THE ROLE OF SELF-REGULATED LEARNING IN PROFESSIONAL GROWTH OF MATHEMATICAL ELEMENTARY TEACHERS

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Abstract

Current reforms in the educational system have raised new goals for teachers' training concerning the professional growth of teachers (NCATE, 2002; NCTM, 2000). It is suggested that the ability to self-regulate learning is essential for teachers' professional growth during their entire career as well as for their ability to promote these processes among students. This study investigates mathematical teachers' professional growth among elementary school teachers exposed to professional program either with supporting self-regulated learning (SRL) or with no SRL support (NS). The SRL support was based on the IMPROVE self-metacognitive questioning that direct students' attention to understanding when, why, and how to solve the problem (Kramarski & Mevarech, 2003). Sixty-four Israeli elementary teachers participated for 16 hours course in a professional development program to enhance algebraic and pedagogical knowledge. The course was a part of a three-year professional development program sponsored by the Israeli Ministry of Education. Teachers' professional growth was assessed with problem solving of a real-life task, lesson planning and SRL questionnaire. Results indicated that the SRL teachers outperformed the NS teachers on various skills, of real-life tasks (e.g., reflection and conceptual mathematical explanations), lesson planning (e.g., learning objectives) and motivation. Observations on teaching of four teachers in practice indicated more regulation of learning in teaching of the SRL teacher than in teaching of the NS teacher. We discuss educational and practical implications.

Current reforms in the educational system have raised new goals for teachers' training concerning the professional growth of teachers (e.g., NCTM, 2000). In essence, these goals maintain that teacher training should not be limited to transmitting subject-matter knowledge and pedagogical knowledge using predefined, fixed methods, but rather should find ways to construct knowledge through self-regulated learning (SRL), applying higher order thinking skills. The ability to self-regulate learning is essential for teachers' professional growth during their entire career as well as for their ability to promote these processes among students. Research indicates that if teachers are incapable of self-regulating their own learning, it will be impossible for them to develop these capabilities among their students (e.g., Putnam & Borko, 2000).

Following this suggestion, our study addressed two research questions: (1) How can in-service mathematical teachers' professional growth be promoted? and (2) What is the effect of SRL support in professional development program on such growth?

Supporting Self-Regulation of Learning (SRL)

SRL refers to a cyclical and recursive process that utilizes feedback mechanisms for learners to understand, control, and adjust their learning accordingly. The process involves a combination of four areas for regulation during learning: cognition, metacognition, motivation, and context condition (e.g., Schraw et al., 2006). Cognition refers to strategies of simple problem solving and critical thinking. Metacognition refers to knowledge and control of cognitive skills. Motivation refers to learners' beliefs in their capacity to learn, their values for the task, and their interest level. Finally, the context refers to evaluation and monitoring of changing task conditions. A number of researchers have argued that several key factors support SRL through instruction, including: "embedding metacognitive instruction in the subject content matter to ensure connectivity; informing learners about the usefulness of metacognitive activities to make them exert the initial extra effort; prolonged training to guarantee the smooth and maintained application of metacognitive activity" (Veenman et al, 2006, p. 9). These researchers emphasized the generality of metacognitive skills and the importance of extensive practice, followed by explicit guidance in the classroom using the self-questioning strategy of WWWH (what, when, why, and how) that helps learners select a specific self-regulatory strategy, approach, or response within learning (e.g., Kramarski & Mevarech, 2003; Schoenfeld, 1992). In particular, they have suggested the utility of structuring self-metacognitive questioning that focuses on learners' understanding of the task, awareness, and self-regulation of strategy application before, during, and after the learning task process.

Mevarech and Kramarski's (1997) IMPROVE method encourages learners to become involved in regulatory learning by using self-metacognitive questioning with regard to: (a) comprehending the problem (e.g., "What is the problem/task"?); (b) constructing connections between previous and new knowledge (e.g., "What are the similarities/differences between the problem/task at hand and the problems/tasks you have solved in the past?, and WHY?"); (c) using appropriate strategies to solve the problem/task (e.g., "What are the strategies/tactics/ principles appropriate for solving the problem/task, and WHY?"; "When/how should I implement a particular strategy?"); and (d) reflecting on the processes and the solution (e.g., "Does the solution make sense?"; "How can I solve the task in another way?"). Generally speaking, research reported that supporting SRL with self-metacognitive questioning elicited positive effects on school students' learning outcomes. However, little research exists in the field of in-service education to accurately determine the benefits and pitfalls of such a model in promoting in-service teachers' professional growth in mathematical domain.

Following this suggestion, the purpose of this study was fourfold:

To investigate elementary school teachers' mathematical knowledge that were either exposed to IMPROVE metacognitive questioning support (SRL) or to no SRL support (NS) with regard to real-life problem solving skills; (b) to compare teachers' pedagogical knowledge with regard to lesson planning; (c) to examine teachers' SRL skills with regard to motivation; and (d) to observe teachers of both groups in practice.

Method

Participants were 64 elementary school teachers from 27 elementary urban schools that comprise students of 6-13 age. Teachers in this level of education lack substantial mathematical knowledge regarding new curriculum topics, such as algebra, and have limited experience in teaching such topics. Teachers participated for a 16 hours course in a professional development program to enhance algebraic and pedagogical knowledge. The course was a part of a three-year professional development program sponsored by the Israeli Ministry of Education One group of thirty teachers was assigned to the SRL support and the other group of thirty four teachers was assigned as no support (NS).

No significant differences between the two groups were found in the variables: Years of experience in teaching mathematics, mathematical and pedagogical knowledge which were assessed by the Ministry of Education measures.

Measurements and procedure

Teachers' mathematical knowledge: Teachers' mathematical knowledge was assessed by problem solving of real-life tasks. The real-life tasks were administrated pre and post study. The tasks were based on the PISA framework of problem solving (PISA, 2003) that focused on three skills of mathematical problem solving: Reproduction, connection, and reflection. According to PISA the reproduction skill refers to the application of routine algorithms and technical skills; the connection skill builds on standard problem solving translation and interpretation and the reflection skill requires an element of insight on the part of the solver about the processes needed or used to solve a problem.

The saving money task (post-test): Shai and Mayan received pocket money from their parents. Each day Shai received 1 N.I.S and Mayan received 2 N.I.S. Before the parents started giving an allowance to the children, Shai had saved 4 N.I.S and Mayan didn't have any money. Teachers were asked to answer on 7 questions (e.g., Reflection skill: "Which saving plan is more profitable? Explain your reasoning"). For each item, teachers received a score for problem solving and mathematical explanations of either 1(full correct answer or argument), or 0 (incorrect answer or argument.

In addition, we analyzed the quality of arguments provided by teachers on three criteria: (1) No mathematical arguments (e.g., providing information without explanation); (2) Procedural arguments (e.g., providing numerical examples or computation process with minor explanations); (3) Conceptual arguments (e.g., providing logic-formal mathematical explanation based on mathematical terms and representations with regard to generalization and conclusions).

Teachers' pedagogical knowledge: Teachers' pedagogical knowledge was assessed by teachers' lesson plan based on the saving task for their students. Planning requires teachers to create new components that demand capabilities such as regulation, control, and evaluation of learning progress. The lesson plan was analyzed according to three categories: (a) Task demands (e.g., identifying the goal of the task, required skills, and students' difficulties in solving the task); (b) Task design (e.g., didactical ways of presenting the task); and (c) Teaching styles (e.g., transmitting knowledge vs. engaging students' in learning*)*. For each category, teachers received a score of either 3 (full use), 2 (partial use), or 1 (no use), and a total score ranging from 1 to 9.

Self-regulate learning questionnaire: The 14-item based on Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich & De-Groot, 1990), assessed teachers' motivational factors:

intrinsic value of learning (e.g., "I think what we are learning in this pedagogical course is interesting") and persistence in the face of difficulties (e.g., "Even when the study materials are dull and uninteresting, I keep working until I finish"). Participants rated each item on a 7-point Likert scale, ranging from 1 (not at all true for me) to 7 (very true for me). Higher scores indicated a higher level of motivation.

Results

Teachers' mathematical knowledge: We performed a one way ANCOVA on the various skills of solving real-life tasks, with pretest scores for the solution of the real-life task, used as a covariate. Table 1 presents the means, adjusted means and standard deviations on problem solving skills.

Table 1: Means, adjusted means and standard deviations on *problem solving* of *real life task* skills, by treatment and time[1]

	SRL N= 34		NS N= 30	
	Pre	Post	Pre	Post
Real-life task (total)				
M	80.77	87.59	82.25	75.77
Adjusted M		87.70		75.66
SD	12.85	7.56	10.96	10.78
Reproduction skills				
M	94.40	87.41	92.35	88.00
Adjusted M		87.86		89.28
SD	2.51	2.91	2.81	5.86
Connection skills				
M	76.62	92.21	75.83	87.33
Adjusted M		92.25		87.28
SD	15.21	7.92	15.97	8.63
Reflection skills				
M	82.16	85.49	84.39	63.00
Adjusted M		85.62		62.85
SD	14.22	11.81	12.80	17.93

Range: 0-100.[1]

Post-test ANCOVA results indicated differences between both methods of treatments on the two criteria of problem solving skills: Connection skills (F (1,61) = 5.70, $p < 0.02$; ES = 0.59), and reflection skills (F (1,61) = 36.93, $p < 0.0001$; ES = 1.51). The greatest difference between teachers' problem solving skills was exhibited on the *reflection* skill, which is the highest order skill of problem solving (PISA. 2003).

Further analysis for quality of arguments indicated significantly differences between the two groups. More *SRL* teachers provided significantly conceptual arguments than the *NS* teachers (68.6%; 29.6%; χ^2 (2) = 15.92, $p < 0.01$ respectively), whereas, more *NS* teachers provided *procedural arguments* (47.6%, 12.9%, χ^2 (2) = 18.23, $p < 0.001$ respectively).

Teachers' pedagogical knowledge: Post-test ANCOVA results indicated differences between both methods of treatments on two criteria of lesson planning: Task demands (M = 79.71*;* SD = 24.0*;* M = 63.42*;* SD = 30.60 respectively for the SRL and NS groups; F (1,61) = 4.78, $p < 0.01$; ES = 0.60), and Teaching styles (M = 91.30*;* SD = 20.64*;* M = 68.12*;* SD = 29.26 respectively F (1,61) = 8.86, $p < 0.01$; ES = 0.93). The SRL teachers were more aware on task demands and they focused on activities for engaging students in learning as asking for explanations.

Self-regulated learning: Two-way analyses of variance (treatments (2) by time (2) with repeated measures on the second factor) indicated significant interaction between treatments and time for motivation criteria (F (1,61) = 4. 79, $p < 0.05$). We found that at the end of the study the SRL teachers exhibited significantly more motivational believes than the NS teachers (ES = 0.38).

Teaching in practice: Finally, we observed class practice of two teachers from each group: *SRL* vs. *NS*. Teachers were selected randomly and were observed during teaching the lesson that they planed for the saving money task. Each lesson was video taped, Tran scripted and analyzed on two criteria of SRL: Learning goals and supporting SRL**.**

*Learning goals***:** We found that both teachers focused on teaching for understanding (e.g., "*We have to teach for understanding and not for technique."*) but the teachers differed in their pedagogical ways to achieve this goal. The SRL teacher more often encouraged students to be engaged in conceptual understanding (e.g., "*The result does not matter me, I want to know how* *you solved the problem*"). Whereas, the NS teacher engaged students more in procedural understanding (e.g., *"Show me the point on the graph; Did you count twice*?).

<u>Supporting SRL</u>: In general, the SRL teacher exhibited more a student-centred approach in class discussion (e.g., "You have to find the conclusions by your self"), whereas, the NS teacher exhibited more a teacher-centred approach for getting conclusions (e.g., "*listen we will find the conclusion together*"). Moreover, we found that the SRL teacher regulated more often students' learning than the NS teacher. For example, the SRL teacher guided the students to ask self-questions (e.g., *"Did you ask your self what is your strategy"?; "How can we compare this task to the one from the previous lesson?"*). The teacher encouraged the students to use explicitly the IMPROVE-self questioning model, which was printed in the students' worksheets. Whereas, the NS teacher summarized steps of the solution and used more often general comments (e.g., "*Your friend obtained the answer; it doesn't mean that the solution is the correct one"*).

Conclusion, implications and future research: Our findings indicate that supporting SRL with IMPROVE self−metacognitive questioning might be a *vehicle* for mathematics elementary teachers' professional growth. Several possible reasons may be considered for the beneficial effect of SRL support on mathematical problem solving, pedagogical knowledge and SRL. First, discourse on *why* and *how* questions seemed to foster teachers' understanding of task demands and pedagogical decisions. Second, the explicit opportunity to elaborate on different perspectives of problem solving, as both learners and as teachers, appeared to lead teachers to focus more on deep understanding of task demands and on a student-centered teaching approach in their lesson planning. In addition, the IMPROVE strategy engaged teachers in more student-centered learning, which seemed to strengthen the teachers' motivational beliefs toward higher levels of interest and persistence in learning.

Our findings extend other findings regarding professional development models designed to deepen teachers' mathematical and pedagogical knowledge. For-example, Farmer, Gerretson and Lassak (2003) found that by reflecting on learning situations teachers noticed critical aspects that promoted their own learning and were motivated to change facets of their own teaching practices. We propose to examine additional effects of SRL support on various topics of elementary school teachers' mathematical knowledge and pedagogical knowledge, and to observe many teachers in class practice.

In conclusion, we recognize the need to continue to define and examine features of professional growth that are linked to qualities of mathematical knowledge, pedagogical knowledge, and self-regulated learning. This work is a step in that direction. Moreover, future research is needed to connect this data directly to student understanding and achievement data.

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