Erzincan Üniversitesi Eğitim Fakültesi Dergisi
Erzincan University Journal of Education Faculty
2022 Cilt 24 Sayı 2 (257-271) https://doi.org/10.17556/erziefd.969103

Investigation of the Metacognition-Themed Articles Consisting of a Mathematical Content and Published in Turkey

Türkiye'de Yayımlanan ve Matematiksel Bir İçerik Barındıran Makelelere Yönelik İnceleme

Fatih Baş[1] Meryem Özturan Sağırlı[2]

[1]Assoc. Prof. Dr., Erzincan Binali Yıldırım University, Faculty of Education, Erzincan, Turkey
[2]Assoc. Prof. Dr., Erzincan Binali Yıldırım University, Faculty of Education, Erzincan, Turkey

Makale Bilgileri

Geliş Tarihi (Received Date)

09.07.2021

Kabul Tarihi (Accepted Date)

03.11.2021

***Sorumlu Yazar**

Erzincan Binali Yıldırım University, Faculty of Education, Department of Mathematics and Science Education, Erzincan, Turkey

+90 446 224 00 89-42222

fbas@erzincan.edu.tr

Abstract: In this research, it is aimed to review the metacognition-themed articles, which have been conducted and published in Turkey on the topic of the mathematics education, within the scope of methodological features and in terms of the subjects/reached results. The research was designed with a descriptive content analysis method. 117 journals published in our country were determined and 41 articles were included in the research. The obtained data were subjected to a descriptive analysis. As a result of the analyses, it was determined that approximately half of the metacognitive-themed articles were conducted with a quantitative approach and descriptive methods. It was noticed that about half of the articles were conducted at the secondary school level, in the second place, that the university level took place with a one-fourth of rate. In terms of the data collection tools, it was found that mostly questionnaire/open-ended questionnaire/scale/tests were used, observation, interview, think-aloud protocol, and documents were applied; in terms of the data analysis techniques, the correlation, descriptive statistics, independent samples t-test, one-way variance analysis, and regression analysis were used. It was reached that when sorted by frequency the correlational, leveling, metacognitive behaviours of the participants in the problem-solving processes were investigated, and experimental research were conducted.

Keywords: Metacognition, mathematics education, metacognition-themed articles in mathematics education

Öz: Bu araştırmada, Türkiye'de matematik eğitimi alanında yapılmış ve yayımlanmış olan üstbiliş temalı makaleleri yöntemsel özellikleri ve konular/ulaşılan sonuçlar bağlamında incelemek amaçlanmıştır. Araştırma betimsel içerik analizi yöntemi temel alınarak tasarlanmıştır. Ülkemizde yayın yapan 117 dergi belirlenmiş ve toplam 40 makale araştırmaya dâhil edilmiştir. Elde edilen veriler betimsel analize tabi tutulmuştur. Analizler sonucunda; yaklaşık yarısının nicel bir yaklaşımla ve betimsel yöntemler kullanılarak gerçekleştirildiği belirlenmiştir. Makalelerin yaklaşık yarısının ortaokul düzeyinde gerçekleştirildiği, ikinci sırada ise yaklaşık dörtte birlik bir bölümle üniversite düzeyinin yer aldığı görülmüştür. En fazla anket/açık uçlu anket/ölçek/testler olmakla birlikte gözlem, görüşme, sesli düşünme protokolü ve dokümanların veri toplama sürecinde tercih edildiği ve verilerin analizinde, korelasyon, betimsel istatistikler, bağımsız örneklem t-testi, tek yönlü varyans analizi ve regresyon analizlerinin kullanıldığı saptanmıştır. Matematik alanında üstbiliş temalı yapılan makaleler konu olarak yapılma sıklığına göre ilişkisel, düzey belirleme, problem çözme sürecinde katılımcıların sergilemiş oldukları üst bilişsel davranışların belirlenmesi ve deneysel araştırmalar şeklinde sıralamıştır.

Anahtar Kelimer: Üstbiliş, matematik eğitimi, matematik eğitiminde üstbiliş temalı makaleler

Baş, F. & Özturan-Sağırlı, M. (2022). Investigation of the metacognition-themed articles consisting of a mathematical content and published in Turkey. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi,* 24(2), 257-271. *https://doi.org/10.17556/erziefd.969103*

Introduction

The metacognition concept, in general terms, includes two fundamental directions: individuals' knowledge about their cognition and the activities of regulating the cognition (Brown, 1978; Depaepe, Corte, & Verschaffel, 2010; Desoete, 2007; Dignath, Buettner, & Langfeldt, 2008; Flavell, 1976; Schraw, 1998; Schraw & Moshman, 1995; Garofalo & Lester, 1985; Lester, Garofalo, & Kroll, 1989; Mevarech & Amrany 2008; Muis, 2008; Schoenfeld, 1987; Veenman, 2006). Metacognition helps a person not only plan to manage or arrange a task but also which strategy to use for a task and when (Khan & Panth, 2017). Therefore, an individual with a developed metacognition is a person who has awareness of what he knows and at the same time has the ability to regulate and control when and how to use what he knows (Depaepe et al., 2010). The metacognitive behaviours (Baş, 2016) that individuals demonstrate even without being aware during a cognitive activity have a close correlation with learning. The reason why metacognition is getting more prominent as a concept is that it is highly effective in acquiring skills such as learning to learn and self-learning - the core of the educational paradigms of our era (Akpunar, 2011). One of the special goals of the Mathematics Course Curriculum emphasizing the learning to learn within the scope of the competencies is stated as "the skill to develop metacognitive knowledge and skills, manage their learning processes consciously" (The Ministry of National Education [MoNE], 2018).

The research, discussing this concept has a close relationship with learning, date back to 1970s (Flavell, 1979; Garner & Alexander 1987; Mazzoni & Nelson, 1998; Schneider & Artelt, 2010), and the metacognition-themed studies have a history of 18 years to take place in the journals in our country (Baş & Özturan Sağırlı, 2017). Although a confusion exists in the literature regarding the use of the metacognition concept (Akaydin, Yorulmaz, & Cokcaliskan, 2020), it is realised that as the meaning of the metacognition word, the concepts "metacognition", "metacognitive", "beyond cognition" and "executive cognition" have been used (Mert, 2017). In addition, the studies were conducted in various fields such as Turkish, Mathematics, Science and Technology, English, Chemistry, Information Technologies, Teaching Designs,

Curriculum Development and Biology (Baş & Özturan Sağırlı, 2017).

The mathematics field, stating in the centre of the present research, is the second field, in which most of the studies with approximately 12% of the metacognition themed articles in our country (Baş & Özturan Sağırlı, 2017). One of the main factors underlying this rate is the role of metacognition in mathematics education. For, this concept, in line with the relevant literature, is directly related to the students' mathematics achievement (Garofalo & Lester, 1985; Jaafar & Ayub, 2010; Özsoy, 2011) and more specifically to solving mathematical problems (Gurat & Medula, 2016; Jacobse & Harskamp, 2012; Lee, Chang & Lee, 2001; Lester, 1982; Verschaffel, 1999; Şengül & Yıldız, 2013; Aydemir & Kubanç, 2014; Panaoura, Philippou, & Christou, 2003; Şengül & Katrancı, 2015; Yıldız, 2020; Yimer & Ellerton, 2010; Yong & Kiong, 2006).

Considering this effect on learning and teaching mathematics, it can be claimed that the studies conducted with metacognition focus will continue increasingly. Determining the tendencies in the field (Ulutaş & Ubuz, 2008), providing information to educators, teachers, students (Çiltaş, Güler, & Sözbilir, 2012) and compiling and gathering studies are significant particularly in terms of shedding light on shaping policies, practices and public perception. As the relevant literature was reviewed, exemplary research on mathematics education was reviewed (Baki, Güven, Karataş, Akkan, & Çakıroğlu, 2011; Çiltaş, 2012; Çiltaş et al, 2012; Kayhan & Özgün Koca, 2004; Ulutaş & Ubuz, 2008; Yücedağ & Erdoğan, 2011), no research on metacognition-themed studies has been encountered in this area. Accordingly, with the conducted study, it is planned to contribute to this gap determined in the literature by providing the meaning and significance(results) of the metacognition theme in terms of mathematics teaching clearly and thus, handle the studies that will be carried out with more specific problems. Considering this point, it was aimed to review the metacognition-themed articles conducted and published in the subject of mathematics in Turkey in terms of their methods and topics/reached results in this research. With this purpose, answers were tried to be found for these questions.

1. What are the methodological features of the metacognition-themed articles on mathematics education published in Turkey?
2. What are the topics and reached results of the metacognition-themed articles mathematics education published in Turkey?

Method

This research, in which the metacognition-themed studies in Turkey were reviewed within the scope of the method and topic/result was shaped by the method of descriptive content analysis described as “dealing with the research conducted on a specific topic, assessing the tendencies and results in a descriptive dimension” (Çalık & Sözbilir, 2014).

Collecting the Data

The data were collected in three steps. In the first step, the keywords that would be used in the process were determined; metacognition word for the articles published in English and for the articles in Turkish, considering the classification by Mert (2017), the meanings of the metacognition word in Turkish as “*üstbiliş, bilişüstü, bilişötesi, bilişsel farkındalık and yürütücü biliş*” concepts were used as the keywords.

In the second step, the journals that are published in our country were determined, the web pages giving information accordingly were used, and 117 journals were determined. 77 of the relevant journals were the education journals prepared by the organizations that are public / private or researchers conducted in our country, 28 of them were the journals of the education faculties and 12 of them were the journals of the social science (institutes).

In the third step, all volumes of the 117 journals that can be handed online and limited to the end of 2019 were reviewed using the determined keywords. In this scope, in gathering the articles to be analysed, these criteria were taken into consideration.

- Passing the determined keywords in title, abstract and keywords
- Forming a design based on a mathematical subject in a related mathematical feature/skill/competence
- Being conducted with the sample of our country (as the focus of our country students)

  For instance;
- The study, conducted by Yabaş and Altun (2009), designed in the centre of the differentiated instructional pattern, to determine the influence of this pattern on the students’ academic achievements, metacognitive skills and perceptions of self-efficacy, was included in the research as it was carried out on the subject of decimal fractions in a mathematics course.
- The study, by Kacar and Sarıçam (2015) and focusing on the topic of the interrelation between metacognitive awareness and maths anxiety levels of the prospective primary school teachers, was included in the study as it used a mathematical feature.
- The study, conducted by Deniz, Küçük, Cansız, Akgün and İşleyen (2014), in which secondary school mathematics teacher candidates' awareness of using metacognitive strategies and the knowledge of cognition and regulation of cognition, which are the dimensions of metacognition, are examined according to grade levels and genders, was excluded from the analysis, as it investigated the general characteristics of students and did not directly focus on a mathematical feature.
- The study, conducted by Hidayat, Norul and Zulnaidi (2018) was excluded from the research as a foreign sample (Indonesia) was used in the research although it was published in a journal in our country.

For the feasibility of the research, the restrictions imposed on the journals and topics in the data collection process brought some limitations to the research. That is, articles conducted in the sample of our country but published in foreign journals are not involved in the research. At the end of the process, 41 studies were decided to be reviewed. The distribution of the relevant articles for their publication years is presented in Figure 1.

As presented in Figure 1, one can notice that the first article on the theme of metacognition on mathematics education in Turkey was published in 2008. From 2014, the number of these studies increased and reached the highest number with

10 articles in 2017. It is seen that this number was 5 in the years 2018 and 2019.

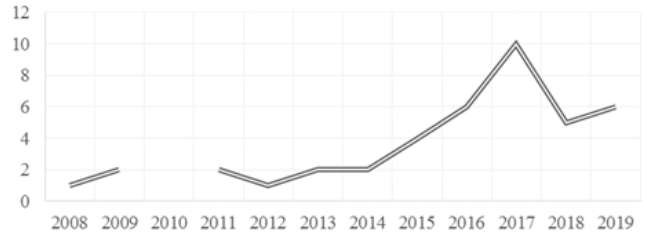

Figure 1. The number of articles included in the analysis for years

Data Analysis

The obtained data were analysed descriptively (Yıldırım & Şimşek, 2008, p. 224), in which the conceptual structure has been previously determined. In analysing the findings of the first sub-problem, the codes and categories created by Baş and Özturan Sağırlı (2017) were applied; four categories as method, study group, data collection tools and data analysis techniques and 52 codes under these categories were determined. Only data collection tools and data analysis methods applied for a metacognitive feature are included in the analysis. The information, which was not specified related to the categories in the reviewed articles (e.g. method, data analysis techniques) was determined considering the opinions of the professionals. In the analyses of the data for the second sub-problem, also the template that Baş and Özturan Sağırlı (2017) used to classify articles according to their subjects; correlational, leveling, experimental, metacognitive behaviour in the problem solving process and other (opinion setting and observation form development) categories and for the articles examined under these categories, the codes as high/low, difference / no difference, relationship / no relationship, predicts/does not predict were applied. The analysis process was concluded with the concurrent study of two researchers based on consensus, and the findings were presented by using tables and graphs by calculating frequency/percentages. Besides, the articles were coded as A1, A2, …. A41 during the analysis process, the data were given in the relevant tables.

Results

Findings consisting of the sub-dimensions are given in order in this part.

Findings for the First Sub-problem as, "What are the methodological features of the metacognition-themed articles on mathematics education published in Turkey?"

Findings related to the method, study group, data collection tools, and data analysis techniques of the reviewed articles are presented under the relevant titles in order.

Distribution according to the method

The distribution of the articles, which were analysed, according to their methods is presented in Figure 2.

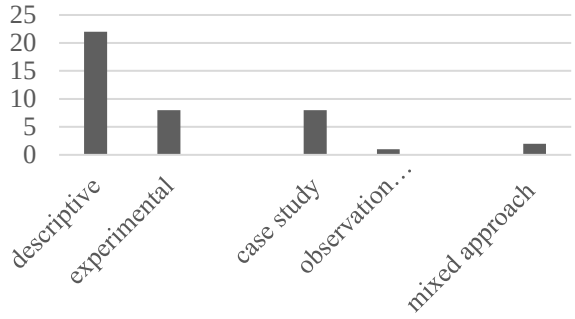

Figure 2. Article numbers, analysed in terms of their methods

As presented in Figure 2, mostly the descriptive studies (22) with the quantitative approach were conducted. Most of these articles are in the correlational article model. 8 of the rest of the articles were designed with the experimental, 8 with the case study. In addition, 2 articles were designed based on the mixed approach and an observation form was developed within the scope of an article.

Distribution according to the study group

The articles, analysed according to their study groups are presented in Figure 3.

As it is presented in Figure 3, most articles (19) were conducted at the secondary school level. Second is the university level (11 articles). Mostly seventh class level (14) was studied in the articles. Considering the sample distribution, it can be claimed that the articles continue from the level of secondary school to the graduate level and teachers. It is remarkable that the number of the articles at high school level is low.

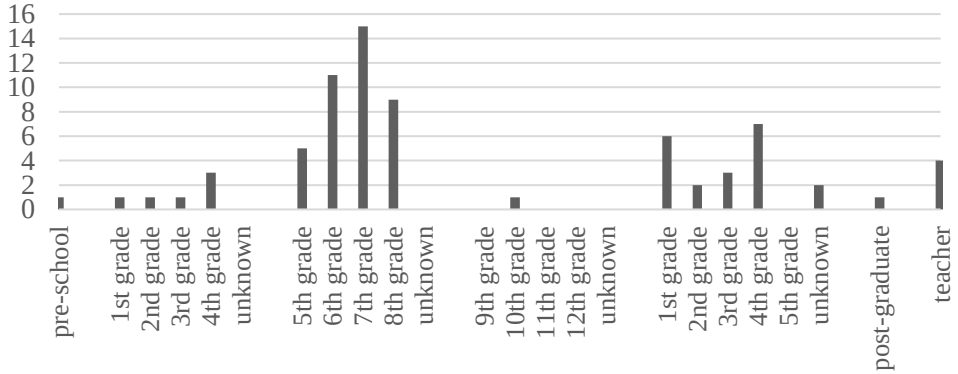

Figure 3. The article volumes, analysed in terms of study groups

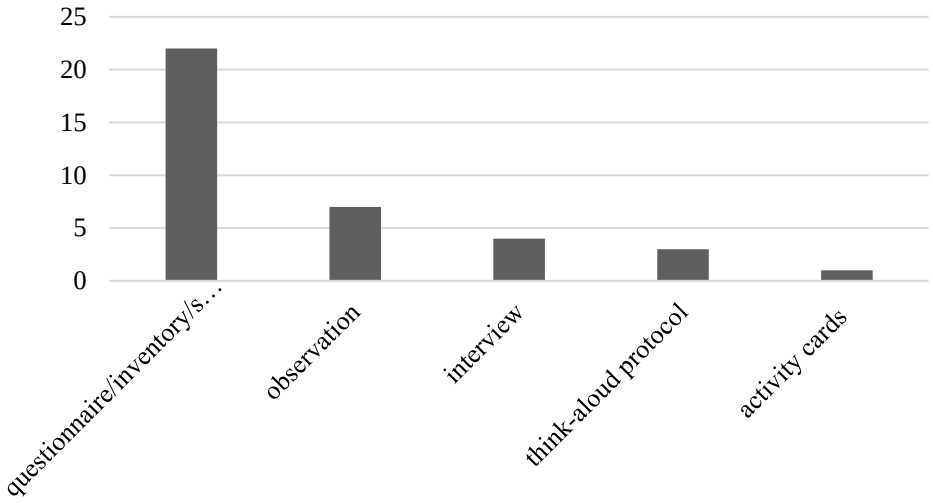

Figure 4. The articles, analysed in terms of the data collection tool

Distribution according to the data collection tool

The articles, analysed according to the data collection tool are presented in Figure 4**.**

As presented in Figure 4, the most used data collection tools in the articles were questionnaire/inventory/scales (22). This is orderly followed by the observation (7) and interview (7) and 3 of the interviews were in think-aloud. Activity cards were also used within the scope of the practice in one research. Information related to the questionnaire/scale/inventories applied in the articles is shown in Table 1.

As it is indicated in Table 1, the questionnaires that were applied most in the articles were The Metacognitive Awareness Inventory, developed by Schraw and Dennison, (1994), and the Motivated Strategies for Learning Questionnaire by Pintrich et al. (1991).

Table 1. Quantitative data collection tools applied in the articles reviewed

Scale Developer	Name of Scale	Scale Adapter
Schraw and Dennison (1994)	Metacognitive Awareness Inventory	Akın, Abacı and Çetin (2007) Sungur (2004)
Pintrich, Smith, Garcia and McKeachie (1991)	Motivated Strategies for Learning Questionnaire	Üredi (2005) Karadeniz, Büyüköztürk, Akgün, Kılıç-Çakmak and Demirel (2008) Altun and Erden (2006)
Sperling, Howard, Miller and Murphy (2002)	Metacognitive Awareness Inventory	Karakelle and Saraç (2007) Aydın and Ubuz (2010) Aydın (2007)
Namlu (2004)	Metacognitive Learning Strategies Scale	
Desoete, Roeyers and Buysse (2001)	Metacognitive Skills and Knowledge Assessment	Özsoy (2007)
Kaplan & Duran (2016)	Mathematical Metacognition Awareness Inventory	
Yıldız, Akpınar, Tatar and Ergin (2009)	Metacognition Scale	
Çetinkaya and Erktin (2002)	Metacognition Inventory	
Wells and Cartwright-Hatton (2004)	Metacognitions Questionnaire	Tosun and Irak (2008)
Şeker and Ader (2018)	Framework for Analysing Mathematics Teaching for the Advancement of Metacognition	
Efklides, Kiorpelidou and Kiosseoglou (2006)	Metacognitive Experiences Scale	Aşık (2009)
Bal and Demir (2011)	Cognitive Couching Questionnaire	

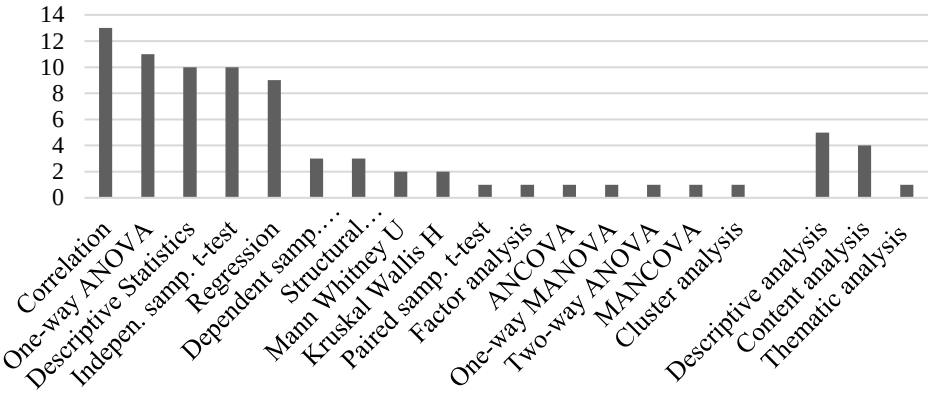

Figure 5. The distribution of the articles, analysed, according to the data analysis technique

Distribution according to their data analysis technique

The distribution of the articles, analysed, according to the data analysis technique is presented in Figure 5.
As presented in Figure 5, 15 different tests were used within the scope of the quantitative research, 3 of the qualitative tests. The most applied test in the quantitative research was the correlation (13), the descriptive statistics (10) and the one-way variance analysis (8) were the other preferred tests. In the qualitative research, the descriptive analysis (5), content analysis (4) thematic analysis (1) were used.

Table 2. Findings, including the data for the level of feature investigated, analysed variables and data related to the class level

Code of Article	Investigated Level of Feature	Investigated Variables	Class Level
A20	Mathematical metacognitive knowledge and skill	In gender, girls are generally higher and lower, and students' metacognitive knowledge and skills are sufficient.	5th class
A12	Metacognitive knowledge	Analysed in general. 59% of the students' metacognitive knowledge levels are at a moderate level, 22% are high.	7th class
A31	Metacognitive awareness	As the grade level increases, metacognitive awareness decreases. Gender difference is in favor of girls.	6, 7 and 8th class
A32	Metacognitive awareness	There is no difference in grade level, no significant difference exists in favor of girls in terms of gender, parental education level, family income level, those who receive preschool education and have a computer at home are higher	6, 7 and 8th class
A19	Mathematical metacognitive awareness	Good in general.	6, 7 and 8th class
A5	Metacognitive awareness	Students with a higher grade level of five and below, the difference in gender in favor of girls, those with higher report cards.	5, 6, 7 and 8th class
A41	Metacognitive awareness	When the grade level increases, metacognitive awareness decreases	5, 6, 7 and 8th class
A36	Using metacognitive learning strategies	The best is the prospective science teachers in terms of the departments, 60% moderate, in general.	Primary school science, social studies teaching, psychological counseling and guidance, ICT 1st class
A33	Metacognitive awareness	Negative metacognitive awareness of women in gender is higher than men, there is no significant difference according to the graduated department and graduated high school type variables	Prospective primary school teachers 3rd and final class prospective maths teachers
A11	Metacognitive awareness	In general, metacognitive awareness levels are high.	Fourth class prospective secondary school maths teachers
A16	Awareness of using metacognition strategies	No significant difference exists in gender. No significant difference exists in terms of higher academic achievement, education level of parents, high school type graduated, and income level of the family.	Fourth class prospective maths teachers
A40	Metacognitive learning strategies	In class level, in favor of 4th class compared with 2nd and 3rd. In favor of girls in terms of gender organization and control strategies sub-dimensions. Metacognitive awareness levels are good.	Prospective secondary school maths teachers 1, 2, 3 and 4th class
A24	Metacognitive awareness	No significant difference exists in terms of the class level.	Prospective secondary school maths teachers 1, 2, 3 and 4th class
A9	Conceptualization of metacognition	It demonstrated that metacognition conceptualizations are parallel to the conceptualizations widely accepted in the literature. School type studied, school level studied, in favor of teachers working in private school and primary school teachers	Maths teachers
A17	Metacognitive knowledge Metacognition calibration	Metacognition scores are high, metacognition calibration achievements are low.	Engineering 1st class students

Findings for the Second Sub-problem as, "What are the topics and reached results of the metacognition-themed articles on mathematics education published in Turkey?"

The topics of the reviewed articles and results handled within the context of the topics are presented under five categories as levelling, correlational, metacognitive behaviours during the process of problem solving, experimental studies and other, considering the frequencies. As the same article can include data for more than one category, the total number of articles in the categories is more than the number of the reviewed article.

Levelling articles

14 of the reviewed articles are the levelling articles and present experimental data regarding the differentiation situation according to the different variables of these levels and investigated the level of feature, analysed variables and data for the class level of the relevant articles are shown in Table 2.

As it is presented in Table 2, the metacognitive features, whose level is investigated in the reviewed articles, are as metacognitive awareness (7), metacognitive learning strategies (2), metacognitive knowledge (2), mathematical metacognitive knowledge and skill (1), mathematical metacognitive awareness (1), the conceptualisation of metacognition (1) and calibration of the metacognition (1). Variables that investigate whether the articles affect these features are mainly gender (7) and class level (5). In addition, others are parents' education level (2), family income level (2), graduated high school type (2), getting pre-school training (1), having a computer at home (1), report card score (1), department (1), graduation department (1), academic achievement (1), worked school type (1) and school level (1). The general finding is that the metacognitive awareness in the studies at the secondary school level has a significant effect on the class level. This effect is in the direction of decreasing metacognitive awareness as the grade level increases. However, there are also article results suggesting that metacognitive awareness does not have a significant effect on class level. It can be concluded that the metacognitive awareness levels of the prospective teachers are high, considering the study results carried out at the university level. In studies where gender and grade level variables are investigated at this level, it is not possible to express a similar or common result, since the variables sometimes have a significant, sometimes meaningless effect. In addition, mathematics teachers' definition of metacognition is similar to the literature and mathematics teachers have the awareness of metacognition and its features for students. In one of the studies in this group, unlike other samples, engineering students took part in the research group. In this study, the metacognitive scores of the research group were high, but the metacognitive calibration achievement was low. However, it was also stated that the high achievement group was better in terms of metacognition calibration.

Correlational articles

12 of the reviewed articles are aimed at determining the relationship and predictive status between variables, and the data of the related articles on the variables used, relationship status and class level are shown in Table 3.

As it is presented in Table 3, variables associated with a metacognitive variable are as mathematics achievement (8), problem solving skill (2), problem solving performance (1), mathematics-oriented academic risk-taking behaviour (1), motivation (1), self-efficacy perception (1), mathematics anxiety (1), problem solving skill (1), mathematical literacy self-efficacy (1), opinion on mathematical proof (1), learning approaches (1), attitude/belief towards problem solving (1), dimensional estimation skill (1), mathematical reasoning (1), attitude towards mathematics (1).

It is stated that metacognition at the primary level has a positive, low correlation with mathematics achievement (1). There are the relationships at the secondary school level, as a positive high level between report card score and metacognitive knowledge and skills (1), a positive moderate level between mathematics success and metacognitive knowledge and skills (1), positive moderate level with metacognitive awareness (2), positive weak level with the metacognitive skill (1). At the university level, a negative high relationship exists between metacognition calibration scores and mathematics achievement (1) and one article suggests no relationship between metacognitive knowledge and mathematics success.

Some of the variables associated with a cognitive feature are variables within the problem-solving process. The results indicated a positive moderate level (1) relationship between mathematical metacognitive awareness and problem-solving skill perception and positive moderate level (1), metacognitive knowledge and experiences and problem-solving performance at the secondary school level. In addition, in one article, it was stated that the increase in performance in problem solving can be predicted by looking at the metacognitive knowledge of the student, and this relationship is largely achieved through metacognitive experiences. Positive moderate correlation between the metacognitive self-regulation strategies and perceived problem-solving skills (1), a negative low correlation between metacognitive awareness and problem-solving skills (1) and a positive low correlation between attitudes and beliefs towards problem solving (1) are even among the results.

In the rest of the articles, the results reached in terms of the class levels can be summarised as at secondary school level, cognitive self-regulation strategies and motivation (1), metacognitive knowledge and metacognitive experiences (1), metacognitive awareness and mathematics-oriented academic risk-taking behaviour (MOARB) (1) and metacognitive knowledge and dimensional prediction skill (1).

As the articles at the university level are analysed, it can be reached to the conclusions suggesting that there is a positive moderate correlation between metacognitive self-regulation strategies and self-efficacy perceptions (1), a positive low relationship between opinion on metacognitive awareness and mathematical proof (1) and a negative low relationship between learning approaches (1), but mathematical literacy self-efficacy has no correlation (1). Furthermore, other results that can be reached are that there is a positive moderate correlation between the metacognitive learning strategies and mathematical reasoning (1), positive moderate relationship between metacognitive strategies using awareness and attitude towards mathematics lesson (1), and no relationship between negative metacognitive awareness and mathematics anxiety (1) and metacognitive knowledge and metacognitive calibration achievement (1).

Table 3. The variables used in the articles that determine the relationship and predictive state, the variables used, the relationship status and findings of the grade level

Code	Related Variable	Related Variable	Relationship Status	Class Level
A39	Metacognition	Mathematics Achievement	Significant, positive, low	Primary School 4th class
	Self-regulation strategies+ Metacognition skills + mathematics motivation predict academic achievement at a moderate level.			
A20	Metacognitive knowledge and skill	Mathematics Achievement	Significant, positive, moderate	5th Class
	Metacognitive knowledge and skill		Significant, positive, high	
		Mathematics Report Card Score		
	Gender, test scores of mathematics achievement and report card score predict their metacognitive knowledge and skill scores at the level of 59%.			
A27	Mathematical metacognitive awareness	Problem solving skill perception	Significant, positive moderate	5, 6, 7 and 8th class
	Confidence in problem solving skills, self-control and avoidance predict metacognitive awareness at the level of 28%.			
A5	Metacognitive awareness	Mathematics achievement	Significant, positive, moderate	5, 6, 7 and 8th class
	Metacognitive awareness + Self-efficacy perception of mathematics predict mathematics achievement at the level of 49%.			
A41	Metacognitive awareness + Mathematics anxiety predict mathematics achievement at the 9,6% level.			6, 7 and 8th class
A32	Awareness of using metacognitive strategies	Mathematics Achievement	No correlation is given	6, 7 and 8th class
	The awareness of using metacognitive strategies predicts mathematics achievement as 20%.			
A19	Metacognitive awareness	Mathematics-oriented academic risk-taking behaviour (MOARB)	Significant, positive, high.	6, 7 and 8th class
	Mathematical metacognitive awareness score and attitude towards mathematics predict 65% of the MOARB attitude score.			
A4	Metacognitive score	Mathematics achievement	Significant, positive, weak	7th class
	Metacognitive skill predicts 18% of the mathematics achievement.			
	Metacognition + mathematics self-efficacy predict 52% of the mathematics achievement.			
A10	Metacognitive awareness	Mathematics achievement	Significant, positive, moderate	7th class
			Significant	
	Metacognitive self-regulation strategies	Metacognitive awareness		
			Significant	
	Metacognitive self-regulation strategies	Motivation		
	Metacognitive self-regulation strategies predict 46 % of the motivation metacognitive awareness.			
A22	Metacognitive knowledge	Metacognitive experiences	Significant, positive, moderate	8th class
	Metacognitive knowledge		Significant, positive, moderate	
		Problem solving performance		
	Metacognitive experiences		Significant, positive, moderate	
		Problem solving performance		
A28	Metacognitive self-regulation strategies	Perceived problem-solving skill	Significant, positive, moderate	University students
		Self-efficacy perception	Significant, positive, moderate	
	Metacognitive self-regulation strategies			
	Metacognitive self-regulation strategies predict 3 % of mathematics achievement.			
A33	Negative metacognitive awareness	Mathematics anxiety	Significant, positive	University 3rd and 4th class
A34	Metacognitive awareness	Problem solving skill	Significant, negative, moderate	University students
			Not significant	
	Metacognitive awareness	Mathematical literacy self-efficacy		
	Problem solving skill predicts 15 % of the metacognitive awareness.			
	Metacognitive awareness + self-efficacy of mathematical literacy predict 18 % of problem solving skills.			
A11	Metacognitive awareness	Opinion on mathematical proof	Significant, positive, moderate	Prospective mathematics teachers
			Significant, negative, moderate	
		Learning approaches		
	Metacognitive awareness and opinion about the mathematical proof			
A24	Metacognitive awareness	Attitude towards problem solving	Significant, positive, low	Prospective secondary school mathematics teachers
		Belief in problem solving	Significant, positive, low	
	Metacognitive awareness			
	Attitude and belief related to problem solving predict 8 % of the metacognitive awareness.			
A36	Metacognitive learning strategies	Mathematical reasoning	Significant, positive, moderate	First-Class level prospective teachers
A12	Metacognitive knowledge	Dimensional prediction skill	Significant, positive, moderate	7th class
A16	Awareness of using metacognition strategies	Attitude towards mathematics lesson	Significant, positive, moderate	Prospective secondary school mathematics teachers
A17	Metacognitive calibration scores	Mathematics exam achievement	Significant, negative, high	Engineering faculty first class students
	Metacognitive knowledge	Metacognition calibration achievement	Not significant	
	Metacognitive knowledge	Mathematics achievement	Not significant	

As it is considered in terms of the prediction studies, at the primary school level, it is suggested that metacognitive skills predict academic achievement together with the self-regulation strategies and mathematics motivation (1). At the

secondary school level, it is stated that metacognitive awareness and mathematics self-efficacy perception (1), metacognitive awareness and mathematics anxiety (1), metacognitive strategies using awareness (1), and metacognitive skills itself (1) and mathematics self-efficacy (1) together predict mathematics achievement. At the university level, it is referred that metacognitive self-regulation strategies predict mathematics achievement (1); in addition, metacognitive awareness and mathematical literacy self-efficacy predict problem solving skills (1).

Besides, at the secondary school level, it is stated that the variables such as trust to problem solving skills, self-control and avoidance (1), metacognitive self-regulation strategies and motivation (1) predict metacognitive awareness. On the other hand, at the university level, problem solving skills (1) and attitude and belief towards problem solving (1) are among the significant predictors of metacognitive awareness.

Metacognitive strategies applied during problem solving (metacognitive behaviours)

Ten of the reviewed articles are related to determining metacognitive behaviours used during problem solving. The articles in this scope are generally those in which the data are collected with the think-aloud protocols during problem solving from the study group and these data are analysed with descriptive and content analysis. The reached results stated in the relevant studies are summarised below.

In an article, in which little children (between 43-73 months) were observed, their behaviours of metacognitive regulation during the problem solving were determined. We found the children demonstrated behaviours as planning, observation, check and evaluation steps during solving three different problems (measurement, pattern and classification). In addition, in the article, the interactions as planning-monitoring, monitoring-control / evaluation between these skills were stressed. In the article carried out with primary school students on non-routine and verbal problems, it was found as a result of data collected through clinical interviews that the students, who used their metacognitive skills and answered questions correctly, successfully achieved the metacognitive behaviours such as restating the problem in their own words, analysing what is given and desired in the problem correctly, solving the problem with alternative strategies, transferring previous experience or knowledge to the question, and most significantly checking the logical accuracy of the problem. Also, in another article conducted with the primary school fourth class students, it was reached that the students with high achievement levels, demonstrated more cognitive-metacognitive behaviours during the problem-solving process; in addition, some behaviours were sometimes cognitive and sometimes metacognitive when the reasons were asked. In an article with secondary school students, the students were divided into three groups as good, moderate and weak in terms of their academic achievement and we determined that the strategies that these three groups used in planning, estimation, monitoring and evaluating sub-dimensions were compared. In the article, it was found that they used five different strategies in the planning dimensions of the metacognition (setting the time, focusing, determining the goal and sub-goals, determining the actions to be taken and carrying out regularly, identifying the obstacles to be encountered and overcoming them), six in the estimation sub-dimension (reread the problem, mark up with a pencil, analyse the situation of the problem, draw figures, analyse what you know, predict possible consequences), six in the observation sub-dimension (recognising and correcting mistakes, keeping the purpose in mind, making sure that the operations are correct, evaluating the result according to the estimated answer, checking the accuracy of the calculations, recording the result found) and four strategies in evaluation dimension (think on the answer, evaluating whether it is successful, thinking about the place of the subject in daily life and questioning yourself at the final part of the study).

The students with moderate, high academic success demonstrated more metacognitive behaviours in each sub-dimension compared with the students with low academic success. In a study with the students with gifted students (6-8th class), it was determined that gifted students demonstrated metacognitive skills (be confident, reviewed their goals (again) and evaluated/controlled themselves at each step) in each of the stages of understanding, planning, applying and evaluating the problem, and as the class level increased, they used higher the metacognitive skills. In an article with seventh class students, the metacognitive knowledge and skills that the students demonstrated while performing the peer teaching activity were investigated and it was concluded that the students used metacognitive skills in the form of planning, monitoring and evaluation, and metacognitive information about themselves, their tasks and strategies while performing their teaching tasks. In addition, in an article with seventh class students, the students were divided into weak, moderate and high groups as metacognitive knowledge level and their use of the dimensional estimation strategy were investigated. In this study, it was also determined that students with high metacognitive knowledge could apply seven different prediction strategies, while the number of prediction strategies used decreased as the level of metacognitive knowledge decreased. In an article, in which the teachers formed the research group and the data were collected by observation, it was determined that the mathematics teachers demonstrated the behaviours that stimulate the metacognition of the students at the least problem-posing step in the plan preparation step. In addition, in another study, the metacognitive skills of mathematics teachers and prospective teachers in the process of proving were examined and eight categories as, "Facilitating operations", "Questioning", "Awareness", "Planning", Strategy determination "," Checking "," Associating "and" Analogical reasoning " It has been determined that eight categories were formed. In an article, the use of planning, thinking and evaluation dimensions of the cognitive coaching approach used while teaching cognitive awareness skills by teachers were evaluated by non-thesis graduate students. The students answered that the teachers used the dimensions of the cognitive coaching approach at a moderate level.

Experimental articles

Eight of the reviewed articles present experimental data, and the findings of the dependent variable, independent variable and class level of the related studies are presented in Table 4.

Table 4. Dependent, independent variable and class levels of studies with experimental data

Code	Independent Variable	Dependent Variable	Class Level
A14	Problem solving activities supported by collaborative metacognitive strategies	Problem solving skill	4th graders
A30	Metacognitive strategy training	Mathematical problem-solving achievement, metacognitive skills	5th graders
A26	Differentiated instructional design	Metacognitive skills	6th graders
A38	Teaching based on multiple intelligences	Metacognitive skills	6th graders
A21	Cooperative learning method supported by metacognitive strategies	To Metacognitive skills	6th graders
A3	Writing activities	To metacognition	7th graders
A6	Mathematical modelling activities	To metacognition (only metacognitive knowledge)	10th graders
A13	A problem-solving approach depend on metacognitive questioning	Metacognitive self-regulation	Prospective Primary School Teachers

As it is presented in Table 4, in four of the reviewed articles, one metacognitive variable was only dependent, three dependent both independent and independent, and only one was the independent variable. In the research, the influence of independent variables on dependent variables is in favor of the experimental group, and the difference is significant statistically. This effect is present in almost all class levels, from primary school to university level. Metacognitive strategy training increased metacognition. In addition, it was also found that the differentiated instructional design, the multiple intelligence-based teaching and writing activities increased metacognition. However, in the practice of mathematical modelling activities, this effect remained only at the metacognitive dimension of metacognition. More than half of the research conducted in this group was carried out at the level of secondary school. There is only one article with primary, high school and undergraduate levels.

There are two opinion determination articles related to taking the opinions of the study group in the research. In one of these articles, the prospective teachers were asked about whether metacognitive self-regulation teaching is necessary or not, and the prospective teachers stated that they thought it was necessary. In another study, opinions were obtained that sixth-class students questioned the problems and procedures related to the development of their metacognitive skills, analysed their mistakes, and planning behaviour improved. And one observation chart development article was determined. The observation form was developed to address each step in order to determine teachers 'behaviours to activate their students' metacognition.

Discussion and Conclusion

Within the context of this study aiming to review the articles conducted on mathematics education and published in Turkey in terms of their methods and topics/ reached results, the results can be summarised as follows.

The results gathered in the context of the methodological features emerged from the components of the used method, sample, data gathering tools and data analysis methods can be summarised as follows.

- It was determined that almost half of the metacognitive-themed articles on mathematics education on account of the methods were conducted with a quantitative approach and using the descriptive methods. Experimental studies and case studies, designed with the qualitative approach, were equal and constituted one-fifth part, and the rest of the studies were designed with the mixed method or related to developing a qualitative data collection tool. This situation coincides with the trend claimed to be included in metacognitive-themed studies conducted by Baş and Sağırlı (2017) within the scope of all fields. The proportional size of the articles on mathematics education, in which the structure of metacognition, its relationship with different variables and the case of prediction are discussed, can be interpreted as the continuing efforts to understand the structure of the concept of metacognition. For, it is possible to encounter the studies (Akpunar, 2011; Desoete & Özsoy, 2009; Doğan, 2013), in which this concept was not clarified in the literature of our country.
- As it is regarded in terms of the study groups, it is noticed that almost half of the articles were carried out at the level of secondary school, secondly at university level with approximately a quarter of rate. This result demonstrates a difference from the result that most studies were conducted at the university level and at the secondary school level second. As it is taken into consideration in terms of the class level, most of the studies were conducted at the seventh-class level. According to the status of being in the study group, the primary school level is in third place and the teachers are in fourth place, respectively. There is one study at each school level as pre-school level, high school and graduate level. The low number of studies, especially at pre-school and primary school levels, may be associated with the limitations in the use and learning of metacognition at this age (Senemoğlu, 2007, p. 337). Study intensity at secondary school and university level can be explained in the context of the relationship between metacognitive development and age progress (Schneider & Lockl, 2002; Veenman et al., 2006; Veenman & Spaans, 2005). Nevertheless, few numbers of studies at the high school level, which is between two levels, is an interesting point expressed by Baş and Özturan Sağırlı (2017).
- When analysed in the context of data collection tools used in articles, it can be stated that most articles / open-ended articles/scales/tests are used, observation, interview, think-aloud protocol and other tools are used. This result is a direct relationship with the methods used in the articles and is an expected result from the determination that qualitative and descriptive articles are predominant. Baş and Özturan Sağırlı (2017) reached a similar result. The most preferred articles are the Metacognitive Awareness Inventory developed by Schraw and Dennison, (1994) and Motivated Strategies for Learning Questionnaire developed by Pintrich et al. (1991). The other is the Metacognitive Awareness Inventory, and it can be referred that these

questionnaires are highly preferred both in our country (Baş & Özturan Sağırlı, 2017) and in the international literature (Doğan, 2013).

- As it is considered on account of the data analysis techniques, it is noticed that correlation, descriptive statistics, independent samples t-test, one-way variance analysis and regression analysis are applied. On the other hand, in qualitative studies, descriptive analysis and content analysis were applied respectively. This result is shaped, without doubt, by the objectives of the relevant research along with the research method. It can be said that while the hypothesis tests are used more in articles with metacognition based on all fields (Baş & Özturan Sağırlı, 2017), relational tests are more intense in mathematics education.

As the metacognition-themed articles conducted in the field of mathematics, it was concluded that the metacognitive behaviours exhibited by the participants in the process of determining and problem solving were examined and experimental studies were conducted. In addition to these topics, there are articles on opinion determination and development of observation form.

In studies investigating the relationship and prediction status, a metacognitive feature was associated with mathematics achievement, problem solving performance, belief/attitude towards problem solving, self-efficacy perception, motivation, mathematics anxiety, mathematical literacy self-efficacy, and mathematical reasoning. Due to a large number of variables in relational articles, metacognitive awareness, metacognitive knowledge, metacognitive self-regulation skills, metacognitive experience, and metacognitive learning strategies are gathered under a single concept as metacognitive variables in order to bring the results of the article together in this section more simply.

It was realised that there was a positive moderate correlation of a metacognitive variable with mathematics achievement at primary school level (Demir & Budak, 2016), positive moderate at the secondary school level (Memiş & Arıcan, 2013; Kurtuluş & Öztürk, 2017; Kaya, 2019) or weak (Kahramanoğlu & Deniz, 2017), no relationship at university level (Aşık & Sevimli, 2015) was realised. The relationship with a problem-solving performance at secondary school level was found as positive moderate (Aşık & Erktin, 2019), positive moderate problem solving skill perception (Kaplan, Duran, & Baş, 2016); negative moderate with problem solving skill at university level (Özçakır Sümen & Çalışıcı, 2016), positive moderate (Alcı, Erden, & Baykal, 2018), positive weak with attitude and belief towards problem solving (Baş, Özturan Sağırlı, & Bekdemir, 2016). Dimensional estimation skill of a metacognitive feature at secondary school level (Şengül & Budak, 2017), motivation (Kaya, 2019) and mathematics-oriented academic risk-taking behaviour (Açıkgül & Şahin, 2019) are among the features associated with the metacognitive variable. At the university level, there is a positive moderate relationship with the self-efficacy perception (Alcı et al., 2008), mathematical reasoning (Ersözlü & Çoban, 2012), attitude towards mathematics lesson (Sarpkaya, Arık, & Kaplan, 2011), opinion related to the mathematical proof (Yavuz, 2019), negative relationship with learning approaches (Yavuz, 2019) and mathematics anxiety (Kacar & Sarıçam, 2015). A significant relationship has not been found with the mathematical literacy self-efficacy (Özçakır Sümen & Çalışıcı, 2016).

Metacognitive skill/awareness predicts mathematics achievement with the variables of self-regulation strategies and mathematics motivation (Demir & Budak, 2016), at the primary school level; by itself (Gürefe, 2015; Kahramanoğlu & Deniz, 2017; Alcı et al., 2018) or with mathematics self-efficacy perception (Kahramanoğlu & Deniz, 2017; Kurtuluş & Öztürk, 2017) and mathematics anxiety (Mert & Baş, 2019) at the level of secondary school. Furthermore, this variable with the variable of attitude toward mathematics is an important predictor of the mathematics-oriented academic risk-taking behaviour (Açıkgül & Şahin, 2019). At the university level, metacognitive awareness and mathematical literacy self-efficacy predict problem solving skill (Özçakır Sümen & Çalışıcı, 2016).

In addition, at the secondary school level, trust to the problem-solving skill, self-control and avoidance (Kaplan et al., 2016), metacognitive self-regulation strategies and motivation (Kaya, 2019), gender, mathematics success test score and report card score (Memiş & Arıcan, 2013) are significant predictors of metacognitive awareness/ knowledge-skills. At the university level, the problem-solving skill (Özçakır Sümen & Çalışıcı, 2016), attitude, and belief towards problem solving (Baş et al., 2016) predict metacognitive awareness.

Metacognitive features used in levelling articles are metacognitive awareness, metacognitive learning strategies, metacognitive knowledge, mathematical metacognitive knowledge and skills, mathematical metacognitive awareness, the conceptualisation of metacognition and metacognition calibration. The variables that the articles investigate whether they have an effect on these features are mostly gender and class level. In addition, others are parents' education level, family income level, type of high school graduated from, pre-school education status, the status of having a computer at home, report card score, department, study field, academic achievement, school type and school level. Although the levelling articles are predominant at the secondary school and university level, mathematics teachers also took part in the study group. As the general finding, measurement results of metacognitive feature in study groups at each education level are at the level of moderate/sufficient (Ersözlü & Çoban, 2012; Memiş & Arıcan, 2013; Şengül & Budak, 2017) or high (Açıkgül & Şahin, 2019; Aşık & Sevimli, 2015; Sırmacı & Taş, 2016; Yavuz, 2019). Except for one of the studies conducted at the secondary school level (Gürefe, 2015), the class level has a significant effect on metacognitive awareness. This effect is that as the class level increases, metacognitive awareness decreases (Erdoğan & Şengül, 2014; Kurtuluş & Öztürk, 2017). That there is no difference at the university level (Baş et al., 2016) or the relevant difference was in favour of upper classes for metacognitive learning strategies (Sırmacı & Taş, 2016) was referred. As it is taken into consideration in terms of gender, results such as the metacognitive awareness/knowledge and skills of girls are higher (Erdoğan & Şengül, 2014; Gürefe, 2015; Memiş & Arıcan, 2013; Kurtuluş & Öztürk, 2017), that this difference in metacognitive characteristics does not exist at the university level (Sarpkaya et al., 2011) or in favor of female participants (Sırmacı & Taş, 2016) or male participants (Kacar & Sarıçam,

2015), were found. It was also realised that students with high academic achievements also have high metacognitive awareness (Kurtuluş & Öztürk, 2017; Sarpkaya et al., 2011), parents' education level (Gürefe, 2015; Sarpkaya et al., 2011), family income (Gürefe, 2015; Sarpkaya et al., 2011), field graduated from (Kacar & Sarıçam, 2015) and high school type graduated from (Kacar & Sarıçam, 2015; Sarpkaya et al., 2011) variables do not demonstrate the difference. In addition, the metacognition description of mathematics teachers demonstrates similarity with the literature and mathematics teachers perceive the significance of metacognition and its features for students (Şeker & Ader, 2018).

The results stated in the articles, in which the metacognitive strategies/behaviours used in problem solving are investigated, can be summarised as follows. Students both at early ages (between 43 and 73 months) (Ünlü & Soylu, 2017), and at primary school level (Durmuş & Özdemir, 2016; Serin & Korkmaz, 2018), and secondary school level (Acar & Ader, 2017; Kaplan & Duran, 2015; Öztürk, Akkan, & Kaplan, 2018) demonstrate metacognitive behaviours at the problem-solving process. The frequency of using these behaviours increases as the problem-solving achievements (Durmuş & Özdemir, 2016), academic achievements (Serin & Korkmaz, 2018; Kaplan & Duran, 2015) and class level variables (Öztürk et al., 2018) increase. It was determined that teachers demonstrated behaviour that stimulates students' metacognition in the plan preparation step most and problem-posing step least (Yıldız & Güven, 2016). In addition, the metacognitive skills of mathematics teachers and prospective teachers in the proof-making process were investigated in a study and it was determined that eight categories were formed as "facilitating operations", "questioning", "awareness", "planning", strategy determination "," controlling "," association "and" analogical reasoning " (Öztürk & Kaplan, 2019). In a study, it was determined that teachers used the behaviours in the dimensions of planning, thinking and evaluation of the cognitive coaching approach at a moderate level. (Demir & Bal, 2011).

In experimental articles, metacognition as an independent variable was generally included in the research as metacognitive strategy training and as the dependent variable, metacognitive skill. It was determined that metacognitive strategy training or different practices supported by this application are effective on students' problem-solving skills (Serin & Korkmaz, 2018) problem solving achievements (Özsoy & Ataman, 2009), metacognitive skills (Ay & Bulut, 2017; Erdoğan & Şengül, 2017; Özsoy & Ataman, 2009). In addition, the differentiated instructional design (Yabaş & Altun, 2009), teaching practices based on multiple intelligences (Durmuş & Özdemir, 2013), writing activities (Ünlü & Soylu, 2017) are effective on the metacognitive skills of secondary school students. It can be claimed that mathematical modeling activities at the high school level are effective in the metacognitive knowledge dimension of metacognition (Deniz, 2017). In this group, researchers mostly studied metacognition with the secondary school group. The practices were carried out on the basis of problem solving, with different subjects (permutation, algebra, decimal numbers, prime numbers). In this group, researchers mostly studied metacognition at the secondary school level.

The prospective teachers stated that they thought that metacognitive self-regulation teaching is vital (Öztürk, Özgöl, & Akkan, 2018). Opinions were obtained that sixth-class students questioned the problems and their operations, analysed their mistakes and that planning behaviour improved (Erdoğan & Şengül, 2017). In an article, to determine the behaviours of teachers towards activating the metacognition of their students, an observation chart was created to address each step.

Recommendations

Metacognition in education is extremely significant specifically for mathematics course in terms of planning, organising, executing, following up and concluding ideas and actions successfully. For this reason, the metacognitive skills should be tried to acquire in the children from the early ages during the education process. Some of the levelling articles, based on the results that the metacognitive characteristics of the participants are at a moderate level and the applications for metacognitive skills increase these skills, emphasis can be given on experimental studies in this area. During these studies, the researchers's measuring the metacognitive behaviours during the application and using different measurement techniques are critical in terms of more reliable results. In addition, in teaching metacognitive strategy teaching, exploring the "writing education" can also be recommended to the researchers. Considering the relationship between problem solving achievement and metacognitive skills, emphasis can be given on classroom practices to teach students these skills. At this point, the metacognitive strategies such as assessment and checking determined to be used by the successful students can be focused more. As the first step of this, teachers' awareness of metacognitive behaviours used in classroom activities and their frequency of use can be increased by microteaching applications.

Author Contribution Rates

All authors equally took part in all processes of the article.

Ethical Declaration

The authors declare that the current study is not subject to the approval of the ethics committee and that the rules set by the Committee on Publication Ethics (COPE) were followed throughout the study.

Conflict Statement

The author declares no competing interests.

References

Acar, F., & Ader, E. (2017). Metacognition used by tutors during peer tutoring sessions in mathematics. *Elementary Education Online, 16*(3), 1185-1200.

Açıkgül, K., & Şahin, K. (2019). Investigation of secondary school students' perceptions on their mathematics-oriented academic risk taking behaviors in terms of gender, grade level, metacognition and attitude variables. *Adiyaman University Journal of Social Sciences, 32*, 1-30. https://doi.org/10.14520/adyusbd.558120

Akaydin, B.B., Yorulmaz, A., & Cokcaliskan, H. (2020). Investigation of primary school students' metacognitive awareness and decision-making skill. *International*

Journal of Progressive Education, 16(4), 157-171. https://doi.org/10.29329/ijpe.2020.268.10

Akin, A., Abacı, R., & Çetin, B. (2007). The validity and reliability of the Turkish version of the metacognitive awareness inventory. *Educational Sciences: Theory & Practice*, *7*(2), 671-678.

Akpunar, B. (2011). The analysis of the concepts of cognition and metacognition in terms of the philosophy of mind. *Turkish Studies*, *6*(4), 353-365.

Alcı, B., Erden, M., & Baykal, A. (2008). Explanatory and predictive pattern of university students' mathematics achievement and their perceived problem solving abilities, self-efficacy perceptions, metacognitive self-regulation strategies, and national university entrance examination points. *Bogazici University Journal of Education*, *25*(2), 53-68.

Altun, S., & Erden, M. (2006). Validity and reliability study of motivating strategies in learning scale. *Yeditepe Üniversitesi. Edu7*, *2*(1), 1-16.

Aşık, G. (2009). *A model study to examine the relationship between metacognitive and motivational regulation and metacognitive experiences during problem solving in mathematics* (Unpublished master's thesis). Boğaziçi University, İstanbul.

Aşık, G., & Erktin, E. (2019). Metacognitive experiences: Mediating the relationship between metacognitive knowledge and problem solving. *Education and Science*, *44*(197), 85-103. https://doi.org/10.15390/EB.2019.7199

Aşık, G., & Sevimli, E. (2015). Investigation of students' metacognitive calibration within the context of math achievement: Case of engineering students. *Bogazici University Journal of Education*, *32*(2), 19-36.

Ay, Z. S., & Bulut, S. (2017). Investigating the effects of problem solving approach based on metacognitive questioning on self-regulation skills. *Elementary Education Online*, *16*(2), 547-565. https://doi.org/10.17051/ilkonline.2017.304716

Aydemir, H., & Kubanç, Y. (2014). Investigation of the cognitive behavioral problem solving process. *Turkish Studies, 9*(2), 203-219. https://doi.org/10.7827/TurkishStudies.6555

Aydın, U. (2007). *A structural equation modeling study: The metacognition-knowledge model for geometry* (Unpublished master's thesis). Middle East Technical University, Ankara.

Aydın, U., & Ubuz, B. (2010). Turkish version of the junior metacognitive awareness inventory: An exploratory and confirmatory factor analysis. *Education and Science*, *35*(157), 30-45.

Baki, A., Güven, B., Karataş, İ., Akkan, Y., & Çakıroğlu, Ü. (2011). Trends in Turkish mathematics education research: from 1998 to 2007. *H. U. Journal of Education, 40*, 57-68.

Bal, A. P., & Demir, Ö. (2011). Cognitive coaching approach in view of prospective teachers. *Journal of Kirsehir Education Faculty*, *12*(4), 325-340.

Baş, F. (2016). Prospective secondary mathematics teachers' metacognitive awareness and metacognitive behaviours in problem solving processes. *Universal Journal of Educational Research, 4*(4), 779-801. https://doi.org/10.13189/ujer.2016.040416

Baş, F., & Sağırlı, M. Ö. (2017). A content analysis of the articles on metacognition in education in turkey. *Education and Science*, *42*(192), 1-33. https://doi.org/10.15390/EB.2017.7115

Baş, F., Özturan-Sağırlı, M., & Bekdemir, M. (2016). The metacognitive awarenesses of prospective secondary school mathematics teachers, beliefs, attitudes on problem solving, and relationship between them. *Journal of Theory and Practice in Education*, *12*(2), 464-482.

Brown, A. L. (1978). Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology*, Vol. 1 (pp. 77–165). Hillsdale: Erlbaum.

Çalık, M., & Sözbilir, M. (2014). Parameters of content analysis. *Education and Science, 39*(174), 33-38. https://doi.org/10.15390/EB.2014.3412

Çetinkaya, P., & Erktin, E. (2002). Assessment of metacognition and its relationship with reading comprehension, achievement, and aptitude. *Bogazici University Journal of Education, 19*(1), 1-11.

Çiltaş, A. (2012). Content analysis of the graduate thesis and dissertations in mathematics education in Turkey between 2005-2010. *The Journal of Academic Social Science Studies, 5*(7), 211-228. https://doi.org/10.9761/JASSS235

Çiltaş, A., Güler, G., & Sözbilir, M. (2012). Mathematics education research in Turkey: a content analysis study. *Educational Sciences: Theory & Practice, 12*(1), 565-580.

Demir, M. K., & Budak, H. (2016). The relationship between self-regulating, motivation and metacognitive skills and mathematics success of 4th grade students. *Buca Faculty of Education Journal, 41*, 30-41.

Demir, Ö., & Bal,A. P. (2011). Investigation on the cognitive coaching approach in the view of ma students major subject mathematics. *Electronic Journal of Social Sciences, 10*(37), 224-243.

Deniz, D. (2017). The impact of model eliciting activities implemented by prospective teachers on tenth-grade students's metacognition awareness. *Bartin University Journal of Faculty of Education, 6*(2), 580-595. https://doi.org/10.14686/buefad.296924

Deniz, D., Küçük, B., Cansız, Ş., Akgün, L., & İşleyen, T. (2014). Examining metacognitive awareness of prospective secondary school mathematics teachers in terms of some variables. *Kastamonu Education Journal, 22*(1), 305-320.

Depaepe, F., Corte, E. D., & Verschaffel, L. (2010). Teachers' metacognitive and heuristic approaches to word problem solving: Analysis and impact on students' beliefs and performance. *ZDM Mathematics Education, 42*, 205-218. https://doi.org/10.1007/s11858-009-0221-5

Desoete, A. (2007). Evaluating and improving the mathematics teaching–learning process through metacognition. *Electronic Journal of Research in Educational Psychology, 5*(3), 705–730.

Desoete, A., & Özsoy, G. (2009). Introduction: Metacognition, more than the lognes monster?. *Online Submission*, *2*(1), 1-6.

Desoete, A., Roeyers, H., & Buysse, A. (2001). Metacognition and mathematical problem solving in grade 3. *Journal of Learning Disabilities*, *34*(5), 435-447.

Dignath, C., Buettner, G., & Langfeldt, H. P. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review, 3*(2), 101–129.

Doğan, A. (2013). Metacognition and metacognition based teaching. *Middle Eastern ve African Journal of Educational Research*, *3*(6), 6-20.

Durmuş, F., & Özdemir, A. Ş. (2013). The effects of the education based on the multiple intelligence approach on the sixth grade students' mathematics course achivement and metacognitive skills. *Turkish Studies*, *8*(12), 443-452.

Efklides, A., Kiorpelidou, K., & Kiosseoglou, G. (2006). Worked-out examples in mathematics: effects on performance and metacognitive experiences. in A. Desoete and M. Veenman (eds.), *Metacognition in Mathematics Education*, pp. 11- 33, New York: Nova Science Publishers, Inc.

Erdoğan, F., & Şengül, S. (2014). A study on the elementary students' self-regulated learning strategies towards mathematics. *Journal of Research in Education and Teaching*, *3*(3), 108-118.

Ersözlü, Z. N., & Çoban, H. (2012). The relationship between candidate teachers' mathematical reasoning skills and their levels of using metacognitive learning strategies. *Mustafa Kemal University Journal of Social Sciences Institute*, *9*(19), 205-221.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. L. Resnick (Ed.), *The nature of intelligence içinde* (s. 231-236). Hillsdale, NJ: Erlbaum.

Flavell, J. H. (1979). Metacognitive and cognitive monitoring: a new area of cognitive developmental inquiry. *American Psychologist, 34*, 906-911.

Garner, R., & Alexander, P. A. (1989) Metacognition: Answered and unanswered questions. *Educational Psychologist, 24*(2), 143-158.

Garofalo, J., & Lester, F. K. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal of Research in Mathematics Education, 16*, 163–176.

Gurat, M. G., & Medula, C. T. (2016). Metacognitive strategy knowledge use through mathematical problem solving amongst prospective teachers. *American Journal of Educational Research, 4*(2), 170-189. https://doi.org/10.12691/education-4-2-5

Gürefe, N. (2015). Investigation of metacognitiveawareness of secondary school students in terms of some variables. *The Journal of International Education Science*, *2*(5), 237-246. https://doi.org/10.16991/INESJOURNAL.158

Hidayat, R., Syed Zamri, S. N. A., & Zulnaidi, H. (2018). Does mastery of goal components mediate the relationship between metacognition and mathematical modelling competency? *Educational Sciences: Theory & Practice, 18*, 579–604. https://doi.org/10.12738/estp.2018.3.0108

Jaafar, W. M. W, & Ayub, A. F. M. (2010) Mathematics self-efficacy and meta-cognition among university students, *Procedia Social and Behavioral Sciences, 8*, 519–524.

Jacobse, A. E., & Harskamp, E. G. (2012). Towards efficient measurement of metacognition in mathematical problem solving. *Metacognition and Learning, 7*, 133-149. https://doi.org/10.1007/s11409-012-9088-x

Kacar, M., & Sarıçam, H. (2015). The examination of the relationship between metacognitive awareness and math anxiety levels in prospective primary school teachers. *Trakya Journal of Education, 5*(2), 137-152.

Kahramanoğlu, R., & Deniz, T. (2017). An investigation of the relationship between middle school students' metacognitive skills, mathematics self-efficacy and mathematics achievement. *Inonu University Journal of the Faculty of Education (INUJFE), 18*(3), 189-200. https://doi.org/10.17679/inuefd.334285

Kaplan, A., & Duran, M. (2015). Comparison of middle school students' metacognitive awareness levels in mathematics course studying. *Bayburt Üniversitesi Eğitim Fakültesi Dergisi*, *10*(2), 417-445.

Kaplan, A., & Duran, M. (2016). Mathematical metacognition awareness inventory towards middle school students: validity and reliability study. *Journal of Kazım Karabekir Education Faculty, 32*, 1-17.

Kaplan, A., Duran, M., & Baş, G. (2016). Examination with the structural equation modeling of the relationship between mathematical metacognition awareness with skill perception of problem solving of secondary school students. *Inonu University Journal of the Faculty of Education, 17*(1), 1-16. https://doi.org/10.17679/iuefd.17119785

Karadeniz, S., Buyukozturk, S., Akgun, O. E., Cakmak, E. K., & Demirel, F. (2008). The Turkish adaptation study of motivated strategies for learning questionnaire (MSLQ) for 12-18 year old children: results of confirmatory factor analysis. *Online Submission*, *7*(4), 1-10.

Karakelle, S., & Saraç, S. (2007). Validity and factor structure of Turkish versions of the metacognitive awareness inventory for children (jr. mai) - A and B forms. *Turkish Psychological Articles*, *10*(20), 87-103.

Kaya, D. (2019). Predicting seventh grade students' mathematics achievements: the role of metacognitive awareness, motivation and, self-regulated learning strategies. *Ondokuz Mayis University Journal of Education Faculty*, *38*(1), 1-18.

Kayhan, M., & Özgün Koca, S. A. (2004). Research subects in mathematics education: 2000-2002. *Hacettepe University Journal of Education,* 26, 72-81.

Khan, R., & Panth, M. (2017). Significance of meta-cognition in academic achievement. *International Journal of Research in Humanities, Arts and* Literature, 7, 1-6.

Kurtuluş, A., & Öztürk, B. (2017). The analysis of the effect of metacognitive awareness and mathematics self-efficacy perceptions on mathematics achievement of middle school students. *Dicle University Journal of Ziya Gökalp Faculty of Education, 31*, 762-778. https://doi.org/10.14582/DUZGEF.1840

Lee, N. H., Chang, A., & Lee, P. Y. (2001). The role of metacognition in the learning of mathematics among low achieving students. *Teaching and Learning, 22*(2), 18-30.

Lester, F. K. (1982). Building bridges between psychological and mathematics education research on problem solving. In F. K. Lester & J. Garofalo (Eds.), *Mathematical problem solving* (pp.55–85). Philadelphia: The Franklin Institute Press.

Lester, F. K. J., Garofalo, J., & Kroll, D. L. (1989). *The role of metacognition in mathematical problem solving: A study of*

two grade seven classes. Final report. Accessed from the ERIC database (ED314255).

Mazzoni, G., & Nelson, T. O. (Eds.). (1998). *Metacognition and cognitive neuropsychology: Monitoring and control processes.* Lawrence Erlbaum Associates Publishers.

MEB [Ministry of Education], (2018). *Matematik dersi öğretim programı (ilkokul ve ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar) [Mathematics lesson curriculum (primary and secondary school 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th grades)]*. Ankara: MEB Publications.

Memiş, A., & Arıcan, H. (2013). The analysis of 5th grade students' mathematical metacognition levels between the variables gender and achievement. *KaraelmasJournal of Educational Sciences*, *1*(1), 76-93.

Mert, M. (2017). *The effect of levels of respect and student awareness for mathematics in mathematical success of secondary school students* (Unpublished master's thesis). Erzincan Binali Yıldırım Üniversitesi Fen bilimleri Enstitüsü, Erzincan.

Mert, M., & Baş, F. (2019). The anxiety and metacognitive awareness levels of secondary school students towards mathematics and the effect of related variables on their mathematics achievements. *Turkish Journal of Computer and Mathematics Education, 10*(3), 732-756. https://doi.org/10.16949/turkbilmat.508347

Mevarech, Z., & Amrany, C. (2008). Immediate and delayed effects of meta-cognitive instruction on regulation of cognition and mathematics achievement. *Metacognition and Learning, 3*(2), 147–157.

Muis, K. R. (2008). Epistemic profiles and self-regulated learning: Examining relations in the context of mathematics problem solving. *Contemporary Educational Psychology, 33*(2), 177–208.

Namlu, A. G. (2004). Metacognitive learning strategies scale: a study of reliability and validity. *Anadolu University Journal of Social Sciences, 4*(2), 123-136.

Özçakır Sümen, Ö., & Çalışıcı, H. (2016). The relationships between preservice teachers' mathematical literacy self efficacy beliefs, metacognitive awareness and problem solving skills. *Participatory Educational Research*, *Special Issue*, 11-19. https://doi.org/10.17275/per.16.spi.2.2

Özsoy, G. (2007). *The effect of metacognitive instruction on problem solving achievement of fifth grade primary school students* (Unpublished doctoral dissertation). Gazi University Graduate School of Educational Sciences, Ankara.

Özsoy, G., & Ataman, A. (2009). The effect of metacognitive strategy training on mathematical problem-solving achievement. *International Electronic Journal of Elementary Education, 1*(2), 67-82.

Özsoy. G. (2011). An investigation of the relationship between metacognition and mathematics achievement, *Asia Pacific Educ. Rev., 12*, 227-235. https://doi.org/10.1007/s12564-010-9129-6

Öztürk, M., Akkan, Y., & Kaplan, A. (2018). The metacognitive skills performed by 6th-8th grade gifted students during the problem solving process: Gümüşhane sample. *Ege Journal of Education, 19*(2), 446-469. https://doi.org/10.12984/egeefd.316662

Öztürk, M., Özgöl, M., & Akkan, Y. (2018). A comparative case study for teaching metacognitive self-regulation in middle school students: prospective elementary math teachers' views and activities they have designed. *Mehmet Akif Ersoy University Journal of Education Faculty, 48*, 54-84. doi: 10.21764/ maeuefd.351644

Panaoura, A., Philippou, G., & C. Christou, C. (2003). *Young pupils' metacognitive ability in mathematics.* Paper presented at CERME 3: Third Conference of the European Society for Research in Mathematics Education. Online available from http://www.dm.unipi.it/~didattica/CERME3/proceedings/Groups/TG3/TG3_Panaoura_cerme3.pdf

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire* (Technical Report 91-B-004). The Regents of the University of Michigan.

Sarpkaya, G., & Arık, A., & Kaplan, H. A. (2011): The relationship between elementary mathematics teacher candidates' awareness of using the metacognitive strategies and their attitudes towards mathematics. *Gaziosmanpaşa University Social Sciences Research Journal, 6*(2), 107-122.

Schneider, W., & Artelt, C. (2010). Metacognition and mathematics education. *ZDM*, *42*(2), 149-161. https://doi.org/10.1007/s11858-010-0240-2

Schneider, W., & Lock, Q. (2002). The development of metacognitive knowledge in children and adolescents. In T. Perfect ve B. Schwartz (Ed.), *Applied metacognition*. West Nyack, NY, USA: Cambridge University Press.

Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 189-215). Hillsdale, NJ: Lawrence Erlbaum Associates

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26*(1), 113- 125. https://doi.org/10.1023/A:1003044231033

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, *19*(4), 460-475. https://doi.org/10.1006/ceps.1994.1033

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*(4), 351-371. https://doi.org/10.1007/BF02212307

Senemoğlu, N. (2007). *Gelişim, öğrenme ve öğretim [Development, learning and teaching]*. Ankara: Gönül Publishing.

Serin, M. K., & Korkmaz, İ. (2018). The effect of metacognitive questioning instruction performed in cooperative learning environments on the mathematical problem-solving skills of 4th grade primary school students. *Elementary Education Online*, *17*(2), 510-531. https://doi.org/10.17051/ilkonline.2018.418893

Sırmacı, N., & Taş, F. (2016). Teacher self-efficacy perceptions and metacognitive learning strategies of prospective mathematics teachers. *Hacettepe University Journal of Education, 31*(3), 551-563. https://doi.org/10.16986/HUJE.2016015698

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of children's knowledge and regulation.

Contemporary Educational Psychology, *27*(1), 51-79. https://doi.org/10.1006/ceps.2001.1091

Sungur, S. (2004). *An implementation of problem-based learning in high school biology courses* (Unpublished doctoral dissertation). Middle East Technical University, Ankara.

Şeker, V., & Ader, E. (2018). Profiling mathematics teachers regarding factors affecting promotion of students' metacognition. *Bogazici University Journal of Education, 35*(1), 51-70.

Şengül, S. & F. Yıldız, F. (2013). The relation between the metacognitive behaviours demonstrated by students in their problem solving process with collaborative learning groups and their mathematical self- efficacy, *International Journal of Social Science, 6*(1), 1295-1324. https://doi.org/10.9761/JASSS_400

Şengül, S., & Budak, E. B. (2017). Examining the measurement estimation skills and strategies of seventh grade students on the basis of metacognitive knowledge. *Journal of Research in Education and Teaching, 6*(2), 149-160.

Şengül, S., & Y. Katrancı, Y. (2015). Meta-cognitive aspects of solving indefinite integral problems, *Procedia - Social and Behavioral Sciences, 197*, 622 – 629. https://doi.org/10.1016/j.sbspro.2015.07.205

Tosun, A., & Irak, M. (2008). Adaptation, validity, and reliability of the metacognition questionnaire-30 for the Turkish population, and its relationship to anxiety and obsessive-compulsive symptoms. *Turkish Journal of Psychiatry, 19*(1), 67-80.

Ulutaş, F., & Ubuz, B. (2008). Research and trends in mathematics education: 2000 to 2006. *Elementary Education Online*, *7*(3), 614-626.

Ünlü, V., & Soylu, D. (2017). The effects of writing activities on students' achievement, attitudes and metacognition in mathematics. *Gazi University Journal of Gazi Educational Faculty*, *37*(1), 345–360.

Üredi, I. (2005). *The contributions of perceived parenting styles to 8th class primary school students' self-regulated learning strategies and motivational beliefs* (Unpublished doctorate dissertation). Yıldız Teknik University, İstanbul.

Veenman, M. V. J. & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences, 15*, 159-176.

Veenman, M. V. J. (2006). The role of intellectual and metacognitive skills in math problem solving. In A. Desoete ve M. V. J. Veenman (Ed.), *Metacognition in Mathematics Education* (pp. 35-50). New York: Nova Science Publishers.

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition Learning*, *1*, 3-14. https://doi.org/10.1007/s11409-006-6893-0

Verschaffel, L. (1999). Realistic mathematical modelling and problem solving in the upper elementary school: Analysis and improvement. In J. H. M. Hamers, J. E. H. Van Luit, & B. Csapo (Eds.), *Teaching and learning thinking skills. Contexts of learning* (pp. 215–240). Lisse: Swets & Zeitlinger.

Wells, A., & Cartwright-Hatton, S. (2004). A short form of the metacognitions questionnaire: properties of the MCQ-30. *Behaviour research and therapy*, *42*(4), 385-396. https://doi.org/10.1016/S0005-7967(03)00147-5

Yabaş, D., & Altun, S. (2009). The effects of differentiated instructional design on students' self-efficacy beliefs, metacognitive skills and academic achievement. *Hacettepe University Journal of Education*, *37*, 201-214.

Yavuz, G. (2019). The Relationship of learning approaches, opinions about mathematical proof and metacognitive awareness. *International Online Journal of Educational Sciences*, *11*(4), 83-94. https://doi.org/10.15345/iojes.2019.04.006

Yıldırım, A., & Şimşek, H. (2008*). Nitel araştırma yöntemleri [Qualitative research methods]* (7th ed.). Ankara: Seçkin Publishing.

Yıldız, A., & Güven, B. (2016). The behaviours of mathematics teachers ıntended to promote the metacognitions of the students in problem solving environment. *Kırşehir Faculty of Education Journal*, *17*(1), 575-598.

Yıldız, E., Akpınar, E., Tatar, N., & Ergin, Ö. (2009). Exploratory and confirmatory factor analysis of the metacognition scale for primary school students. *Educational Sciences: Theory & Practice, 9*(3), 1573-1604.

Yıldız, S. G. (2020). Geometrical problem-solving performance of preservice teachers: exploring the effectiveness of metacognitive strategies. *Malaysian Online Journal of Educational Sciences, 8*(4), 34-47.

Yimer, A., & N. F. Ellerton. (2010) A five-phase model for mathematical problem solving: Identifying synergies in prospective-teachers' metacognitive and cognitive actions. *ZDM Mathematics Education, 42*(2), 245–261. https://doi.org/10.1007/s11858-009-0223-3

Yong, . T. Y., & Kiong. L. N. K. (2006). *Metacognitive aspect of mathematics problem solving*. MARA University of Technology Malaysia, Kuala Lumpur.

Yücedağ, T., & Erdoğan, A. (2011). Investigation of mathematics education studies according to some variables studied between 2000–2009 years in Turkey. *Gaziantep University Journal of Social Sciences, 10*(2), 825-838.