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Metacognitive awareness and math anxiety in gifted students

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Abstract

The basic purpose of this study has been to examine the relationships between metacognitive awareness and maths anxiety in gifted students. The second aim was to compare with gifted and non-gifted students' metacognitive awareness and maths anxiety levels. The participants were 300 (150 gifted, 150 non-gifted) volunteer secondary school students in Turkey. The mean age of the participants was 12.56 years ranging from 12 to 13 years. For gathering data, the Maths Anxiety Scale for Elementary School Students and The Metacognitive Awareness Inventory for Children were used. For analysing the data, Spearman correlation analysis, the Mann Whitney U test, and linear regression analysis were used. According to the findings: firstly, gifted students' metacognitive awareness scores were higher than those of non-gifted students. On the other hand, non-gifted students' maths anxiety levels were higher than those of gifted students. Secondly, there was negative correlation between metacognitive awareness and math anxiety. Finally, the findings of linear regression analysis indicated that metacognitive awareness is explained by 48% total variance of maths anxiety in gifted students.

Keywords: Metacognitive awareness, maths anxiety, gifted.

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1. Introduction

Metacognition is of importance to academic performance, problem solving and student learning. For instance, several researchers have viewed metacognition as a predictor of learning (Flavell, 1979; Glaser, 1990; Veenman & Elshout, 1995; Wang, Haertel & Walberg, 1993). Metacognition involves knowledge of the cognitive, affective and motivational characteristics of thinking (Paris & Winograd, 1990). Metacognition is thinking about thinking (Corno & Mandinach, 1983). Metacognitive skills include the procedural knowledge that is required for the regulation of and control over one's learning activities such as task analysis, planning, monitoring, checking, and reflection (Brown, 1978; Brown & DeLoache, 1978; Flavell, 1992; Kluwe, 1987). Knowledge of cognition refers to metacognitive awareness. Although metacognitive awareness may occur at an earlier age (Kluwe, 1987; Kuhn, 1999), the development of metacognitive skills may arise at 10–12 years of age (Berk, 2003; Kuhn, 1999).

Some researchers claimed that using metacognitive strategies may be the result of greater intelligence (e.g., Kurtz & Borkowski, 1987; Schneider, Borkowski, Kurtz & Kerwin, 1986; Schneider, Kordel & Weinert, 1987, Swanson, 1987). In addition, Sternberg (1990) considered metacognitive skills as a main component of his triarchic theory of intelligence. Gifted students display greater metacognitive awareness than non-gifted children (Dover and Shore, 1991). Schofield and Ashman (1987) have discovered that gifted students receive higher scores on measures of planning and metacognitive knowledge than non-gifted students. Kanevsky (1992) has demonstrated that gifted children had better ability to explain their own strategies, and the reason for using the strategies. Alexander, Carr and Schwanenflugel (1995) also found that gifted children possess greater metacognition than non-gifted peers. Similarly, Kurtz and Weinert (1989) indicate that gifted children have more metacognitive knowledge than non-gifted children.

Schraw and Graham (1997) claim that metacognitive knowledge most likely begins to improve in early stages amongst gifted students than non-gifted students. In addition to early beginnings, gifted children who have metacognitive skills are more likely to develop rapidly than those of the non-gifted (Borkowski & Peck, 1986). Several researchers have shown that gifted children use different metacognitive strategies than non-gifted peers (Cheng, 1993; Hannah & Shore, 1995; Rogers, 1986; Shore & Dover, 1987; Span & Overtoom-Corsmit, 1986; Overtoom-Corsmit, Dekker & Span, 1990; Zimmerman & Martinez-Pons, 1990). For instance, gifted students monitor comprehension more effectively than non-gifted students (Boufard-Bouchard, Parent and Larivee, 1993). In addition, gifted students identify the problem more properly, have better ability to find solutions and monitor the accuracy of these solutions (Rogers, 1986). Overtoom-Corsmit et al. (1990) found that gifted students spend more time orienting themselves towards a task, reflecting on the task before starting it and planning their approach.

Jausovec (1998) discovered that gifted students are more intellectually efficient compared with the non-gifted students when asked to do problem-solving, especially when given more difficult problems. Similarly, Borkowski and Peck (1986) found that gifted students were more proficient in using metacognitive abilities to solve problems. Borkowski and Kurtz (1987) summarised the results of studies that gifted children were more likely to use strategies more efficiently, learn new strategies more easily and transfer them to new situations more readily than non-gifted peers. Benito (2000) states that a six year old gifted child can select what strategy to use for solving a maths problem because a gifted child already has knowledge of some mathematical basic operations and can select what strategy to use when solving a problem.

Although metacognition has a positive influence on learning, maths anxiety has a negative effect on academic performance. Although students who are utilising metacognitive skills can easily recall and use their past knowledge to challenging problems (Kapa, 2007), on the other hand individuals with anxiety have difficulty storing and retrieving information (Nelson & Harwood, 2011). Maths anxiety is defined as feeling a fear or tension association with maths performance (Ashcraft & Kirk, 2001). This anxiety or tension notably occurs when solving mathematics problems and using numbers in daily and academic life (Sahin, 2000). Maths anxiety is a learned behaviour (Davidson & Levitov, 1993). Many studies have showed that maths anxiety has a negative influence on learning and performance in mathematics (Ashcraft, 2002; Fiore, 1999; Stuart, 2000, Hembree, 1990; Wadlington and Wadlington, 2008; Zakaria and Nordin, 2008). Moreover, results of the PISA math assessment indicate an overall high negative correlation (-0.65) between maths scores and math anxiety (Dobson, 2012). Some students have experienced anxiety in learning mathematics from elementary school level to university (Hembree, 1990; Skiba, 1990; Bessant, 1992; Chipman et al., 1992; Gierl and Bisanz, 1995; Campbell and Evans, 1997; Zettle and Raines, 2000; Sahin, 2004). Maths anxiety is most likely to occur around fourth grade and peak in high school (Geist, 2010; Legg & Locker, 2009; Woodard, 2004). There has been a widespread bias in regard to difficulties in mathematics in our country (Basar et al., 2002).

Lucangeli, Coi and Bosco (1997) found that fifth graders viewed problems containing large numbers as more difficult than problems with smaller numbers in their study examining the metacognition of maths difficulty in elementary school children. In this study, students who were classified as poor problem solvers showed lower metacognitive awareness and made more errors when solving problem. Cardell-Elawar (1995) indicated that metacognitive training has led to improvement in performance and attitudes toward mathematics amongst elementary and middle school age children. Therefore, the studies discussed bring to mind a relationship between math performance and metacognition.

Maths anxiety was investigated among gifted populations. Dreger and Aiken (1956) discovered that there was a little relationship between maths anxiety and general intelligence. Researchers stated that maths anxiety is present in gifted and talented students (Betz, 1978; Lupkowski and Schumacker, 1991; Yong, 1993). Chiu and Henry (1990) found that gifted students suffered from math anxiety as well as non-gifted students. On the other hand, Pajares (1996) found that gifted students had higher math self-efficacy and lower maths anxiety than non-gifted students. The studies concluded mixed results about gifted students and maths anxiety.

It is important to know about the expressions of maths anxiety in gifted samples. To date, no study about math anxiety and gifted students has not seen for the Turkish population. The current research furthers the description of possible differences in thinking between gifted and non-gifted children. The results of this study will provide new evidence regarding the maths anxiety level of gifted children. In the present study we have aimed to determine the relationships between metacognitive awareness and maths anxiety in gifted students. Besides, the other aim was to compare gifted and non-gifted students' metacognitive awareness and math anxiety levels.

2. Method

2.1. Participants

Data was obtained from 300 (150 gifted, 150 non-gifted) volunteer secondary school students in Turkey. Gifted students attended the Science and Art Centre, while their non-gifted peers enrolled in public secondary school. The ages of the participants ranged from 12 to 13 years and the mean age of the participants was 12.56 years. Of the gifted students, there were 80 boys (53.33%) and 70 girls (46.67%); 73 gifted students were in 6th grade, while 77 gifted students were in 7th grade. In the non-gifted students, there were 67 boys 44.67% (n = 67); and 83 girls 55.33%, besides 72 non-gifted students are 6th grade, 78 non- gifted students were 7th grade. Information about all the participants was given in Table 1.

Table 1. Descriptive information of participants

Students	Boys	Girls	Total	6th grade	7th grade
Gifted	80	70	150	73	77
Non-gifted	67	83	150	72	78
Total	147	153	300	145	155

2.2. Instruments

Math Anxiety Scale for Elementary School Students (MAS Ess): Maths anxiety levels were measured by using MAS Ess. It was developed by Bindak (2005), and it consists of 10-items (e.g. "Math is funny for me") and one dimension. Each item was rated on a 5-point Likert-type scale (1=always to 5=never). Factor loadings ranged from .50 to .78. Cronbach alfa internal consistency coefficient was found as .84 while the Sperman-Brown reliability coefficient was found as .83 for scale. Corrected item total correlation values ranged from 43 to 71.

Metacognitive Awareness Inventory for Children (Jr. MAI) B Form: Metacognitive skills were measured via Jr. MAI-B Form was developed Sperling, Howard, Miller and Murphy (2002). Jr. MAI-B Form is a self-report scale and it consists of 18-items and two-dimensions (1. Knowledge of cognition and 2. Regulation of cognition) and seven factors (A1. Declarative knowledge, A2. Conditional knowledge, A3. Conditional knowledge, B1. Information management skill, B2. Evaluation, B3. Monitoring, B4. Planning). Each item was rated on a 5-point Likert-type scale (1=always to 5=never). The Jr. MAI-B Form was adapted for Turkish use by Karakelle and Sarac (2007). The Turkish version of Jr. MAI-B Form is the one dimensional model. Factor loadings ranged from .34 to .75. The Cronbach alfa internal consistency coefficient was found to be .80, while the test and re-test reliability coefficient was found as .72 for scale. Corrected item total correlations values ranged from .38 to .60.

2.3. Procedure

The gifted and non-gifted students, who were given parental and managerial permission to participate, received a packet of surveys (paper-and-pencil) during 10 minutes of one class period. Researchers administered the self-report questionnaires to the students in the classroom environment. All the participants were volunteer students and not from intact classes. The measures were counterbalanced in administration.

While analysing the data, the Pearson correlation analysis and Mann Whitney U test were used because the data did not provide a criteria for parametric tests. For example, Kolmogorov Smirnov values were found as .167 and .219 ($p<.05$) for math anxiety; .167 and .134 ($p<.05$) for metacognitive awareness. If these values are statistically important, non-parametric tests should be used (Justel, Pena & Zamar, 1997; Marsaglia, Tsang & Wang, 2003). In other words, data did not normally distribute. Linear regression analysis was used to test the predictive role of metacognitive awareness on maths anxiety in gifted students because the gifted students' dataset followed a normal distribution. In this study, maths anxiety was the dependent variable, while metacognitive awareness was the independent variable.

3. Results

3.1. Comparison analysis

The Mann Whitney U test was applied in order to understand whether gifted and non-gifted students' maths anxiety and metacognitive awareness levels show differences. The findings are given in Table 2.

Table 2. Mann Whitney U test results about gifted and non-gifted students' maths anxiety and metacognitive awareness levels

Variables	Students	N	Mean of rank	Sum of Ranks	U	p
Math anxiety	Non-gifted	150	177.28	26592	72.33**	.00
	Gifted	150	123.72	18558		
Metacognitive awareness	Non-gifted	150	133.11	19966.50	8641.50**	.00
	Gifted	150	167.89	25183.50		

**p< .01

As illustrated in Table 1, the maths anxiety mean of rank for gifted students (χ=123.72) was lower than those of non-gifted students (χ=177.28; Z=-5.39), U= 72.33 with a significance level of .01. This finding indicates that there is a difference statistically between gifted and non-gifted students' maths anxiety levels. Besides, metacognitive awareness mean of rank for gifted students (χ=167.89) were higher than those of non-gifted students (χ=133.11; Z= -3.48), U= 8641.50 with a significance level of .01. This finding shows that there is a difference statistically between gifted and non-gifted students' metacognitive awareness scores.

3.2. Correlation analysis

For gifted students, Table 3 shows the inter-correlations of the variables, means, standard deviations and internal consistency coefficients of the variables used.

Table 3. Descriptive statistics, alphas, and inter correlations of the variables

Variables	1	2
1. Math anxiety	1	
2. Metacognitive awareness	-.47**	1
Mean	13.52	54.04
Standard deviation	4.59	5.89
Cronbach α	.80	.79

**p<.01

When Table 2 was examined, we observed that there are significant correlations between maths anxiety and metacognitive awareness. Maths anxiety was related negatively to metacognitive awareness (r_s=.47, p<.01). Namely, if metacognitive awareness increases, then maths anxiety decreases in gifted students, or vice versa.

3.3. Regression Analysis

For the last hypothesis, simple regression analysis was verified in which the dependent variable was maths anxiety, while the independent variable was metacognitive awareness. Furthermore, this analysis was applied for showing no multicollinearity and normality in gifted students. According to the findings, metacognitive awareness and maths anxiety (dependent variable) were negatively related. The results were shown in Table 4.

Table 4. Simple linear regression analysis for maths anxiety

V	R	R^2	F	β	t	p
MA	.69	.48	139.60**	-,.697	11.85	.00

Dependent variable: Maths anxiety (MA)
Independent variable: Metacognitive awareness (MTA)

As a result of the regression analysis made, it is observed that the model is significant (R=.697, R^2= .485, F= 139.601, p= 0,000) and the independent variable entering the regression analysis explains 48% of the changes on the dependent variable. Videlicet, metacognitive awareness is a very important predictor for maths anxiety.

4. Discussion

The purpose of this study has been to compare gifted and non-gifted students' metacognitive awareness and math anxiety levels and to address the relationships between metacognitive awareness and maths anxiety amongst the gifted population. One of the findings of the present study is that metacognitive awareness of gifted students was higher than those of non-gifted students. This finding was consistent with those of earlier studies (Alexander, Carr and Schwanenflugel, 1995; Kanevsky, 1992; Kurtz and Weinert, 1989; Dover and Shore, 1991; Schofield and Ashman, 1987) in demonstrating that gifted students possessed higher metacognitive awareness and skills than non-gifted ones. This may be the result of the fact that gifted students possess a knowledge base that supports metacognitive skills (Bouffard-Bouchard et al., 1993).

Bouffard-Bouchard et al. (1993) found that gifted students used more strategies consistently and monitored more accurately than non-gifted students. Gifted students also transfered newly acquired strategies more successfully to a new context than non-gifted peers (Scruggs, Mastropieri, Jorgensen & Monson, 1986). Shore (2000) demonstrates that gifted children have similar metacognition, strategy, flexibility, strategy planning and the use of hypotheses with adult experts. Sheppard (1992) also indicated that gifted children were more aware of their own self-regulatory processes. Using more strategies, monitoring and transferring accurately, being aware of their self-regulatory process also may contribute to the superior metacognitive awareness among gifted students.

The other result of this study demonstrates that there is a difference statistically between gifted and non-gifted students' maths anxiety levels. Gifted students had a lower maths anxiety level than non-gifted peers. Higher self-efficacy amongst gifted students (Cox, 1976; Zimmerman & Martinez-Pons, 1990) may reduce their maths anxiety, due to the fact that self-efficacy is a strong predictor of math anxiety (Pajeras, 1996). In addition, lower general anxiety in gifted students may contribute to this result. Some researchers reported lower levels of general and test anxiety in gifted students compared to non-gifted children (Davis and Connell, 1985; Milgram and Milgram, 1976; Reynolds and Bradley, 1983; Zeidner and Schleyer, 1999). A number of studies (Feldhusen & Nimlos-Hippen, 1992; Mulcahy, Wilgosh & Peat, 1991; Zimmerman & Martinez-Pons, 1990) indicated that gifted students perceive themselves as more competent. This self-perception of competency may also lead to lower maths anxiety among gifted students.

With regard to the relation between maths anxiety and metacognitive awareness, math anxiety is related negatively to metacognitive awareness. According to the study results, metacognitive awareness explains 48% of the changes in maths anxiety. Therefore, metacognitive awareness is a very important predictor of maths anxiety. This result was supported by prior study results. For example, Legg (2009) demonstrated that metacognition had a moderating relationship with maths anxiety. The researcher concluded that highly anxious individuals benefit from higher levels of metacognition. In a recent study amongst pre-service primary school teachers, it was found that there was a positive relationship between the metacognitive awareness levels of pre-service primary school teachers and maths anxiety (Kacar & Sarıcam, 2015). Similarly, Everson, Smodlaka and Tobias (1994) found that individuals who have low anxiety are better able to use metacognition in a positive way. Maths anxious students may sometimes feel that they cannot understand because their maximum mathematical potential is insufficient (Yenilmez, Girginer & Uzun, 2007).

On the other hand, metacognitive awareness encompasses exact knowledge and insight about their own cognitions or thoughts. Other researchers showed that students who experienced lower anxiety used more metacognitive regulation (Kacar & Saricam, 2015; Kesici, Baloglu & Deniz, 2011). It could be argued that if the task leads to some stress, individuals that are also high in metacognition awareness utilise effectively the beneficial aspects of metacognition. Lucangeli, Coi and Bosco (1997) found that poor problem solvers showed lower metacognitive awareness. Therefore, if a student cannot solve a problem, then the anxiety may increase. Similarly, Swanson (1990) found that metacognitive awareness was helpful for the regulation of problem solving amongst fifth and sixth grade students.

5. Conclusion and Recommendations

We may conclude that gifted students had higher metacognitive awareness and lower math anxiety than non-gifted peers. These differences should be taken into account in school settings, especially when educating gifted children. In addition, metacognitive awareness and maths anxiety were negatively correlated significantly in the study. One educational implication of this finding would be to advocate metacognitive training to reduce maths anxiety. Many researchers suggest metacognitive training to help students (Kramarski & Mevarech, 2003; Kruger and Dunning 1999; Teong, 2003).

In terms of the limitations of the current study, it should be noted that the maths anxiety and metacognitive awareness were measured with self-report questionnaires so it is probable that participants will answer the questions in a socially desirable way. Experimental, longitudinal and qualitative research designs are recommended for further exploration of the qualitative differences between young gifted and non-gifted students in terms of metacognitive awareness and maths anxiety. In addition, future research should attempt to explore other elements, such as the planning, prediction and evaluation of metacognitive knowledge in gifted students. Mathematically gifted students or students interested in mathematics can be examined in terms of metacognition and maths anxiety.

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