. That is, both students and teachers think that students learn best when teachers use fun activities, let students discover answers, move around the class and help individual students, they also both like to use pair work and group work in class and like the idea of teaching test taking skills [13]. The degree of agreement between students' and teachers' self-reports regarding dimensions of learning is frequently dependent on the precision of their estimations. Many theorists claim that the teachers offer the most precise evaluation of students' behaviors [16]. The precision of teachers' estimates is depended on the methodology used to evaluate the concept studied as well as on students' age. This means that different kind of methods (e.g., self-report measures, observation) that teachers use to evaluate students' behaviors affect the precision of these estimates. It is also claimed that the older the students are the more teachers' - and parents'- evaluations correspond with the actual behaviors and the evaluations of students [14]. To conclude, the empirical evidence shows that, progressively, students and teachers are getting able to adapt to each other's styles and preferences which implies that both groups are coming closer as regards their estimations and self-reports. The older the students are the closer their reports are getting to significant others' reports.

The present study

The aim of the present study was to investigate the degree of agreement between the reports of students and teachers regarding the self-regulatory strategies used during mathematics learning and teaching respectively. Literature shows that a progressive agreement is observed between students' and teachers' reports regarding various dimensions of learning. Further information on this issue might help us to better comprehend the interactions between students and teachers. If, for example, teachers have different views regarding priorities regarding strategic learning mathematics in comparison to their students' priorities, then, confusions or/and misunderstandings in mathematics learning might arise.

Students' and teachers' self-reports were assessed by means of two different instruments with reference to mathematics. Based on previous research evidence, the following hypotheses were formulated:

Hypothesis 1. The reports of students and teachers regarding the strategies employed or asked to be employed during mathematics were expected to be quite similar.

Hypothesis 2. The reports of older students (6^{th} grade students) regarding the use of strategies during mathematics were expected to be more similar to the teachers' reports in comparison to the younger students' reports (5^{th} grade).

METHOD

Participants

In this study there were two samples, elementary school students and teachers.

Students. There were 344 students of 5th and 6th grade from 7 different primary state schools Greece. The students were about equally distributed to the 5th and the 6th grade of primary school (173 students from 5th grade and 171 students from the 6th grade). Concerning the gender of the participant students, 52.6 % were males (181 students) and 47.4 % were females (163 students).

Teachers. The sample consisted of 292 elementary school teachers of whom 43.2 % were males (126 teachers) and 56.8 % were females (166 teachers). Teachers' mean age was about 42 years old and their teaching experience ranged from 1 to 34 years (Mean = 13.28, S.D. = 8.02).

Instruments

Students' reports regarding self-regulated learning in mathematics. This questionnaire was developed by Dermitzaki and Efklides [6] and assesses students' reports about the self-regulatory strategies used during problem solving. Eleven strategies and practices are included. Students were asked to report on a 5-point answer scale from 1 (I never do it) to 5 (I always do it) how frequently they employ the specific behaviors during mathematics learning and problem solving. A pilot study conducted with a sample of 125 students illustrated that the questionnaire had acceptable internal consistency and structural validity. Principal component factor analysis with oblimin rotation showed 2 factors explaining 42.49 % of the variance. The first factor of the reported self-regulatory strategies was named Metacognition and Reflection (8 items, α = .75, e.g. "I think of various ways in order to solve a problem in mathematics and afterwards I choose the best one"). The second factor was named Deep Comprehension and Memorisation (3 items, α = .60, e.g. "After I have studied carefully the material in maths, I explain in my own words what the problem or the unit is all about").

Teachers' reports regarding teaching for self-regulation in mathematics. Teaching of self-regulatory strategies during mathematics instruction was assessed by means of an 18-item questionnaire based on Hartman's [12] and Mevarech and Kramarski' s [18] work. During the instrument development, care was taken for the correspondence between the two instruments' items (students' and teachers'), although the teachers' questionnaire was more extended than that of the students'. Teachers were asked to report on a 5-point answer scale from 1 (I never do it) to 5 (I always do it) how frequently they employ the specific behaviors during mathematics teaching in order to activate and develop their students' metacognition and self-regulated learning. The questionnaire's internal consistency and structural validity had been found to be acceptable in a pilot study. Principal component factor analysis using oblimin rotation suggested 5 factors explaining 57.70% of the variance. The first factor was Developing Forethought (5 items, α = .69, e.g. "Help students understand that their strategies in maths learning are related to their academic outcomes, e.g., I explain that learning by heart is an appropriate strategy for some subjects but not for others"). The second factor was Encouraging Metacognition and Cooperation (5 items, α = .72, e.g. "After finishing studying, I encourage students to consider if they have learnt what they wanted to learn"). The third factor was Inducing Practice and Modelling Problem Solving (3 items, α = .56, e.g. "I demonstrate to students how they should approach a problem to be solved, e.g., I think aloud in order to show them how to solve a problem"). The fourth factor was Instigating Deep Understanding (2 items, α = .63, e.g. "Ask students to spot the key points of the problem that will help them reach a solution"). Finally, the fifth factor was Solution Evaluation (2 items, α = .62, e.g. "Ask students to check the correctness of their answers and the solution in each mathematical problem").

Procedure

The Headmasters' consent of each one of the primary schools had been ensured before distributing questionnaires to teachers and their students. Teachers were asked to complete the questionnaire at home. Teachers were also asked to permit the researcher to distribute the questionnaires to their students and were informed that the whole process would last about 15 minutes. During questionnaire completion by the students, the researcher was reading aloud each question and waiting for all of the students to write down their answers.

RESULTS

Students

Table 1 presents the descriptive statistics for the items of the students' questionnaire assessing use of self-regulatory strategies in mathematics. Descriptive statistics are presented separately for the total sample of the students, for the 5th and for the 6th grades. The ranking of each item, i.e., its position in a continuum from the most to the least frequent use of a strategy, is also presented in Table 1. For example, the item with a ranking order 1 means that this particular strategy was reported to be used most frequently by this group of students.

Insert Table 1 about here

The most frequently employed strategic behavior reported by the total sample of students was "I try to spot the key points of each mathematical problem that will help me reach a solution". The second most frequently used strategy by the students was "After I have solved a problem in mathematics, I think if the solution is reasonable, if it makes sense". The third strategy was "Before I start solving a problem or studying a unit in mathematics, I think of what I should already know for it in order to reach a solution". The least frequently employed strategic activity was "During solving a problem or studying something new in mathematics, I ask myself how I am doing". While the second least frequently employed strategy was "After I solve a problem in mathematics, I wonder if there was a better way of solving it".

The ranking of the strategies was very similar between the students of 5th and 6th grade. However, a difference in ranking was observed between the two age groups in the following strategies: "After I have solved a problem in mathematics, I think if the solution is reasonable, if it makes sense" which for 6th graders was the strategy mostly used (1st in ranking) whereas for 5th

graders it was ranked in the 4th position. Regarding the strategy “After I have studied carefully the material in maths, I explain in my own words what the problem or the unit is all about”, it was ranked in the 2nd position from the 5th graders and in the 6th position from the 6th graders. Independent samples t-test showed significant difference between 5th and 6th graders in relation to this strategy ($t_{(341)} = 3.561, p = .000$). In particular, 5th graders reported that they explain in their own words what the problem or the unit is all about more frequently (M = 4.30, S.D. = .80) than 6th graders (M = 3.94, S.D. = 1.04).

Teachers

Table 2 shows the descriptive statistics (Means and Standard Deviations) and the ranking of the items of the teachers’ questionnaire assessing how frequently they ask or induce their students to do so during mathematics teaching in order to activate and develop their metacognition and self-regulated learning. The reported strategies ranking is shown in a descending order.

Insert Table 2 about here

Specifically, the teachers reported that, first, they most frequently ask students to spot the key points of the problem that will help them reach a solution and, second, that they ask students to think if the solution they gave is reasonable - if it makes sense. Third in ranking was “Ask students to check the correctness of their answers and the solution in each mathematical problem”. The least frequently used strategies that corresponded to the students’ questionnaire items were “Induce students to monitor their progress during studying or problem solving in mathematics” (15th in ranking) and “After finishing studying, I encourage students to consider if they have learnt what they wanted to learn” (13th in ranking).

Agreement between students’ and teachers’ self-reports

Comparing the ranking of the items in Tables 1 and 2, a general agreement between students’ (total sample) and teachers’ reports regarding the most and the least employed strategies during mathematics was observed. Both groups reported that the two most frequently employed strategies were “to spot the key points of each mathematical problem” and “to think if the solution produced is reasonable - if it makes sense”. Both groups also reported that the least frequently employed strategic activity was that of students’ self-monitoring during dealing with mathematics learning and problem solving.

However, some differences were also noticed between students’ and teachers’ self-reports. Regarding the strategy “Before I start solving a problem or studying a unit in mathematics, I think of what I should already know for it in order to reach a solution”, students ranked it in the 3rd position whereas teachers ranked it in the 7th position. Regarding the strategy “As soon as I solve a problem in mathematics, I check the correctness of the solution”, students ranked it in the 7th position whereas teachers ranked it in the 3rd position. Finally, students ranked in the 9th position the strategy “I think of various ways in order to solve a problem in mathematics and afterwards I choose the best one” whereas teachers ranked it in the 6th position.

As regards the two age groups of students and teachers’ self-reports, there was more similarity between teachers’ reports and the 6th graders reports than with 5th graders. Specifically, 6th graders ranked in the first two positions the same strategies as teachers did, whereas 5th graders only one. Moreover, the distance in rankings between teachers and the 6th graders was smaller in comparison to the 5th graders’ rankings.

DISCUSSION

The purpose of this study was to investigate elementary students’ and teachers’ self-reports regarding the most and the least frequently used self-regulatory strategies in mathematics learning and to find out how close these self-reports were. It is believed that the results of such an investigation could shed light on the nature of academic interactions between students and teachers within the domain of mathematics and on the priorities each group is setting for mathematics learning.

In general, data analyses demonstrated that elementary school students and teachers report similar strategies as the most and the least frequently used during mathematics learning and teaching. Both groups reported that the two most frequently employed strategies were “to spot the key points of each mathematical problem” and “to think if the solution produced is reasonable – if it makes sense”. The reports of students and teachers were also similar regarding the least frequently employed strategic behaviors. Both groups reported that the least frequently employed strategic activity was that of students’ self-monitoring when dealing with mathematics learning and problem solving. Moreover, one of the least frequently used strategic behaviors for both groups was “to think if there was a better way to solve the maths problem”. These results are consistent with previous research illustrating that there is an agreement between students and teachers in terms of preferred learning and teaching styles [13]. Consequently, the first hypothesis of the study has been generally confirmed by the results of the study.

Students’ and teachers’ self-reports presented also some differentiations. Regarding the strategy “Before I start solving a problem or studying a unit in mathematics, I think of what I should already know for it in order to reach a solution”, students reported that they use it frequently (ranked in the 3rd place) whereas teachers reported that they do not ask for it so frequently (ranked in the 7th place). Regarding the strategy “Ask students to check the correctness of their answers and the solution in each mathematical problem”, although teachers reported that they ask very frequently their students to enact it (ranked in the 3rd place), students reported that they do not check for the correctness of the solution so frequently (ranked in the 7th place). Further investigation is needed in order to identify the different priorities that students and teachers might hold regarding the ways they approach mathematics learning. This issue is of great importance if deep comprehension of the academic interactions between students and teachers is the case. Significant gaps between students and teachers regarding their beliefs and priorities in mathematics might affect the cognitive outcomes but also enjoyment of mathematics learning.

Regarding the reports of older students (6th grade), they were roughly found to be more similar to the teachers’ reports concerning the most and the least frequently used self-regulatory strategies during mathematics in comparison to the 5th graders’ reports. Specifically, 6th graders ranked in the first two positions the same strategies as teachers did, whereas in 5th graders only the first strategy in ranking was common with the teachers’. Moreover, the distance in rankings between teachers and the 6th graders was somewhat smaller in comparison to the 5th graders. This finding is consistent with previous research showing that the older the students are the more teachers’ evaluations correspond with the actual behaviors and the evaluations of students [14, 15]. As a result, the second hypothesis of the study concerning the agreement between older students’ and teachers’ reports regarding the self-regulatory strategies used during mathematics has been confirmed.

The results of this study showed also that the ranking of the strategies was very similar between the students of 5th and 6th grade. However, a difference in ranking was observed between the two age groups regarding the strategy “After I have studied carefully the material in maths, I explain in my own words what the problem or the unit is all about”, which was ranked in the 2nd position from the 5th graders and in the 6th position from the 6th graders. This finding shows that younger students may need more than the older students to overtly explain to themselves the information to be proceeded.

Overall, the present data suggest that elementary school students and teachers report similar self-regulatory strategies as the most and the least frequently used during mathematics learning and teaching respectively. This is promising as it implies that, in general, teachers’ priorities and ways of approaching mathematics learning is close to their students’, at least at the last grades of elementary school. However, this study showed that there are also some differences between students’ and teachers’ priorities in mathematics learning. Further research could focus on investigating such differences and their causes in the domain of mathematics as well as to suggest ways to overcome them.

One of the limitations of the present study is that it focuses on students’ and teachers’ self-reports concerning self-regulatory strategy use and not on their actual strategy use as it unfolds during learning. There is a need in future research for more objective measurements of students’ self-regulatory behavior [see for example, 7]. Another limitation of the study is that students and teachers self-reports have been investigated with reference to the mathematics domain meaning that they do not necessarily hold in other domains as well. Future research should further investigate such relations by replicating them not only in mathematics but in other cognitive domains as well.

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Tables and figures

Table 1. Descriptive statistics and ranking for the items of the students' questionnaire

Items	Total sample			5th grade			6th grade		
	Mean	S.D.	Ranking	Mean	S.D.	Ranking	Mean	S.D.	Ranking
• I try to spot the key points of each mathematical problem that will help me reach a solution.	4.27	.89	1	4.32	.86	1	4.22	.93	2
• After I have solved a problem in mathematics, I think if the solution is reasonable, if it makes sense.	4.26	1.02	2	4.18	1.05	4	4.34	.98	1
• Before I start solving a problem or studying a unit in mathematics, I think of what I should already know for it in order to reach a solution.	4.21	1.02	3	4.23	1.09	3	4.18	.95	3
• After I have studied carefully the material in maths, I explain in my own words what the problem or the unit is all about.	4.13	.95	4	4.30	.80	2	3.94	1.04	6
• I try to find ways in order to better remember rules, information and tactics of problem solving in mathematics.	4.07	1.10	5	4.06	1.08	6	4.07	1.12	4
• Before I begin to solve the exercises or to study mathematics, I think of which steps I should make in order to manage it.	4.07	1.06	6	4.10	1.09	5	4.03	1.04	5
• As soon as I solve a problem in mathematics, I check the correctness of the solution.	3.94	1.23	7	3.97	1.22	8	3.91	1.24	7
• When I finish studying mathematics, I wonder if I have learned what I wanted to learn.	3.92	1.19	8	4.01	1.25	7	3.84	1.13	9
• I think of various ways in order to solve a problem in mathematics and afterwards I choose the best one.	3.90	1.11	9	3.95	1.12	9	3.85	1.10	8
• After I solve a problem in mathematics, I wonder if there was a better way of solving it.	3.42	1.25	10	3.57	1.29	10	3.26	1.21	10
• During solving a problem or studying something new in mathematics, I ask myself how I am doing.	3.04	1.40	11	3.20	1.35	11	2.88	1.44	11

Table 2. Descriptive statistics and ranking for the items of the teachers' questionnaire

Items	Mean	S.D.	Ranking
• Ask students to spot the key points of the problem that will help them reach a solution.	4.47	.70	1
• Ask students to think if the solution they gave is reasonable – if it makes sense.	4.43	.75	2
• Ask students to check the correctness of their answers and the solution in each mathematical problem.	4.43	.74	3
• Ask students to explain in their own words what the mathematical problem asks for or what the unit is about.	4.15	.86	4
• I demonstrate to students how they should approach a problem to be solved (e.g., I think aloud in order to show them how to solve a problem).*	4.13	.86	5
• Ask students to think of different strategies or ways in order to reach a solution in a maths problem and, then, choose the best.	4.09	.76	6
• Ask students to think of what they have to know in advance before start studying a unit or solving a problem.	4.09	.88	7
• Demonstrate to students how they should plan their steps of action in order to learn a concept in maths or to solve a problem.	4.03	.87	8
• Ask students to think of ways in order to better remember information, rules etc. in mathematics.	3.93	.79	9
• Ask students to communicate with each other in order to understand a concept of solve a problem, e.g., through conversation in class, through team-work, etc.*	3.91	.84	10
• Prompt students to think if there was a better way to solve the maths problem.	3.88	.89	11
• Ask students to detect mathematical relations and concepts through their everyday life experience.*	3.81	.83	12
• After finishing studying, I encourage students to consider if they have learnt what they wanted to learn.	3.78	.91	13
• Help students to think about how and under which conditions they learn maths better (e.g. ''when I feel relaxed I am dealing first with the difficult problems'').*	3.70	.93	14
• Induce students to monitor their progress during studying or problem solving in mathematics.	3.67	.94	15
• Present material to students in different modalities (e.g. verbal, visual, auditory, tactile-kinaesthetic).*	3.59	.96	16
• Help students understand that their strategies in maths learning are related to their academic outcomes (e.g., I explain that learning by heart is an appropriate strategy for some subjects but not for others).*	3.55	1.05	17
• I give students additional problems, handouts, etc. in each lecture.*	3.46	1.09	18

Note: Items noted with an asterisk (*) were not included in the students' questionnaire.