The Study of Teaching and Learning for Teachers and Students Meta Cognitive Approach – Comparison of Fostering Knowledge versus Regulation of Cognition

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Abstract

The central purpose of the present study is to investigate the interactions between math teachers' achievements and their students' achievements in the realm of meta-cognition and number sense.

In recent decades significant changes have occurred in views on contents and style in math instruction. The new principles and standards of mathematical education emphasize building of significant knowledge through solving number sense tasks, constructing mathematical connections and use of tools that encourage mathematical discourse (Mullis, Martin, Foy, & Arora, 2012; National Council of Teachers of Mathematics [NCTM], 2014). Different studies have shown that despite the many efforts made over the years to train students to solve **number sense** tasks, **many learners at different ages still find it difficult** to acquire the knowledge and skills necessary for solving these tasks (Mullis et al., 2012; NCTM, 2000; Organisation for Economic Co-operation and Development [OECD], 2014; Verschaffel, Greer, & De Corte, 2000).

According to various investigators, **teachers' difficulties** in assimilating the new standards in math instruction and applying them in the field stem from two factors: the teachers' **beliefs** toward these standards, and **lack of pedagogic mathematical knowledge** (Buehl & Alexander, 2006; Hill, Rowan, & Ball, 2005; Kramarski & Michalsky, 2009, in press; Kramarski & Revach, 2009; Michalsky & Kramarski, 2015).

According to research literature, the way to deal with teachers' and students' difficulties is instruction based on self-regulated learning with methods that foster metacognition (Kramarski & Mevarech, 2003; Kramarski & Revach, 2009; Michalsky & Kramarski, 2015; Randi, 2004; Veenman, Van-Hout- Wolfers & Afflenbach, 2006; Zimmerman, 2008).

Meta-cognition is a process of "thinking about thinking" that is activated while coping with task solutions in different fields. Meta-cognition has **a complex, multidimensional structure** that includes two central components: knowledge of cognition including the learner's own knowledge about himself, the task and the strategy for task solution, and regulation of cognition, which includes the ability to adjust and control the process (Flavell, 1979; Pintrich, 2000b; Schraw, 1998).

Researchers agree that the best way to influence students' learning behaviors is to first influence teachers' learning behaviors (Kramarski & Revach, 2009; Wilson & Bai, 2010). In studies that examined to what extent **teachers** employ meta-cognitive elements in their classes, it was found that teachers use these elements in a hidden fashion, and do not discuss them **explicitly**. As a result, researchers recommend employment of **structured** programs to foster meta-cognitive components among **teachers**, and their application to the students in the class (Gillard, Van Dooren, Schaeken, & Verschaffel, 2009; Kistner, Rakoczy, Dignath, Otto, Büttner, & Klieme, 2010; Schneider & Artelt, 2010). Despite the theoretical importance ascribed to explicit integration of meta-cognitive skills in teaching and learning, **studies are still lacking that deal with the influence of cultivating teachers' meta-cognitive skills on their students achievements in the meta-cognitive field generally, and in the field of mathematics in particular.**

The current study reduces this gap, as it integrates examination of **knowledge development and cognitive regulation** among **teachers** with its cultivation among their **students**, and their influence on **teachers' and students' beliefs toward teaching and learning and toward self-efficacy, mathematical pedagogic knowledge for teachers, and students' mathematical knowledge in the field of number sense.** Furthermore, the current study offers a **yet uninvestigated, unique approach,** which focuses on **cultivation of all meta-cognitive components, knowledge of and regulation of cognition,** separately in each research group (one group that received guidance about knowledge of cognition, a group that received guidance about regulation of cognition and a comparison group), and examination of the influence of this cultivation on meta-cognitive development as a whole, both for **teachers as well as for their students**. Accordingly, we tested whether cultivation of a single component could bring about the existence of another component.

Toward that end, two intervention plans were developed in this study, each of which was intended to cultivate one of the meta-cognitive components**: knowledge of cognition and regulation of cognition.** Teachers and their students were divided randomly into three groups: a group that received guidance in **knowledge of cognition,** a group that received guidance in **regulation** of cognition, and a comparison group. Participants in the **knowledge** group were asked individual meta-cognitive questions directed to the learner and to strategic solution according to a **linear model,** intended to encourage **declarative knowledge**, **procedural knowledge**

and conditional knowledge in the learner (Schraw, 1998; Schoenfeld, 1985). Participants in the regulation group were asked individual meta-cognitive questions according to the cyclical model that focuses on solution stages: questions asked before the action – the planning stage; questions asked during the action – the monitoring stage; and questions asked at the conclusion of the action – the evaluation stage (Kramarski & Mevarech, 2003; Mevarech & Kramarski, 1997; Zimmerman, 2008). The comparison group was only exposed to strategic instruction.

Evaluation of intervention programs was done using advanced quantitative tools on the statements of teachers and their students, and through application of qualitative tools in practice, in real time (video recordings of the lessons). In addition, the efficiency of transmission across time was evaluated through interviews with teachers and students, and a thinking aloud solution of the problem in a **focus group**.

At the inception of the present study four **research questions** were raised. Three of them related to the differences between the different research groups and the comparison group on several measures: 1. **the meta-cognitive component's two dimensions (knowledge and regulation)** among teachers and their students; 2. Teachers' and students' **beliefs toward teaching and learning methods and self-efficacy;** 3. Teachers' **mathematical pedagogic knowledge**, and their students' **mathematical knowledge**. The fourth question dealt with the connection between **cultivation of meta-cognition among teachers** and **its cultivation among students**.

The sample included 48 teachers and their 1,219 fifth grade students from different schools in central Israel, who were randomly divided into 3 research groups, according to the intervention program. The intervention programs ran for four months, and included 16 meetings.

Research tools included questionnaires to examine meta-cognition and beliefs about teaching, learning and self-efficacy, a questionnaire to examine students' confidence in their judgment regarding the correctness of their answers, tests for mathematical pedagogic knowledge (teachers) and tests for mathematical knowledge concerning number sense (students). These tools were administered at two points in time: prior to the intervention and immediately afterwards. Toward conclusion of the intervention two lessons in each class were videotaped. In order to test transference over time, some of the students solved a verbal problem out loud, and interviews were conducted with some of the teachers and some of the students (focus groups), three months post intervention.

Following are the main research findings:

According to the quantitative results derived from the questionnaires, for all measures examined, the **teachers'** achievements in the research groups, the **knowledge and regulation** groups, exceeded those of the comparison group teachers. Reinforcement for that finding also appeared in examination of these measures in practice and in real time (review of the recorded lessons). Teachers in the experimental groups used a variety of "talk moves" (Chapin, O'Connor & Anderson, 2009), so that the mathematical discourse in their classes was of good quality (one of the measures for examining pedagogic mathematical knowledge). Furthermore, these teachers used many meta-cognitive statements, by contrast with teachers in the comparison group. Even so, a difference was found between the two experimental groups. The level of discourse in the classes of teachers from the **regulation** group was higher than that in the class of teachers in the **knowledge** group. Teachers in the regulation group did not offer a lot of explanations, but rather directed their students through questions to provide explanations, and gave them time to think about it. By contrast, teachers in the knowledge group gave many explanations, and the level of discourse in their classes was lower than that in the regulation group. Teachers in the comparison group generally didn't give explanations, the discourse in their classes was mostly on a low level, and they related primarily to basic strategic knowledge. Thus, in practice in real time it was found that teachers' achievements in the regulation group were better than those of teachers in the knowledge group. Confirmation of these findings was also found in examination of transference across time in the focus group, three months after intervention. Even three months after conclusion of the intervention, achievements of **regulation** group teachers were higher than those of teachers in the knowledge group in meta-cognition and mathematical pedagogic knowledge.

Regarding the **students,** students' achievements in **the regulation group** for most measures surpassed those of students in other groups, according to both the questionnaires, as well as in examination of practice in real time, and transference over time. Achievements of comparison group students were the lowest on all measures. Furthermore, their achievements in self-efficacy and mathematical knowledge on the subject of number sense after the intervention were lower than at the beginning of the intervention.

This study makes a contribution in the theoretical area, in the methodological- research area, and in the area of application.

In the theoretical realm, the study innovates with regard to the importance of cultivating the entirety of meta-cognitive components among teachers and their young students while solving number sense tasks. Study findings shed light on the influence of meta-cognitive cultivation of teachers on their students' achievements. This study makes a unique cross-comparison between teachers' achievements and their students' achievements in the meta-cognitive and mathematical field while testing them with the same valid and reliable research tools. The study suggests methods for further investigation of the interrelations between teachers' professional development and their students' achievements.

In the methodological area, this study made use of a wide variety of quantitative and qualitative measuring instruments (Mix methods). Findings have been validated through **triangulation** (questionnaires, video recordings of lessons, interviews and thinking aloud solution of an insight task to examine the process in real time and over time). In the study's framework tools and indicators were developed, and graphic presentations were used to represent the interrelations in classroom interaction. The present study thus clarifies the importance of using a variety of tools in general, and examination of qualitative processes in real time in particular.

In the area of implementation, the intervention programs proposed in this study can contribute to **practicing teachers' professional development and the preparation of pre service teachers.** Similarly**,** teachers can use the programs to develop their students' meta-cognitive skills, in order to improve their mathematical achievements. Furthermore, the programs can be adapted to age groups other than those examined in the study, and to transfer them to other mathematical subjects, and even to other fields of knowledge.