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# A study for profiling mathematics teachers regarding factors affecting promotion of students' metacognition

Vuslat Şeker<sup>1</sup> and Engin Ader<sup>2</sup>

1 Middle East Technical University, Faculty of Education, Ankara, Turkey, [vuslat.seker@boun.edu.tr](mailto:vuslat.seker@boun.edu.tr)

2 Boğaziçi University, Faculty of Education, İstanbul, Turkey

*The main objective of this study was to describe mathematics teachers' profiles on factors affecting their promotion of students' metacognition through developing profiling tools. In the light of this aim, four factors from the Framework for Analysing Mathematics Teaching for the Advancement of Metacognition -FAMTAM- (Ader, 2009) were used. The factors were (1) teachers' conceptualization of metacognition, (2) teachers' perceptions of students' features and needs, (3) distribution of mathematical authority in the classroom and (4) the external pressure perceived by teachers. The sample consisted of 314 middle and secondary school mathematics teachers. In this study, descriptive, correlational and causal comparative research designs were used. The main findings indicated that most mathematics teachers were conceptualized what metacognition is. They were aware of students' features and needs. They supported a learning environment where mathematical authority was exercised by students. They perceived high external pressure from various factors influencing their promotion of students' metacognition.*

**Keywords:** Mathematics, metacognition, teaching of metacognition.

## INTRODUCTION

Metacognition is briefly defined as the regulation of and knowledge about cognitive activities (Flavell, 1979). It has an important place in mathematics education (Lucangeli & Cornoldi, 1997). It appears in early stages of problem solving process with accurate representations and the planning of problem solving (Desoete & Veenman, 2006). Metacognitive activities improve students' mathematical learning (Jacobse & Harskamp, 2012). Therefore teachers must arrange

learning environments where learners are encouraged to learn mathematics through exercising metacognition (Lombaerts, Engels, & Athanasou, 2007).

There are various teaching practices for the development of students' metacognition by taking their needs and the learning environment into account. The promotion of metacognition should be examined in a broader sense in order to contribute the development of students' metacognition. For example, why teachers promote or not promote metacognition in their classrooms should be considered in order to help teachers to create effective learning environments (Lombaerts, Engels, & van Braak, 2009).

Several factors affecting teachers' promotion of metacognition or self-regulation has emerged in recent studies (Dignath-van Ewijk & van der Werf, 2012; Lombaerts et al., 2009; Lombaerts, Engels, & Vanderfaellie, 2007). Mainly three different determinants namely, teacher characteristics, school context characteristics and pupil characteristics were described as factors affecting teaching practices of teachers on promotion of self-regulation (Lombaerts et al., 2009). Teacher beliefs, previous teaching experiences and educational experiences are given as teacher characteristics that affect the introduction of metacognition in teachers' teaching practices. Furthermore, curricular changes, timetables, number of students, textbooks, the relationship among teachers are certain examples for school context characteristics. Lastly, pupil characteristics affecting teaching practices on stimulation of metacognition or self-regulation are cognitive and metacognitive abilities of learners.

Ader (2009) developed a framework for analyzing mathematics teaching for the improvement of metacognition of students. The reason for developing such a framework came from “the lack of emphasis on teacher’s role and teaching practices within the efforts to incorporate metacognition into mathematics classrooms” (Ader, 2013, p. 7). The framework consists of four factors; (1) teachers’ conceptualization of metacognition, (2) teachers’ perceptions of students’ features and needs, (3) distribution of mathematical authority in the classroom and (4) external pressures perceived by teachers. FAMTAM was believed to be a good source for “exploring the teachers’ approaches to promotion of students’ metacognition” (Ader, 2009, p. 282).

The conceptualization of metacognition (Flavell, 1979) is defined as a factor in FAMTAM. Conceptualization of such complex and multifaceted phenomenon is important to investigate since the complex phenomena can be interpreted and implemented in a different perspective because of the structure (Ader, 2009). Secondly, teachers’ perceptions of students’ features and needs is another component of FAMTAM since it is an indicator of how teachers act with respect to the features and needs of students for effective mathematics teaching (Jaworski, 1992). Therefore, the perceptions give encouragement for students to use metacognition in their learning progress. Thirdly, the distribution of mathematical authority is a factor described as the way teachers encourage learners to use mathematics since mathematics or discipline of mathematics can be taken as authority where members of mathematical communities are working on mathematics (Schoenfeld, 1992). Boaler (2002) identified the members of a community of a classroom that lack mathematical authority (i.e. mathematical problem solving) as not contributors in each other’s mathematical learning, not doing mathematics, but as only receivers of mathematical knowledge. Hence, metacognition can be conceptualized as a way of practicing mathematical authority because metacognitive and problem solving processes are intertwined (Ader, 2009). Lastly, external pressures perceived by teachers were given as another factor in FAMTAM. External pressures stemmed not from classroom practices, but from policies of educational system and demand or expectations of educational institutions that make teachers feel pressure on their teaching practices, such as curriculum content, national exam,

time constraint and so on (Ader, 2013; Lombaerts et al., 2009).

The purpose of the study is to describe mathematics teachers’ profiles on factors affecting promotion of metacognition through developing profiling tools which were developed and validated based on FAMTAM. It is aimed to explore mathematics teachers’ approaches to promotion of students’ metacognition considering the four factors in FAMTAM. This study is significant in a way the developed scales describe a teacher profile with regard to the factors affecting metacognitive implications or promotion in their classrooms. As a result of the study, such profile identification may help researchers and policymakers to make sense of the effects of teachers’ promotion of metacognition for future actions. When the profile of teachers based on pre-determined reasons or factors are determined, this can also help teachers to tackle some of the issues that influence their promotion of metacognition by eliminating negative conditions and supporting positive ones.

## METHOD

Three research questions were investigated; (1) What is the teacher profile on the factors affecting mathematics teachers’ promotion of metacognition? (2) Are there significant correlations between variables derived from FAMTAM as conceptualization of metacognition, perceptions of students’ features and needs, distribution of mathematical authority and perceived external pressure affecting mathematics’ promotion of metacognition? (3) Is there a difference in the four variables derived from FAMTAM according to teachers’ demographic variables?

## Sample

For the description of profiles of mathematics teachers on the factors affecting promotion of metacognition, the main study was conducted with 314 (161 from middle school and 153 from secondary school) mathematics teachers from Turkey. There were 175 female and 139 male participants. Of these, 34 participants were from private schools and 280 participants were from public schools. Moreover, 116 of 163 middle and 43 of 153 secondary school mathematics teachers were graduates of faculties of education. 4 middle school mathematics teachers did not state the faculty they graduated. Remaining teachers graduated from faculties of science and got a teaching certificate. The

sample of main study was chosen conveniently. 199 of 314 mathematics teachers filled out web-version of the instruments. 105 of 314 mathematics teachers filled out hard-copy version of the instruments.

### **Instruments**

Four profiling tools addressing the four factors in FAMTAM were developed and validated for reaching the purpose of the study. The factors affecting promotion of metacognition within FAMTAM were supported by related literature as discussed in previous section. Within the process of development of four profiling tools, two pilot studies were conducted. The first sample was used in order to develop the four scales. The second sample was used for assessing psychometric qualities of the instruments that were revised after the pilot study.

The Teachers' Conceptualization of Metacognition Scale consists of 9 items. The teachers are asked to state to what extent they agree with the importance of addressing the statements given in the items in their teaching (e.g., "students' planning of their thought"). The individual total score for this scale indicated the level of fit between teachers' conceptualization of metacognition and what has been mainly documented in literature (e.g., Flavell, 1979). The Cronbach's alpha level of this scale is .91 for reliability and two structures as metacognitive knowledge and metacognitive skills were observed through factor analysis so there was an evidence for construct validity.

The Teachers' Perceptions of Students' Features and Needs Scale consists of 6 items (e.g., "Teacher should help learner to improve metacognitive skills and knowledge by using various teaching methods (e.g., modeling, think aloud, direct teaching)"). The items of this scale asked to what extent teachers agreed with the statements in the items. Cronbach's alpha level of this scale is .81 for reliability. Experts agreed on the items that within this scale they covered important issues regarding content provided through literature on teachers' perceptions of students' features and needs. Therefore, it was an indicator of content validity for this scale.

The Distribution of Mathematical Authority Scale consists of 10 items (e.g., "A learning environment should be constructed where teacher and students reason together"). The questions in this scale asked teachers to code the items according to the following

criteria: "by considering the power of determining what is right or wrong should be on mathematics; such a classroom environment, state to what extent you agree or disagree the statements below". Cronbach's alpha level of this scale is .65. Four factors were observed in factor analysis and this was accepted as evidence for construct validity of this scale since each factor was derived from the definition of where mathematical authority resides in.

The External Pressure Perceived by Teachers Scale consists of 9 items (e.g., "change in curricular and teaching approach"). The questions in the items asked for teachers to state to what extent they agree or disagree with the listed factors about their effect on their teaching practices. Cronbach's alpha level of this scale is .73. Two dimensions obtained from the exploratory factor analysis supported the construct so there was evidence of construct validity for this scale.

### **STATISTICAL ANALYSIS**

Since the aim of the study is to determine mathematics teachers' profile on factors affecting their promotion of metacognition through developing profiling tools, descriptive and inferential analysis were used.

For descriptive statistical analysis, means, standard deviations and possible range for four scales were calculated in order to describe the data set. Furthermore, the distribution of data for each scale was demonstrated through histograms. For correlational analysis, Pearson Product Moment correlation coefficient was carried out in order to seek answers for to what extent four variables were related to each other.

Group comparisons were done in order to observe how the profiling tools discriminated between scores of groups of teachers according to certain variables as gender, age, years of experience, education level, teaching level, school type. It was aimed to explore different aspects of the profiling tools. For this reason, firstly, normality test was also conducted. When the assumption of homogeneity of variances was satisfied, a one-way Analysis of Variance (ANOVA) was used. When the assumption of homogeneity of variances was violated, Brown-Forsythe F- ratio was used. In order to explore effect size, partial eta squared was calculated.

FAMTAM Variables	N	Possible Range	Mean	Standard Deviation
Conceptualization of Metacognition	314	9–45	38.53	7.06
Perceptions of Students' Features and Needs	314	6–30	25.89	3.23
Distribution of Mathematical Authority	314	25–50	38.83	5.55
Perceived External Pressure	314	9–45	34.07	6.36

**Table 1:** Descriptive statistics

## RESULTS

The results showed that most mathematics teachers conceptualized metacognition in accordance with the commonly accepted conceptualizations in the literature. They were aware of students' features and needs. They supported a learning environment where mathematical authority was exercised by students. However, they perceived high external pressure from various factors influencing their promotion of students' metacognition.

Secondly, it was seen that there was a significant correlation between conceptualization of metacognition variable and distribution of mathematical authority variable. Although there was a significant relationship between these variables, the correlation coefficient was relatively low. Therefore, it was a weak positive relationship,  $r=.16$ ,  $p < .01$ . It was same with the relationship between conceptualization of metacognition variable and perceived external pressure variable,  $r = .20$ ,  $p < .01$ . Perceptions of students' features and needs variable was significantly, but weakly correlated with distribution of mathematical authority variable,  $r=.21$ ,  $p < .01$ . Furthermore, same situation can be observed in the relationship between perceptions of students' features and needs variable and perceived external pressure variable,  $r=.23$ ,  $p < .01$ . Only non-significant correlation was found between distribution of mathematical authority variable and perceived external pressure variable. The relationship between conceptualization of metacognition variable and perceptions of students' features and needs variable was found as significant, but there was moderate correlation between them,  $r= .43$ ,  $p < .01$ . The result indicated that when the teachers had high conceptualization of metacognition that they got high scores in The Conceptualization of Metacognition Scale, then they better perceived students' features and needs based on metacognition.

Significant gender differences were observed on teachers' claims about their distribution of mathematical authority,  $F(1,312)=8.86$ ,  $p=.05$ , partial, perceived external pressure,  $F(1,312)=18.052$ ,  $p=.00$ , partial, and conceptualization of metacognition,  $F(1, 263.96) = 8.24$ ,  $p=.00$ , partial, in favor of female teachers. Significant differences according to age,  $F(3,310)=15.127$ ,  $p=.00$ , partial, and years of experience,  $F(3, 282.90)=6.57$ ,  $p=.00$ , partial, were observed only on teachers' distribution of mathematical authority in favor of teachers with 20–29 age group and 1–5 years of experience respectively. There were also significant differences on distribution of mathematical authority,  $F(1,312) = 8.06$ ,  $p=.00$ , partial, and perceived external pressure,  $F(1,148.78) = 1.76$ ,  $p = .01$ , partial, according to teachers' educational background. Teachers with a master's degree supported the distribution of mathematical authority more and perceived less external pressure than teachers with a bachelor degree. In addition, significant teaching level differences were found on each factor in favor of middle school mathematics teachers. Lastly, perceived external pressure,  $F(1,312)=5.75$ ,  $p=.02$ , partial, and teachers' conceptualization of metacognition,  $F(1,59.22)=.01$ , partial, also significantly differed on school types. Teachers working at a public school perceived higher external pressure and their conceptualization of metacognition's scores were lower than teachers working at a private school.

Most participants were found to conceptualize metacognition as a multiphase phenomenon which include those commonly accepted principles in the relevant literature. It shows that teachers' beliefs about the presence of metacognition in their teaching are positive. Although the positive results might be a result of social desirability, it is important to keep in mind that the teachers are aware of the importance of metacognition in mathematics classrooms. The awareness of teachers might lead them to introduce and promote metacognitive activities within their teaching practices (Lombaerts et al., 2009). It can be stated that better teachers' conceptualization of metacognition paral-

lel to those in the literature reflecting the details and sophistication might influence teachers' promotion of metacognition positively when hampering factors were diminished or eliminated. As a remarkable and significant difference on teachers' conceptualization of metacognition was observed on teachers working at different school types which could be a result of the fact that secondary school mathematics teachers are mostly graduates of faculties of science (111 out of 153), not of faculties of education (42 out of 153).

Secondly, most participants perceived students' features and needs in terms of metacognition. They mostly stated they were aware of metacognitive characteristics of students and acting upon it. In order to promote metacognition and self-regulation, learning environments should be arranged accordingly (Lombaerts et al., 2007). Teachers who give priority to students' characteristics in terms of their developmental milestones, their way of knowledge construction, and participation of the learning process, are described as the ones taking "learning needs and experiences of students as starting point" (Vandeveld, Vandebussche, & Van Keer, 2012, p. 1563). Therefore the results showed that there is a positive approach to promote metacognition with respect to this issue. Furthermore, in perceptions of students' features and needs variable, only significant difference was found according to teaching level in favor of middle school level. The reason might be the nurturing, parent-like nature of primary education (Louis, Marks, & Kruse, 1996). As they stated, the concerns in high school shift to a more academic plane.

Thirdly, mathematical authority is rather a new concept that provides a student-centered learning environment for teachers and learners (Wilson & Llyod, 2000). As Amid and Fried (2005) pointed out when authority in classroom is discussed, most people including teachers imagine the teacher as "the head of a classroom" (p. 145). However, mathematical authority in the classroom might exist within a classroom when teacher authority as expert authority is eliminated (Amid & Fried, 2005). The results of the study showed the majority of participants stated a distribution of mathematical authority in which mathematics teachers guide learners to use mathematical concepts and procedures in order to reach conclusions through creating an environment where learners share their knowledge, discuss their mathematical thinking and form communities of practices

(Schoenfeld, 1992). The results might be interpreted such that most participants might provide learners with a learning environment where mathematical activities, processes or problems can be interpreted and conceptualized through multiple viewpoints and where learners share and discuss their mathematical ideas through taking responsibility of their learning (Wilson & Lloyd, 2000). When group comparisons were investigated on distribution of mathematical authority variable, there are remarkable results found with respect to gender, age and education level. Younger and less-experienced teachers distributed mathematical authority well since the reason might be that they have more positive towards integrating educational innovations into teaching practices (Ghaith & Yaghi, 1997). Furthermore, teachers' educational background also contributed their adaptation to new perspectives in their teaching practices through learning more about reform changes. Therefore, as a further investigation, it is important to examine teachers' varying backgrounds in (e.g. ,their age, career stage, generational identity of teachers) with respect to authority within the classroom to have an idea about the effectiveness of educational changes (e.g., student-centered learning) (Hargreaves, 2005).

Lastly, external pressure is highly perceived by most teachers in the sample. Especially change in curriculum, timing, content, and students' attitudes towards mathematics, classroom size, parental expectations and achievement test were found to be important factors affecting teaching practices such as promotion of metacognition. School context characteristics consisting of classroom size, curriculum, parental expectations, expectations from principal and timing creates occupational stress or pressure on teachers that affect promotion of self-regulation or metacognition negatively (Lombaerts et al., 2009). When group comparisons were taken into account in terms of perceived external pressure, on the contrary to literature (Karaköse & Kocabaş, 2006), public school mathematics teachers perceived higher external pressure than private school teachers in this study. Furthermore, the study indicated middle and secondary school mathematics teachers also differed with respect to perceived external pressure in favor of middle school mathematics teachers. The reason for this result could be given as the characteristics of age-group taught and primary learning environment (Kokkinos, 2007).

For this study, four instruments as the profiling tools were developed and validated. The data were gathered from 314 middle and secondary school mathematics teachers. The results indicated that most mathematics teachers' current thoughts on three factors namely as teachers' conceptualization of metacognition, teachers' perceptions of students' features and needs, the distribution of mathematical authority were positive. However, most mathematics teachers felt external pressures on their teaching practices. The results indicated that although most teachers have positive approaches towards promotion of metacognition, external pressure they perceived might have a negative influence on promotion of metacognition as an educational innovation. The negative factors created pressure or stress on teachers so especially teachers hesitating integrating educational changes in their classrooms may have problems with adjusting their learning environment for example with respect to promotion of metacognition (Lombaerts et al., 2009). One limitation of this study is the use of self-report instruments as the single data source. Group comparisons for factors affecting promotion of metacognition are significant, but effect sizes of the group comparisons were relatively small. The small amount of explained variances is a limitation for explaining the factors affecting promotion of metacognition (Lombaerts et al., 2009). It would be informative to describe such data in-detail through using qualitative methods (Dignath-van Ewijk & Van der Werf, 2012). The researchers would investigate FAMTAM variables based on the items of the scales through qualitative methods to check whether such variables included in these scales and teachers' statements on FAMTAM match with teachers' existing practices. For the further studies, it would be better to describe the profiles of mathematics teachers with a larger sample size in order to improve the generalizability of findings derived from the profiling tools. All in all, the study showed that mathematics teachers have already had positive approaches towards promotion of metacognition with respect to conceptualization of metacognition variable, perceptions of students' features and needs variables and distribution of mathematical authority variable. However, perceived external pressure might have negative influence on their teaching practices. As a possible next major step in research on teachers' promotion of metacognition, the investigation to what extent the variables affect promotion of metacognition can be suggested.

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