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# TEACHING MATHEMATICS WITH SELF-REGULATION AND FOR SELF-REGULATION: TEACHERS' REPORTS

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***Abstract*****:** The aim of this study was to investigate whether elementary school teachers' reported use of self-regulatory instructional strategies regarding mathematics corresponds to the different aspects of the construct of self-regulatory teaching described in literature. Two hundred and ninety two Greek teachers responded to two questionnaires assessing: (a) the strategies they use themselves to plan, monitor, and evaluate mathematics instruction, i.e., teaching *with* self-regulation, and (b) the strategies they use to activate and enhance students' self-regulated learning in mathematics, i.e., teaching *for* self-regulation. Confirmatory factor analysis showed that teachers' reported use of self-regulatory teaching is explained by factors of various levels of generality. Teaching *with* and teaching *for* self-regulation emerged as distinct conceptual factors. In addition, the cyclic model of self-regulation (Zimmerman, 2000) was confirmed regarding promotion of students' self-regulated learning in mathematics (i.e., strategies enacted before, during, and after learning) but not regarding teachers' self-regulatory instruction. Associations between teachers' gender, teaching experience, and age, and their reported self-regulatory strategy use were also investigated. Gender differences in favour of women teachers were found with regard to the use of strategies for planning learning and instruction. The results are discussed within the frame of teachers' professional growth and students' improvement of mathematics learning.

***Key words*****:** Mathematics, Self-regulatory strategies, Strategic teaching, Teachers' self-regulation

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## INTRODUCTION

Individuals' capacity to monitor and modify behaviour, cognition, affect, and environment in order to achieve a goal has been the focus of research on self-regulation of learning (Efklides, Niemivirta, & Yamauchi, 2002). Self-regulated individuals use a variety of self-regulatory strategies, that is, active processes that involve agency and purpose (Zimmerman, 2000). Strategic action to effectively monitor and regulate behaviour and problem-solving processes is an essential characteristic of self-regulated individuals. Strategic action is critical in educational settings for both students and teachers (Alexander, Graham, & Harris, 1998; Andreassen & Braten, 2011; Efklides, 2011; Weinstein, Husman, & Dierking, 2000).

While research on students' self-regulated learning and self-regulatory strategies has grown rapidly over the last 20 years, more recently a gradually developing literature focuses on how teachers can engage in this process themselves (e.g., Dabbagh & Kitsantas, 2009; Kitsantas, this issue; Kramarski & Revach, 2009; Kreber, Castleden, Erfani, & Wright, 2005; Tonks & Taboada, 2011; Zohar, 2004). Teachers need to use various strategies to self-regulate their instruction in order to maximise their teaching effectiveness and to facilitate students' academic learning and achievement (Artzt & Armour-Thomas, 2001; Hartman, 2001; Kramarski & Revach, 2009; Kreber et al., 2005; Pape, Bell, & Yetkin-Özdemir, 2013). Some of these strategies include setting clear teaching objectives, planning and monitoring instruction, reflecting on achievement of teaching goals, and, regarding students, promoting self-regulatory skills, such as self-monitoring, reflective practice, and self-assessment.

To the best of our knowledge, no study so far has investigated whether self-regulatory teaching comprises distinct aspects, such as self-regulation of teaching and regulation of students' self-regulatory strategies. Specifically, a research question that warrants investigation is whether teachers perceive their own efforts to strategically regulate their instruction as distinct from instructional strategies that support students' efforts to self-regulate their learning. Moreover, it is interesting to investigate whether Zimmerman's (2000) cyclical model of self-regulated learning, also emerges from teachers' self-reports about their teaching: do teachers report preparing, implementing, and reflecting on their instruction as well as facilitating students' self-regulation? Furthermore, it is important to know whether teachers' individual differences factors, such as gender, age, and teaching experience, account for differences in the use of self-regulatory instructional strategies and practices. Such explorative data can contribute to our understanding of the role of self-regulatory teaching in teachers' professional growth. It is possibly through engagement in self-regulatory instructional practices that school teachers develop their potential and capacities as teachers (Kreber et al., 2005).

For the purposes of this study, self-regulatory instructional strategy use was studied with reference to mathematics as it is a subject of major importance in the elementary school curriculum. In addition, mathematics as a subject domain is clearly structured, and presumably this facilitates the use of self-regulatory teaching strategies.

### *Self-regulatory instructional strategies*

The importance of self-regulated instruction and learning has led to the development of various theoretical models (e.g., Boekaerts & Niemivirta, 2000; Pintrich, 2000; Zimmerman, 1998, 2000). This study adopted the socio-cognitive cyclical model of self-regulated learning proposed by Zimmerman (2000). According to this model, the process of self-regulated learning follows three cyclical phases, that is, forethought, performance or volitional control, and self-reflection. Forethought refers to processes that precede efforts to act, such as goal setting and strategic planning. The second phase, performance or volitional control, involves processes that occur during action; these are processes such as attention focusing, use of cognitive strategies and self-observation. The third phase, self-reflection, involves processes that occur after performance. They include the person's response to the experiences they had had during the performance phase, such as self-reflection and self-evaluation.

Hartman (2001) made a theoretical distinction between teaching *with* metacognition and teaching *for* metacognition. A similar distinction could be invoked between teaching *with* self-regulation and teaching *for* self-regulation as a broader construct including metacognitive processes. Teaching *with* self-regulation means that teachers need to self-regulate their instruction before, during, and after conducting lessons in order to enhance the effectiveness of their instruction. It has been shown that effective teachers conduct lessons with advance planning of their teaching, monitor their instruction and take time for reflection, self-evaluation and revision of their teaching practices (Hartman, 2001; Kramarski & Revach, 2009; Porter & Brophy, 1998).These self-regulatory practices are in line with Zimmerman's (2000) model. Specifically, applying Zimmerman's model in mathematics teaching one would expect that at the forethought phase, that is, before the implementation of mathematics instruction, teachers prepare their teaching, set teaching goals, plan their actions, and organise the instructional and teaching material (Artzt & Armour-Thomas, 2001). At the performance phase, that is, during instruction in the classroom, teachers monitor students' understanding, identify and resolve misconceptions; at the same time they monitor and regulate their own instructional efforts and activities. Finally, after instruction, at the self-reflection phase, teachers evaluate the effectiveness of their instruction and of teaching strategies employed, reflect on them but also evaluate their students' understanding of the notions taught and their progress.

Moreover, teachers' ability to cultivate self-regulated learners is tied to teachers' own self-regulation (Kramarski & Michalsky, 2009; Zohar, 2004). Students should be given the tools they need by teachers in order to keep up with learning demands themselves. Teaching *for* self-regulation means that teachers activate or 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. Students are empowered through self-regulatory strategy use to take control of their own learning, allowing their performance to match their potential (Alexander et al., 1998; Fuchs, Prentice, Burch, Hamlett, Owen, et al., 2003; Pressley & Hilden, 2006). Regarding mathematics, teachers must support students to build strategic competence, skills, behaviours, and positive attitudes that will enable them to regulate their mathematics learning and achievement (Pape et al., 2013).

To conclude, both teaching *with* and teaching *for* self-regulation are needed in order to improve instructional outcomes, classroom communication and facilitate students' effective performance. In this study, two different categories of teachers' strategic activities were investigated via self-reports, that is, strategies for teachers' own self-regulation and strategies for enhancing students' self-regulation. It was examined whether teachers' reports reflect these two aspects of self-regulatory teaching strategies as relatively independent sets of practices. Furthermore, it was investigated whether teachers' self-reported teaching practices can be accounted for by the three phases of the cyclical model of self-regulation (Zimmerman, 2000).

### *Individual factors associated with self-regulatory use of instructional strategies*

Research findings suggest that teachers' gender, age, and teaching experience are associated with differences in teachers' practices, instructional strategies, and in the ways they motivate students (Kreber et al., 2005; Skinner & Belmont, 1993; Zohar, 2004).

#### *Gender effects*

Regarding instructional strategies for teachers' self-regulation of teaching, Singer

(1996) investigated the effect of personal and context variables such as gender, academic discipline, age, academic rank, class level, and class size on the use of instructional practices by college teachers of mathematics, English, biology, and psychology. Gender was the most important predictive factor of instructional strategy use in all academic subjects examined. Female teachers were more likely than male to invest time in planning their lessons, in the design of learning activities as well as in the evaluation of teaching outcomes. However, other researchers reported (e.g., Stewart, Cooper, & Moulding, 2007) that no gender differences were found in teachers' self-reports as regards metacognitive knowledge and metacognitive self-regulation assessed by the Metacognitive Awareness Inventory (MAI, Schraw & Dennison, 1994).

Regarding teachers' self-reported use of strategies for enhancing students' self-regulation, Retelsdorf, Butler, Streblow, and Schiefele (2010) found that female teachers in elementary education were more likely than male teachers to report that they generally use student-oriented instructional practices (e.g., "In my class, special efforts are made to identify individual student progress, even though the level of their grades is low", "The individual development of my students is especially important for me in my classroom"). Moreover, Singer (1996) reported that female teachers tended to promote learning environments that were more student-focused, more convenient and effective and appeared to use discussion in the classroom more often than male teachers. They also tended to encourage cooperation and emotional learning techniques more than other educational behaviours. However, other researchers reported that the gender of the teacher does not matter much with respect to classroom practice characteristics (Opdenakker & Van Damme, 2006)

In conclusion, when comparing male and female teachers' self-reports of their own teaching and strategies for enhancing students' learning the findings are not consistent. Some studies have shown that female teachers report more often than male teachers that they use strategies to self-regulate their own instruction and strategies for enhancing students' self-regulation but other studies have not. It is likely that the research findings are influenced by the subject area/course being studied or the type of strategies being examined in each study.

### *Teaching experience and age*

Teaching experience has been linked to teachers' flexibility and confidence which influence classroom practices (Bransford, Brown, & Cocking, 1999). One could argue that teaching experience co-varies with age, and, therefore, the two variables have similar effects on self-regulatory strategy use. However, this is not always the case. For example, Stewart et al. (2007) reported that teaching experience was significantly associated only with teachers' metacognitive regulation and not with their metacognitive knowledge, while teacher age correlated significantly both with metacognitive regulation and with metacognitive knowledge. In general, experienced teachers scored higher on metacognitive regulation compared to pre-service teachers. This suggests that higher self-reports of metacognitive regulation skills reflect changes that take place as people grow up and as they teach others as professional educators (Stewart et al., 2007). Artzt and Armour-Thomas (2001) also reported that more experienced teachers engaged more in metacognition in their instructional practice to promote student learning and understanding, whereas novice teachers focused on content coverage and time management.

However, while the experience one accumulates is an important part of expertise, experience by itself does not warrant the development of expertise (Berliner, 1994; Bruer, 1993; Kreber et al., 2005). Research regarding teaching expertise indicates that there are both quantitative and qualitative differences between experts and novice teachers. These differences have been found in a variety of fields including teaching physics, architecture, electronics, etc. (Bruer 1993; Swanson, O'Connor & Cooney, 1990). Studies comparing expert with novice teachers suggest that there are differences in planning, instruction, as well as perception of and reflection on classroom events (Housner & Griffey, 1985; Zohar, 2004).

The present study examined the role of teachers' gender, teaching experience, and age in the self-reported strategies with- and for self-regulation.

### *The present study*

The aim of this study was to explore whether the construct of self-regulatory teaching for Greek teachers consists of two distinct groups of strategies, namely, teaching *with* and teaching *for* self-regulation. A second aim was to investigate whether the three phases of self-regulatory teaching -preparation, implementation, reflection and self-evaluation- are also perceived as distinct. A third aim was to investigate the effect of individual differences factors such as teacher gender, age, and teaching experience, on self-reported strategy use.

For the purposes of the present study, two self-report instruments for teachers were developed in order to assess perceptions of self-regulatory strategy use with reference to mathematics instruction in elementary school. The participating teachers were asked to report: (a) how frequently they use a series of self-regulatory strategies and practices that tap preparation, implementation, and reflection on mathematics instruction, that is teaching *with* self-regulation. These strategic activities will be called Strategies for Teachers' Self-Regulation (STSR). (b) How frequently they enact strategies and practices that promote and enhance students' self-regulated learning, that is, teaching *for* self-regulation. These strategic activities will be called Strategies for enhancing Students' Self-Regulation (SSSR).

The hypotheses tested were the following:

1. Self-regulatory teaching is a higher-order factor comprising two more narrow factors, one tapping teaching with self-regulation and one tapping teaching for self-regulation (Hypothesis 1).
2. Each of the narrow factors will consist of three groups of strategies, representing the three phases of self-regulated learning, namely preparation, implementation and self-reflection; or put it differently, strategies enacted before, during, and after mathematics instruction (Hypothesis 2).
3. Female teachers will report more frequent use of strategies for self-regulation of their teaching as well as for students' self-regulated learning than their male colleagues (Hypothesis 3).
4. More experienced teachers will report more frequent use of strategies for self-regulation of their teaching and for students' self-regulated learning than novice teachers (Hypothesis 4).
5. Older in age teachers will report more frequent use of strategies for self-regulation of their teaching and for students' self-regulated learning compared to younger teachers (Hypothesis 5).

## METHOD

### *Participants*

Participants were 292 elementary school teachers from 90 different state schools located at 3 medium-sized towns in Greece. The teachers were teaching mathematics in the six grades of the elementary school and they were about equally distributed along the six grades. There were 166 female teachers (56.8 %) and 126 males (43.2 %). Their teaching experience ranged from 1 to 34 years ($M = 13.28$) and their mean age was 42 years.

### *Instruments*

*Strategies for Teachers' Self-Regulation (STSR)*

In order to assess the self-regulatory strategies that elementary school teachers report using in order to prepare, implement and evaluate the instruction of mathematics, a scale was developed by the authors based on the work of Hartman (2001) and Mevarech and Kramarski (1997). The development of the questionnaire is described in Chatzistamatiou and Dermitzaki (2009). The instrument comprises of 11 statements corresponding to the three phases of self-regulated learning and teaching (Zimmerman, 2000), that is, before (6 items), during (3 items), and after (2 items) the implementation of instruction. Example items are: "During planning mathematics instruction, I clearly state to myself the objectives of teaching mathematics, e.g., what students need to have learnt at the end of the lesson or which skills they need to practice" and "I monitor myself during math instruction pointing out my strengths and weaknesses as a teacher". The participants reported the frequency of use of each strategy on a Likert-type response scale ranging from 1 (*Never*) to 5 (*Always*).

*Strategies for Students' Self-Regulation (SSSR)*

Enactment of strategies to enhance students' self-regulated learning in mathematics was assessed by means of a 13-item questionnaire developed for the purposes of the present study. It was based on the work of Dermitzaki and Efklides (2002) and Mevarech and Kramarski (1997). A first version of the questionnaire was tested in a pilot study (Chatzistamatiou & Dermitzaki, 2009). Teachers were asked to report on a Likert-type scale ranging from 1 (*Never*) to 5 (*Always*) how frequently they employ specific strategies in order to activate and enhance their students' self-regulated learning during mathematics teaching. The items represented the three phases of self-regulated learning (Zimmerman, 2000), that is, before (4 items), during (5 items), and after (4 items) the instruction. Example items are: "I ask students to plan their steps of action in order to attain a goal in mathematics, e.g., in order to learn a concept in math or to solve a problem", and "I ask students to check the correctness of their answers or the solution produced for a mathematical problem".

### *Procedure*

The participant teachers were approached during school intervals after the consent of the director of each school had been ensured. They completed the questionnaires during school intervals or at home. For the purposes of the study, permission was obtained by the Ministry of Education.

## RESULTS

### *Factor structure of the self-regulatory teaching strategies scales*

Hypotheses 1 and 2 regarded the structure of the two questionnaires of the study. It was hypothesized that there are distinct categories of self-regulatory instructional strategies at various levels of generality. Specifically, it was hypothesized that self-regulatory teaching is a general construct reflecting teachers' efforts to regulate mathematics instruction and their students' learning. Therefore, this construct should be represented by a general common factor explaining all the strategies used by the teacher to self-regulate mathematics instruction and learning. Furthermore, the teaching *with* self-regulation and teaching *for* self-regulation should be reflected in two distinct factors, each representing the respective scale (STSR and SSSR). Finally, within each scale three different groups of strategies should be evident corresponding to the three phases of self-regulated learning and teaching (before, during and after instruction).

In order to test this set of hypotheses, Confirmatory Factor Analysis (CFA) was applied on the data using the EQS statistical program (EQS - Structural Equation Modeling Software) Version 6.1 for Windows (Bentler, 2006). The maximum likelihood method (Hu & Bentler, 1999) was applied. The nested-factor method was applied to the data. The nested-factor model (NF-model) technique allows directly specifying the relations between observed variables and latent variables (factors) of different degrees of generality. This technique allows the decomposition of the variance of observed variables into components of variance from sources of different degrees of generality (Gustafsson, 1994). The NF-model has the advantage of allowing more straightforward interpretations while, in contrast, in the higher-order models "...the general factor stands in a more remote and indirect relationship with the observed variables" (Gustafsson, 1994, p. 58). General factors are introduced first and more narrow or specific factors are introduced at subsequent steps in order of generality. Entering an additional factor each time should improve the model fit. In this study, individual item scores were treated as indicators of the hypothesized latent factors. All the items were included in the analyses.

The model tested was a NF-model with the following factors accounting for the variance of the items of the two scales: (a) a general Self-regulatory Strategies factor accounting for the variance of all the 24 items of the two scales; (b) two factors representing STSR and SSSR accounting for the variance of 11 and 13 items respectively, and (c) specific factors representing the three phases of self-regulation, i.e., three factors within STSR and three factors within SSSR. The six factors were considered as nested within two higher-order factors and within one general factor.

The steps towards building the NF-model were the following. In Step 1, a general Self-regulatory Strategies factor accounted for the variance of all the 24 items of the two scales. The fit of Model 1 was not satisfactory (see Table 1). In Step 2, a more narrow factor accounting for the variance of the 11 items assessing teachers' self-regulation (STSR) was introduced. The fit of the model was significantly improved. In Step 3, a second narrow factor accounting for the variance of the 13 items assessing strategies for students' self-regulation (SSSR) was introduced. The inter-correlation between the two narrow factors was included in this model. Again, the fit of the model was significantly improved. In Steps 4, 5, and 6 the most narrow or specific factors of STSR were being introduced successively one at a time. Inter-correlations between the factors were also included. However, in Step 6, when introducing the third specific factor that reflected teachers' self-evaluation and reflection after the instruction, the fit of the model became worse. Therefore, we decided to omit this step and to collapse the two items of this factor into the first and the second factor of STSR, as suggested by the LM Test. In the following steps -6, 7, and 8- the three specific factors of SSSR were introduced successively one at a time. Inter-correlations between the factors were included. The fit of each successive model tested is shown in Table 1.

***Table 1. Comparison of model fit indices (Steps 1-8) of the successive models of the scales on teaching strategies***

| | $x^2$ | $p$ | $\Delta x^2$ | $\Delta df$ | BBNFI | BBNNFI | CFI | SRMR | RMSEA |
|---|---|---|---|---|---|---|---|---|---|
| Step1 | (252, $N$ = 292) 692.337 | < .001 | | | .630 | .697 | .724 | .073 | .078 |
| Step2 | (241, $N$ = 292) 571.270 | < .001 | 121.067 | 11 | .694 | .763 | .793 | .065 | .069 |
| Step3 | (227, $N$ = 292) 449.432 | < .001 | 121.838 | 14 | .760 | .830 | .860 | .055 | .058 |
| Step4 | (220, $N$ = 292) 421.376 | < .001 | 28.056 | 7 | .775 | .841 | .874 | .053 | .056 |
| Step5 | (215, $N$ = 292) 411.852 | < .001 | 9.524 | 5 | .780 | .841 | .876 | .053 | .056 |
| Step6 | (209, $N$ = 292) 338.413 | < .001 | 73.439 | 6 | .819 | .893 | .919 | .045 | .046 |
| Step7 | (201, $N$ = 292) 304.289 | < .001 | 34.124 | 8 | .837 | .911 | .935 | .044 | .042 |
| Step8 | (193, $N$ = 292) 262.585 | < .001 | 41.704 | 8 | .860 | .938 | .956 | .040 | .035 |

$\Delta x^2$ = chi square difference; $\Delta df$ = degrees of freedom difference; BBNFI = Bentler-Bonett Normed Fit Index; BBNNFI = Bentler-Bonett Non-Normed Fit Index; CFI = Comparative Fit Index; SRMR = Standardised Root Mean-Square Residual; RMSEA = Root Mean-Square Error of Approximation.

The full model (Step 8) is presented in Table 2. The fit indices for the full model were: $\chi^2(193, N = 292)$ 262.585, $p < .001$, Bentler-Bonett Normed Fit Index (BBNFI) = .860, Bentler-Bonett Non-Normed Fit Index (BBNNFI) = .938, Comparative Fit Index (CFI) = .956, Standardized Root Mean-Squared Residual (SRMR) = .04, Root Mean-Square Error of Approximation (RMSEA) = .035. The fit of this final model is good. The $\chi^2$/df ratio is 1.35 (lower than 1.96) and the SRMR, RMSEA, and CFA indexes meet the statistical cut-off criteria for a good fit (Hu & Bentler, 1999; Marsh, Balla, & Hau, 1996).

Inspection of Table 2 shows that most of the item loadings on the general factor (F1) were statistically significant. Moreover, the variance of the items Q8, Q9, and Q11, of the factor Monitoring Instruction and Reflecting (F5) of the STSR, was better explained by the general factor than by the respective narrow factors. The two narrow factors, F2 and F3, were robust as they explained a significant part of the variance of the respective items. Moreover, the STSR (F2) factor better explained the variance of the items of the factor Planning Instruction and Evaluating Goals (F4) in comparison to the F4 factor.

Further, the five specific factors (F4-F8) were indicative of the distinct aspects or groups of strategies within each one of the two scales. Regarding the STSR, the F4-Planning Instruction and Evaluating Goals factor (7 items, Cronbach's $\alpha = .73$) represented the phase of lesson preparation before teaching as well as reflection whether the teaching goals had been accomplished. The F5-Monitoring Instruction and Reflecting factor (4 items, Cronbach's $\alpha = .61$) mainly included practices that teachers use to monitor the course of their instruction in order to be effective as well as enactment of further self-reflection with reference to their teaching. Three specific factors were nested within the SSSR reflecting the three phases of self-regulated learning: The F6-Deep Understanding of the task and Forethought (4 items, Cronbach's $\alpha = .67$), the F7-Encouraging Metacognition and Reflecting (5 items, Cronbach's $\alpha = .76$), and the F8-Solution Evaluation (4 items, Cronbach's $\alpha = .65$). All the items but one (Q15) loaded significantly on their respective specific factor.

Finally, medium-sized correlations were observed between the F2-STSR and F3-SSSR factors ($r = .58$). Moreover, medium-sized correlations of the F6-Deep Understanding of the task and Forethought factors with both the F4-Planning Instruction and Evaluating Goals ($r = .55$) and F5-Monitoring Instruction and Reflecting ($r = .57$) factors were observed.

***Table 2. The nested-factor model of the self-regulatory teaching strategies in mathematics***

| | F1-General self-regulatory teaching | F2-Teachers' self-regulation (STSR) | F3-Students' self-regulation (SSSR) | F4 | F5 | F6 | F7 | F8 | Error |
|---|---|---|---|---|---|---|---|---|---|
| F4-Planning Instruction and Evaluating Goals (STSR) | | | | | | | | | |
| Q1 | .12* | .21 | | .42 | | | | | .87 |
| Q2 | .21 | .39 | | .22 | | | | | .87 |
| Q3 | .07* | .42 | | .18 | | | | | .88 |
| Q4 | .25 | .43 | | .26 | | | | | .83 |
| Q5 | .29 | .60 | | .11* | | | | | .73 |
| Q6 | .18 | .29 | | .23 | | | | | .91 |
| Q7 | .22 | .42 | | .61 | | | | | .63 |
| F5-Monitoring Instruction and Reflecting (STSR) | | | | | | | | | |
| Q8 | .65 | .07* | | | .04* | | | | .75 |
| Q9 | .51 | .13* | | | .04* | | | | .85 |
| Q10 | .23 | .16* | | | .76 | | | | .58 |
| Q11 | .33 | .33 | | | .31 | | | | .82 |
| F6-Deep Understanding and Forethought (SSSR) | | | | | | | | | |
| Q12 | .25 | | .21 | | | .69 | | | .63 |
| Q13 | -.01* | | .31 | | | .57 | | | .76 |
| Q14 | .16* | | .59 | | | .25 | | | .74 |
| Q15 | .33 | | .57 | | | .05* | | | .78 |
| F7-Encouraging Metacognition and Reflecting (SSSR) | | | | | | | | | |
| Q16 | .48 | | .19 | | | | .36 | | .77 |
| Q17 | .29 | | .39 | | | | .71 | | .51 |
| Q18 | .31 | | .41 | | | | .28 | | .81 |
| Q19 | .24 | | .48 | | | | .33 | | .77 |
| Q20 | .44 | | .37 | | | | .19 | | .79 |
| F8-Solution Evaluation (SSSR) | | | | | | | | | |
| Q21 | .35 | | .48 | | | | | .25 | .76 |
| Q22 | .42 | | .23 | | | | | .19 | .85 |
| Q23 | .31 | | .03* | | | | | .81 | .49 |
| Q24 | .27 | | .22 | | | | | .43 | .83 |

***(continued)***

***Table 2. The nested-factor model of the self-regulatory teaching strategies in mathematics (continued)***

| | F1- General self-regulatory teaching | F2- Teachers' self-regulation (STSR) | F3- Students' self-regulation (SSSR) | F4 | F5 | F6 | F7 | F8 | Error |
|---|---|---|---|---|---|---|---|---|---|
| <u>*Covariance between factors*</u> | | | | | | | | | |
| STSR X SSSR | | | .58 | | | | | | |
| Planning Instruction and Evaluating Goals X Monitoring Instruction and Reflecting | | | .53 | | | | | | |
| Planning Instruction and Evaluating Goals X Deep Understanding and Forethought | | | .55 | | | | | | |
| Planning Instruction and Evaluating Goals X Encouraging Metacognition and Reflecting | | | .19* | | | | | | |
| Planning Instruction and Evaluating Goals X Solution Evaluation | | | .48 | | | | | | |
| Monitoring Instruction and Reflecting X Deep Understanding and Forethought | | | .57 | | | | | | |
| Monitoring Instruction and Reflecting X Encouraging Metacognition and Reflecting | | | .13* | | | | | | |
| Monitoring Instruction and Reflecting X Solution Evaluation | | | .02* | | | | | | |
| Deep Understanding and Forethought X Encouraging Metacognition and Reflecting | | | .17* | | | | | | |
| Deep Understanding and Forethought X Solution Evaluation | | | .28 | | | | | | |
| Encouraging Metacognition and Reflecting X Solution Evaluation | | | .20 | | | | | | |

***Note:*** Loadings and correlations noted with asterisk (*) were non-significant.

### *Descriptive statistics and correlations between the variables of the study*

Five different composite scores with regard to instructional strategy use were created on the basis of the results of Confirmatory Factor Analysis (CFA). Table 3 presents the descriptive statistics and Pearson's $r$ correlation coefficients between the five specific groups of self-regulatory strategies confirmed by means of CFA. Table 3 shows that teachers reported relatively low use of strategies for Encouraging students' Metacognition and Reflecting. Moreover, inspection of Table 3 shows that there were moderate correlations between the self-regulatory strategies. Strategies for Teachers' Self-Regulation (STSR) were moderately associated to Strategies for Enhancing Students' Self-Regulation (SSSR) ($.37 < r < .48$).

***Table 3. Descriptive statistics and Pearson's r correlation coefficients among the variables of the study***

| | Total | | | | | | |
|---|---|---|---|---|---|---|---|
| | *M* | *SD* | 1. | 2. | 3. | 4. | 5. |
| 1. Planning Instruction & Evaluating Goals (STSR) | 4.53 | .38 | - | | | | |
| 2. Monitoring Instruction & Reflecting (STSR) | 4.14 | .55 | .48** | - | | | |
| 3. Deep Understanding & Forethought (SSSR) | 4.20 | .57 | .46** | .40** | - | | |
| 4. Encouraging Metacognition & Reflecting (SSSR) | 3.70 | .67 | .37** | .43** | .47** | - | |
| 5. Solution Evaluation (SSSR) | 4.20 | .55 | .44** | .39** | .45** | .48** | - |

***Note:*** STSR = Strategies for Teachers' Self-Regulation, SSSR = Strategies for Students' Self-Regulation ** $p < .01$

***Individual differences effects in teachers' reports of self-regulatory teaching***

The descriptive statistics (Means and Standard Deviations) of group differences in self-regulatory strategy use as a function of gender, age, and teaching experience are presented in Table 4.

*Gender effects*

Multivariate analyses of variance (MANOVAs) were applied on the data in order to investigate whether gender differentiated teachers' reports. In the first MANOVA, gender was the independent variable and the two factors of the STSR were the dependent variables. Results showed a significant multivariate effect: *Pillai's trace* = .027, $F(2, 289) = 4.020$, $p = .019$, partial $\eta^2 = .027$. Univariate tests showed a statistically significant difference between male and female teachers for Planning Instruction and Evaluating Goals (see Table 4). Specifically, female teachers reported that they use more often planning and preparation strategies for mathematics instruction as well as strategies for evaluating the attainment of teaching goals in comparison to their male colleagues.

In the second MANOVA, the independent variable was gender and the dependent variables were the three factors of the SSSR. The results showed a significant multivariate effect: *Pillai's trace* = .051, $F(3, 287) = 5.180$, $p = .002$, partial $\eta^2 = .051$. Univariate tests showed a statistically significant difference between male and female teachers as regards Deep Task Understanding and Forethought (SSSR). That is, female teachers reported that they more frequently encourage students to use strategies for deep understanding of mathematics problems, to find the key terms, and solution strategies compared to male teachers.

***Table 4. Descriptives and Fs of self-regulatory strategy use as a function of gender, age, and teaching experience***

| | Gender | | | | | | Age | | | | | | Teaching experience | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | | | | | Younger | Older | | | | | Novice | Experienced | | | | |
| | *M* (*SD*) | *M* (*SD*) | *F* | *df* | *p* | Partial $\eta^2$ | *M* (*SD*) | *M* (*SD*) | *F* | *df* | *p* | Partial $\eta^2$ | *M* (*SD*) | *M* (*SD*) | *F* | *df* | *p* | Partial $\eta^2$ |
| Planning Instruction & Evaluating Goals (STSR) | 4.44 (.40) | 4.58 (.36) | 8.01 | 1 | .005 | .027 | 4.49 (.42) | 4.55 (.35) | | | *ns* | | 4.43 (.39) | 4.64 (.31) | 5.60 | 1 | .021 | .076 |
| Monitoring Instruction & Reflecting (STSR) | 4.08 (.58) | 4.19 (.53) | | | *ns* | | 4.11 (.57) | 4.17 (.54) | | | *ns* | | 4.09 (.65) | 4.21 (.59) | | | *ns* | |
| Deep Understanding & Forethought (SSSR) | 4.08 (.57) | 4.29 (.55) | 10.00 | 1 | .002 | .033 | 4.16 (.57) | 4.22 (.56) | | | *ns* | | 4.23 (.44) | 4.46 (.47) | 4.05 | 1 | .048 | .056 |
| Encouraging Metacognition & Reflecting (SSSR) | 3.71 (.61) | 3.69 (.71) | | | *ns* | | 3.62 (.72) | 3.75 (.63) | | | *ns* | | 3.49 (.86) | 3.82 (.66) | | | *ns* | |
| Solution Evaluation (SSSR) | 4.21 (.50) | 4.20 (.58) | | | *ns* | | 4.12 (.60) | 4.25 (.51) | 4.24 | 1 | .040 | .014 | 4.13 (.60) | 4.28 (.42) | | | *ns* | |

***Note:*** *ns:* non-significant difference

*Teaching experience*

In the next set of MANOVAs, the independent variable was the teaching experience with two categories according to the teachers' years of instruction. Two groups were specified: Novice and experienced teachers. The mean ± 1 SD of years of teaching was used as cut off point in order to create the two groups. Novice teachers were those falling into the category 1-5 years of teaching experience ($n$ = 33) and experienced teachers were those falling into the category 22-34 years of teaching experience ($n$ = 52). In the first MANOVA, the dependent variables were the two factors of the Strategies for Teachers' Self-Regulation (STSR) scale and the independent variable was the two levels of teaching experience. Multivariate results of this analysis were not significant. However, univariate tests showed a statistically significant difference between novice and experienced teachers for Planning and Evaluating instructional Goals with experienced teachers reporting that they use more frequently these strategies than novice teachers (see Table 4).

In the second MANOVA, the dependent variables were the three factors of the Strategies for Students' Self-Regulation (SSSR) scale and independent variable was the two levels of teaching experience. Again, multivariate results of this analysis were not significant. However, univariate tests showed a marginally statistical significant difference between novice and experienced teachers as regards the factor Deep Task Understanding and Forethought with experienced teachers reporting that they encourage students to use strategies for deep understanding of problems in mathematics as well as strategies for evaluation of solutions to mathematical problems more often than novice teachers.

Age differences

To investigate whether teachers' age differentiates their reported strategy use, again two MANOVAs were applied. Teachers were divided into two groups: Teachers between 20-39 years of age ($n$ = 118) were the younger group and teachers between 40-59 years of age ($n$ = 174) were the older group. In the first MANOVA, the dependent variables were the two factors of the STSR and the independent variable was teachers' age with two levels. The results of the analysis showed that there was no statistically significant difference between younger and older teachers' reports.

In the second MANOVA, the dependent variables were the three factors of the Strategies for Students' Self-Regulation (SSSR) scale. Again, the results of the analysis showed that there was no overall statistically significant difference. However, univariate tests showed a marginally significant difference between younger and older teachers' reports concerning Solution Evaluation with the older teachers reporting that they tend to use more frequently strategies to enhance students' solution evaluation in comparison to the younger teachers.

## DISCUSSION

A gradually growing body of research investigates how teachers engage in the process of self-regulated teaching and learning (e.g., Dabbagh & Kitsantas, 2009; Hartman, 2001; Kramarski & Revach, 2009; Kreber et al., 2005; Zohar, 2004). The present study examined elementary school teachers' self-reports concerning mathematics teaching *with* self-regulation, i.e., how they engage themselves in self-regulation of the teaching process, and teaching *for* enhancing their students' self-regulated mathematics learning. CFA on the two scales used for the recording of teachers' perceptions of their self-regulatory teaching in mathematics showed that self-regulated teaching is a general construct reflecting self-regulation both for developing one's own teaching or students' self-regulated learning. At the same time, teachers' reports reflected the two sides of self-regulatory instructional strategies, i.e., teaching *with* and teaching *for* self-regulation in mathematics.

Specifically, Hypotheses 1 and 2 posited that there are distinct categories of self-regulatory instructional strategies at various levels of generality. CFA fully confirmed Hypothesis 1. CFA supported the existence of one common general factor explaining all the strategies assessed in the study and of two narrow factors reflecting teachers' own engagement in self-regulatory teaching (i.e., items of the STSR) and promotion of students' self-regulated learning in mathematics (i.e., items of the SSSR). This means that teachers perceive as relatively distinct domains the strategies for teaching subject matter and for promoting their students' engagement in self-regulated learning.

Further, Hypothesis 2 predicted that each of the narrow factors will consist of three groups of strategies, representing the three phases of self-regulated learning and teaching (i.e., before, during, and after teaching and learning) as suggested by Zimmerman (2000). This hypothesis was confirmed for the SSSR, that is for promoting students' self-regulated learning in elementary school mathematics. Indeed, teachers' reports reflected use of strategies for cultivating students' planning and forethought skills, metacognitive and reflection skills, and solution evaluation skills. Regarding the STSR -teachers' own engagement in self-regulation of their mathematics teaching- only two phases were confirmed: (a) Planning instruction and evaluating goals, and (b) Monitoring instruction and reflecting. It seems that teachers perceive planning the instruction and evaluation of teaching goals (possibly related to goal setting) as strongly related types of strategies. Monitoring instruction as it takes place and reflection after instruction implementation were also perceived as strongly related types of strategies.

The present study also investigated potential differences in teachers' reports of self-regulatory strategy use associated with gender, teaching experience, and age. Specifically, Hypothesis 3 stated that female teachers would report more frequent use of self-regulatory instructional strategies in comparison to their male colleagues. Past findings (e.g., Retelsdorf et al., 2010; Singer, 1996) reported that teachers' gender, in favour of female teachers, was the most important predictive factor of instructional strategy use among a number of personal and context variables examined. However, other researchers (e.g., Stewart et al., 2007) found no gender differences in teachers' reports as regards metacognitive knowledge and metacognitive self-regulation. The results of the present study partly confirmed Hypothesis 4. Significant differences between male and female teachers were found with regard to the reported use of strategies for Planning Instruction and Evaluating Goals (STSR) and for enhancing students' Deep Task Understanding and Forethought (SSSR). Specifically, concerning the strategies for teachers' self-regulation, women teachers reported that they use more often than males preparation and planning strategies for mathematics instruction as well as strategies for evaluating the attainment of teaching goals. However, although gender was associated with more differences in teachers' reported strategy use than teaching experience and age, these differences regarded mainly the Forethought phase of self-regulated teaching of mathematics and do not generalize to the other sets of strategies examined.

Hypothesis 4 predicted that experienced teachers will report more frequent use of strategies for the self-regulation of their teaching and for enhancing students' self-regulated learning than novice teachers. Extant research has shown that experienced teachers score higher on metacognitive regulation compared to pre-service teachers (Stewart et al., 2007) and that they engage more in metacognition in their instructional practice to promote student learning and understanding, whereas novice teachers focus more on content coverage and time management (Artzt & Armour-Thomas, 2001; Housner & Griffey, 1985). The results of the present study partly confirmed Hypothesis 4. Although the multivariate test was not significant, the univariate tests showed that experienced teachers reported significantly more frequent use of self-regulatory strategies than novice teachers with regard to two groups of strategies: Planning instruction and Evaluating the teaching goals (STSR) and Enhancing students' Deep Understanding of the task and Forethought (SSSR). It seems that teaching experience accounts for the use of self-regulatory instructional strategies mainly for the Forethought phase of teaching and learning in mathematics.

Finally, it was hypothesized that older teachers will report more frequent use of strategies for self-regulation and for students' self-regulation compared to younger teachers (Hypothesis 5). Stewart et al. (2007) reported that teachers' metacognitive regulation and metacognitive knowledge improved significantly with age. However, the results of the present study do not confirm Hypothesis 5, as the multivariate test was not significant. Univariate tests showed that the older teachers reported that they use marginally more frequently strategies for enhancing students' evaluation of the solution produced in mathematical problems in comparison to the younger teachers. Overall, with reference to mathematics and to this sample of participant teachers, age did not account for differences in reported strategy use.

### *Limitations of the study and future research*

A main limitation of the present study is that it examined teachers' beliefs regarding instructional strategy use by means of self-report instruments and not through measures of actual use of strategies within the classroom setting. Future research should link teachers' reports to their actual teaching practices and/or to students' responses via more objective measures of teachers' strategic activity. Multi-method research designs could also highlight the differences between findings. Moreover, teachers' reported self-regulatory instructional strategy use was examined with reference to the mathematics domain only. The findings of the study regarding mathematics teaching should be replicated in the future because they do not necessarily hold for other cognitive domains or educational-cultural contexts. The same regards the gender differences found in this study. It might be the case that female teachers report higher use of instructional strategies because mathematics is not considered a strong female domain. Individual differences in motivation and affect, such as self-efficacy in mathematics teaching, the value attributed to mathematics, and teachers' professional commitment, might be implicated in the reported use of self-regulation strategies both for their own teaching and for enhancing students' self-regulation in mathematics (Chatzistamatiou, Dermitzaki, & Bagiatis, in press).

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