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THE EFFECT OF FIFTH-GRADE STUDENTS' SCIENCE ANXIETY ON METACOGNITIVE AWARENESS

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Abstract. *Successful students who do not experience anxiety can participate in future progress both at local and international levels. It is necessary to identify students' anxiety and to enhance research into the effect of anxiety on the cognitive burden of science, which is one of the top priorities for future progress. Thus, the main aim of this research was to explore the effect of students' science anxiety on metacognitive awareness. The research, therefore, adopts a relational survey model and uses a random selection sampling method. The sample consisted of 346 students with an equal number of males and females. To explore the effect of fifth-grade students' science anxiety on metacognitive awareness, data were collected by means of a prepared three-part sample form. The first part of the form collected data about gender, classroom size and school campus. The second part contained an anxiety scale for science and technology lessons and the last part used a metacognitive awareness scale. The research results showed that gender is not an important factor for anxiety or metacognitive awareness, but classroom size has an important effect on science anxiety. Nonetheless, students' science anxiety is a significant predictor of their metacognitive awareness.*

Keywords: *metacognitive awareness, relational survey model, science anxiety.*

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Introduction

Students' decision-making processes about their future and their conscious choice of profession are mostly in line with their interests and curiosity. One of the reasons why students' interest in science may be negatively affected is due to science anxiety (Udo, Ramsey & Mallow, 2004). Mallow (1978) defined the term science anxiety as a fear that has a weakening effect on science learning and cognition. This kind of anxiety can mostly be seen in science lessons, exams and performance-based test activities and some studies have been conducted on how to overcome this anxiety (Mallow, 1986). Furthermore, science anxiety acts as a kind of filter for students' taking science lessons. According to Udo et al (2004), female students have more science anxiety, and this results in fewer female researchers in disciplines such as physics. Zuway (2010) defines science anxiety as one of the worst situations that affect students' science learning. It is, however, known that this problem can be addressed through student guidance and can be transformed into a better performance.

According to the results of researches conducted on science anxiety, it is generally seen that science anxiety exists in most countries (Czerniak & Chiarelott, 1984). While in some countries the reaction to this anxiety can be seen physically, in others it can be seen both physically and psychologically. Physical reactions are sweaty palms, stomach disorders, headaches and skin rashes. On the other hand, psychological reactions may be manifested through tension, such as nail biting, distractibility, hair pulling or the continuous swinging of feet (Mallow, 1981). These kinds of tensions are thought to create huge obstacles to learning (Avcı & Kırbaşlar, 2017). Researches show that the reasons for anxiety include students' experiences in the past, the effect of science teachers, the role of gender in the society, racial prejudice, popular media and stereotypical beliefs about science (Mallow & Greenburg, 1982). However, to some extent, anxiety can trigger students' science learning, but it is known that anxiety can have drawbacks for learning if the students' anxiety level is high and they show the previously noted signs of tension (Cüceloğlu, 1996). Hence, a high level of anxiety causes a lowering of students' academic success (Okur & Bahar, 2010), negatively affects students' participation in the learning process and results in weak or inadequate performances (Jegede, 2007; Osborne, Simon, & Collins, 2003). According to experimental research based on psychoanalytic theories, the correlation between anxiety and other variables is negative and linear. In other words, if the anxiety level

is not high, it works as a push factor. Nevertheless, the correlation between anxiety and other variables is not always linear. Training or support provided to reduce anxiety can be effective in this situation (Zuway, 2010). In the research of science anxiety, it is found that anxiety has an effect on science learning and teaching and, thus, anxiety needs to be taken into consideration. Together with the evaluation of the effects of anxiety on academic achievement and real performance, a research is thought to be useful in terms of understanding the effects of anxiety on students' cognitive burden.

The constructivist approach to teaching speaks of the process of integrating one's prior knowledge into new knowledge. For new learning, one has to work his or her own mental processes and control his or her behaviour throughout the process. Students' associating new knowledge with the knowledge they already have, following their own learning process and owning the knowledge by using the new knowledge in different fields, will only occur if they are aware of how they learn (Öztürk & Kurtuluş, 2017). In this respect, one of the theories that complement the constructivist learning theory is that of metacognition. Metacognition is defined as the awareness of and control over the mental activities of a person's perception, remembering and thinking (Hacker & Dunlosky, 2003). According to Flavell (1987), the operations within which individuals perceive, monitor, supervise and organize their own cognitive processes are called metacognition. With regard to the concept of metacognition in Turkey, a number of expressions have been used - "meta cognition, meta cognitive, executive cognition, cognitive knowledge, self-regulation, consciousness" (Doğan, 2013) - and no common expression has been agreed. In this research, the term "metacognition" is preferred. In order to control the information, it is necessary to use superior cognitive skills, abilities and various strategies (Harrison & Vallin, 2018). Metacognition consists of two main components: metacognitive knowledge and metacognitive control (Brown, 1987). The individual's cognitive arrangements are realized through continuous learning and evaluation (Harrison & Vallin, 2018). Metacognitive awareness is the level of cognition that an individual uses to control his or her cognitive processes (Brown, 1987). According to Subaşı (2000), metacognitive awareness provides individuals with information about opportunities, irrespective of whether these have been learned, about monitoring the learning process and about how to proceed when the learning has not been realized. According to Young and Fry (2008), metacognitive knowledge has been achieved when students develop cognitive skills and cognitive organization skills, and this makes them superior in academic terms. Therefore, it is necessary to examine the importance and effects of the metacognitive knowledge and skills of the students in terms of the other components. Researches of metacognition have been carried out abroad since the 1970s and in Turkey since the beginning of the 2000s. These studies are generally related to teaching candidates (Deniz, Küçük, Cansız, Akgün, & İşleyen, 2014; Kana, 2015) or secondary school students (Cabı, Erdem, & Kırkan, 2016; Gürefe, 2015). It is also examined that the correlation between metacognitive awareness and intelligence, problem-solving perception, the need to think, reading comprehension, academic self-efficacy, motivational beliefs, the perception of self-efficacy, mental risk-taking, academic achievement and the motivation for learning science (Atay, 2014; Çakır & Yaman, 2015; Karakelle, 2012; Öztürk & Kurtuluş, 2017; Yıldız, 2015; Yoğurtçu, 2015; Young & Fry, 2008). In order to measure metacognitive processes, researchers have used various types of data collection tools. Self-report questionnaires (Dinsmore, Alexander, & Laughlin, 2008), loud speech protocols (Karakelle & Saraç, 2007), observation (Kramarski & Mizrachi, 2004) and scales (Schraw & Dennison, 1994) are the most commonly used measurement tools.

In order to develop and change world conditions, it is necessary to increase the quality of education and, thus, to strengthen students' metacognition skills (Siswati & Corebima, 2017). When students with enhanced metacognition meet with different situations they can identify appropriate methods and reach a solution more easily (Young & Fry, 2008). In addition, the research on metacognitive awareness has concluded that metacognition is an important part of children's education and of increasing their success and that the level of metacognitive awareness can be increased through educational training (Öztürk & Kurtuluş, 2017). The following skills are included in science teaching programmes in Turkey: scientific process skills, life skills (analytical thinking, decision-making, creative thinking, entrepreneurship, communication and teamwork) and engineering and design (innovative thinking) (Ministry of National Education [MNE], 2018). This shows that metacognitive awareness that is based on cognitive skills may be effective in increasing students' science achievement through a programme that supports other skills. Supporting the development of their cognitive skills alongside other skills will motivate the students and develop perceptions about their existing abilities. On this basis, it is necessary to examine the factors that influence students' metacognitive awareness. Students with no anxiety who are successful at a high level can play a role in future development, both locally and internationally. In the field of science, which is a priority area for future development, it is necessary to identify the students' concerns, to support their improvement and to examine

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the effect of anxiety on their cognitive loads. However, situations where anxiety and metacognitive awareness are related need to be identified. Based on the above-mentioned literature, it is necessary to examine whether the gender of the students, the size of the class in which they are studying and the school campus affect their anxiety and metacognitive awareness. Therefore, the main aim of this research was to examine the effect of science anxiety on students' metacognitive awareness. Hence the research questions are as follows:

1. Is there a significant difference between gender and students' anxiety levels and between gender and metacognitive awareness?
2. Do gender and classroom size affect science anxiety?
3. Is anxiety a meaningful predictor of metacognitive awareness?
4. Is anxiety, together with classroom size and school campus, a significant predictor of students' metacognitive awareness?

Methodology of Research

General Background

This research was examined the effect of fifth-grade students' science anxiety on metacognitive awareness. In addition, the research was examined whether gender and school campus affect students' anxiety and metacognitive awareness. For this reason, in the research was used the relational survey model. Relational survey models aim to determine the presence and/or degree of mutual exchange between two or more variables (Karasar, 2009). This model also includes different variables that are thought to influence anxiety and metacognitive awareness. The research was carried out during the second semester of the 2017/2018 academic year in a city in the Black Sea region of Turkey.

Sample

The research was based on a randomly selected sample of fifth-grade students studying in villages, districts and city centres. The reason for this choice is related to the education system in Turkey. In Turkey, the 4+4+4 education system is implemented. After the first four years of study, students enter the middle school level and the courses are divided into branches. Students are faced with a science teacher for the first time when they are in the fifth grade and their opinions, thoughts or concerns about science are shaped through this course. Therefore, these students were chosen to sample. Permission to conduct the research was requested through a two-stage process: permission was first obtained in writing from the provincial national education directorate and, subsequently, with the necessary permission from the class teachers, students were approached during a science lesson. Table 1 presents the status of the students in relation to the variables in the study. A total of 346 students participated in the research with an equal number of female and male students (n = 346). A total of 120 students were studying in classrooms with a class size of 25–30 and 90 students were studying in classrooms with a class size of 30 and above. Only 32 of the students were studying in classrooms with a size of 15–20. A total of 133 students were from the villages, 84 students were from the district centre and 129 students were from the province centre.

Table 1. Distribution of the sample according to the research variables.

School Campus	Gender	Class Size					Total
		10-15 students	15-20 students	20-25 students	25-30 students	30 and above	
Village	Female	37	12	24	-	-	73
	Male	20	20	20	-	-	60
	Total	57	32	44	-	-	133
District Center	Female	-	-	-	20	27	47
	Male	-	-	-	5	32	37
	Total	-	-	-	25	59	84

School Campus	Gender	Class Size					Total
		10-15 students	15-20 students	20-25 students	25-30 students	30 and above	
Provincial Center	Female	1	-	1	35	16	53
	Male	0	-	1	60	15	76
	Total	1	-	2	95	31	129
Total	Female	38	12	25	55	43	173
	Male	20	20	21	65	47	173
	Total	58	32	46	120	90	346

Instrument and Procedure

This research used a three-level form to collect data from the students. In the first part of the form, students were asked about their gender, the class size in which they studied and information about the school campus. The second part of the form used the Science and Technology Lesson Anxiety Scale, developed by Kağıtçı and Kurbanoğlu (2013). This scale was consist of 18 items, all of which were positive. The Cronbach alpha coefficient of the scale was 0.89 and it was 0.90 in this research. The items of the scale were determined as "never", "occasionally", "frequently", "often" and "always" and were graded from one to five. The items supporting anxiety were rated as 1, 2, 3, 4 and 5, starting from the category "never". Thus, at least 18 points and at most 90 points can be taken from the scale. The metacognitive awareness scale was used in the third part of the form. The 5-point Likert-scale metacognitive awareness scale, which Sperling, Howard, Miller and Murphy (2002) had developed for middle school students, was translated into Turkish by Aydın (2007). The scale consists of two main dimensions: metacognitive knowledge and metacognition regulation. The items of the scale were determined as "never", "occasionally", "frequently", "often" and "always' and were graded from one to five. On the scale where there was no negative item, the lowest score was 18 and the highest score was 90. The Cronbach alpha coefficient was .80 and it was .90 in this research.

Data Analysis

The decision to apply parametric tests to the data obtained for science anxiety and metacognitive awareness was based on normality tests and descriptive statistics. The Kolmogorov-Smirnov test is recommended for the normality test if the sample size is over 50 (Büyüköztürk, 2011). In order to determine the normality of the analysis, the Kolmogorov-Smirnov test score was $p<.05$. Since this value is meaningful, the values of skewness and kurtosis of the data were examined. The skewness and kurtosis values of the data were found to be between +2.0 and –2.0 (Skewness value: -1.179, kurtosis value: +1.611). These values show a normal distribution according to George and Mallery (2010). Therefore, the data were considered to be parametric and related tests were applied. The SPSS 20 programme was used to analyse the research data.

Results of Research

The independent samples t-test was used to determine whether the level of science anxiety and metacognitive awareness of fifth-grade students showed a meaningful difference according to gender. The data obtained are presented in Table 2.

Table 2. Examination of students' anxiety levels and metacognitive awareness according to gender

		N	*X*	*S*	*t*	*p*
Anxiety	Female	173	1.38	0.54	0.209	.835
	Male	173	1.37	0.54		
Meta Cognition Awareness	Female	173	4.06	0.78	0.609	.543
	Male	173	4.01	0.80		

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The test showed that gender had no significant difference on science anxiety and metacognitive awareness (t_{344}=0.209, p>.05). Similarly, it was found that gender had no significant difference on students' metacognitive levels (t_{344}=0.609, p>.05).

The effect of class size and gender on students' anxiety levels were tested with the two-way ANOVA for independent samples test. The data obtained from the measurements are presented in Table 3.

Table 3. Examination of students' science anxiety levels according to class size and gender

Source of Variance	Sum of Squares	*SD*	Mean Square	*F*	*p*
Gender	0.077	1	0.077	0.279	.59
Class size	7.232	4	1.808	6.546	.001*
G*C	1.895	4	0.474	1.716	.14
Error	92.801	336	0.276		

**p<.05*

It was found that the science anxiety levels of the students differed significantly according to class size (F=6.546, p<.05). The results of the post-hoc test, conducted to find out where the difference came from, are presented in Table 4. The results show that the science anxiety levels of students in class sizes of 20–25 are higher than those of students in other class sizes (p<.05).

Table 4. Anxiety levels Post-Hoc Tukey test results.

Class Size (i)	Class Size (j)	Mean Difference	Std. Error	*p*
10-15	15-20	.1060	.11573	.891
	20-25	-.3250	.10376	.016*
	25-30	-.0230	.08405	.999
	30 and above	.1457	.08849	.469
15-20	10-15	-.1060	.11573	.891
	20-25	-.4310	.12098	.004*
	25-30	-.1289	.10456	.732
	30 and above	.0397	.10817	.996
20-25	10-15	.3250	.10376	.016*
	15-20	.4310	.12098	.004*
	25-30	.3021	.09114	.009*
	30 and above	.4707	.09525	.001*
25-30	10-15	.0230	.08405	.999
	15-20	.1289	.10456	.732
	20-25	-.3021	.09114	.009*
	30 and above	.1687	.07328	.147
30 and above	10-15	-.1457	.08849	.469
	15-20	-.0397	.10817	.996
	20-25	-.4707	.09525	.001*
	25-30	-.1687	.07328	.147

**p<.05*

Given the study's interest in examining the difference between students' science anxiety and their metacognitive awareness, simple linear regression analysis was used to test whether science anxiety levels in fifth-grade students are a significant predictor of metacognitive awareness. The measurement results are presented in Table 5.

Table 5. Simple linear regression analysis result regarding prediction of metacognitive awareness.

Variable	B	Std. Error	Beta	*t*	*p*
Constant	4.850	0.107	0.400	45.180	.001
Anxiety	-.585	0.072		-8.101	.001*

**p<.05*

The results showed that science anxiety has a high and meaningful relation to metacognitive awareness (R=0.80, R^2=0.64, p<.05). According to this finding, science anxiety explains 64% of the total variance in metacognitive awareness. When the standardized beta coefficient and t values are examined, it can be said that science anxiety is a significant predictor of metacognitive awareness.

Finally, this research also examined the correlation between science anxiety, class size, school campus and metacognitive awareness. In order to do so, multiple linear regression analysis was used to test whether anxiety, class size and school campus together predict metacognitive awareness in a meaningful way. The results obtained from the measurements are presented in Table 6.

Table 6. Multiple linear regression analysis results regarding prediction of metacognitive awareness

Variable	B	Std.Error	Beta	t	p
Constant	4.788	0.155	-	30.861	.001
Class Size	0.064	0.040	0.113	1.594	.11
School Campus	-0.078	0.065	-0.085	-1.194	.23
Anxiety	-0.588	0.073	-0.402	-8.080	.001*

R= 0.408, R2= 0.166
F(3,342)=22.757, p=.001

Taken together, the variables of science anxiety, class size and school campus reveal a low and meaningful correlation with students' metacognitive awareness (R=0.408, R^2= 0.166, p<.05). Together, these three variables explain approximately 17% of the total variance of metacognitive awareness. According to the standardized regression coefficient (beta), the relative importance of the predictive variables on metacognitive awareness is as follows: science anxiety, class size and school campus. When the t-test results of the significance of the regression coefficients are examined, only the anxiety variable appears to be a significant predictor of metacognitive awareness. Based on the results of the regression analysis, the regression equation (mathematical modelling) related to the prediction of metacognitive awareness is presented below.

Metacognitive Awareness= 4.788+0.064 Class Size-0.078 School Campus-0.588 Science Anxiety

Discussion

The aim of this research was to examine the effect of fifth-grade students' science anxiety on metacognitive awareness. For this purpose, the research was carried out with a total of 346 students who study in different class sizes and at different school campuses. The data obtained from the research show that there is no significant difference between science anxiety and gender. The related literature includes researches that support this finding (Czerniak & Chiarelott, 1984; Kağıtçı, 2014). Bursal's (2007) research, which examined the science teaching beliefs and science anxiety of primary school teachers, found that female teacher candidates had lower science anxiety than male teacher candidates. Akça's (2017) research, which measured middle school students' science anxiety, found, as a sub-dimension of environmental factors, that male students had higher science anxiety than female students. This suggests that the positive factors that lead to the lack of science anxiety in female students need to be investigated. Thus, in order to increase the female workforce in the field of science, there is a need to foreground policies, rather than incentives, for development and progress. In the literature on researches of metacognitive awareness, it was found that at different levels of education, female students had a higher level of awareness than

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male students (Atay, 2014; Bağçeci, Döş, & Sarıca, 2011; Gürefe, 2015; Kana, 2015; Öztürk & Kurtuluş, 2017). According to Öztürk and Kurtuluş (2017), the reason why female students have a higher level of cognitive awareness is that they have the ability to think in detail and are good at focusing their attention. However, no significant difference between the gender in terms of the level of metacognitive awareness was found in this research. Therefore, it may be that students tend to think in accordance with the needs that are appropriate for their age. It can be said that this finding is a result of the fact that the revised curriculum in Turkey (MNE, 2006; MNE, 2013; MNE, 2018) has placed thinking skills at the forefront and has attached importance to scientific process skills.

This research also examined the effects of the school campus and class size on metacognitive awareness and science anxiety. The results show that students who study in a class size of 20–25 have higher science anxiety than students in the other groups. This finding is quite remarkable given that a class size of 20–25 students is considered to be the ideal class size. There is no research in the related literature that examines the correlation class size and science anxiety. Gömleksiz and Yüksel (2003) examined the science anxiety of fourth and fifth-grade students in public schools and private schools and found that even though they were in a private school, some of the students' science anxieties were higher than those in public schools. Given the ideal class sizes in private schools, it can be said that there is no correlation between science anxiety and ideal class size. Therefore, this finding suggests the need for further research. It is necessary to examine the reasons why anxiety emerges despite being in an ideal class size environment and despite the fact that the school campus does not have an effect on anxiety. It is, therefore, important to determine whether the anxiety is caused by internal or external factors (e.g., family, teacher attitude, examination preferences).

The combined effect of class size and school campus on metacognitive awareness was also examined in this research, as well as the effect of science anxiety alone. According to the results of the analysis, these three factors have a low but significant effect on metacognitive awareness. However, science anxiety alone is a high-level predictor of metacognitive awareness. When the results of researches on metacognitive awareness are considered, the factors affecting cognition, such as pre-school education and having a computer at home (Gürefe, 2015), also appear to be influential. Akça (2017) examined the mental risk-taking behaviours and science concerns of middle school students and found that the mental risk-taking tendencies of students with a high level of anxiety also decrease. Kağıtçı (2014) found a moderate, negative and meaningful difference between students' science anxiety scores and their attitude scores regarding science lessons. This was a moderate difference in which the science lesson attitude scores increase when the students' anxiety scores for the science lessons decrease, even if only a little. Thus, anxiety is influential on cognitive factors and influences metacognitive awareness. When these findings are discussed in the related literature, it appears that anxiety and metacognitive awareness have an interacting structure.

Conclusion and Implications

This research is considered to be important in that it shows that science anxiety in students affects metacognitive awareness. Despite being in an ideal class size, students experience science anxiety. It, thus, appears that large class sizes (30 and above), which are considered to be a disadvantage or classes that allow more individualized teaching (10–15 people), have no effect on science anxiety. This indicates that the anxiety cannot be explained solely in terms of the physical or financial resources of the schools. Furthermore, contrary to the results obtained in the related literature, in this research, gender was not found to be an important factor in either science anxiety or metacognitive awareness. In addition, it was found that when the anxiety state is combined with the factors of class size and school campus, this affects metacognitive awareness. Researches conducted to date have noted that science anxiety has physical, psychological or both physical and psychological manifestations. This research shows that anxiety also affects cognitive factors. This is because the regression analysis conducted to test whether anxiety is a significant predictor of metacognitive awareness showed it to be a predictor at a high and significant level. However, it was also determined that it is a low but still significant predictor when class size and school campus factors are included.

It is not only a necessity but also an obligation for pupils to have metacognitive awareness in accordance with the needs of the times. For this, it is necessary to address science anxiety, which has become a priority area for research, and to prepare activities to support cognition. Based on the fact that individuals whose science anxiety has been removed will be open to inquiry change and innovation, it is necessary for them to be directed to analysis, synthesis and evaluation activities that will activate their metacognitive awareness. Further, the science anxiety clinical practices conducted abroad could also be conducted in Turkey. However, through teamwork created by

science educators, these applications should be designed not only to prevent or eliminate anxiety but also to support metacognition and should include practices that will impart knowledge to the students.

This research has found that science anxiety is an important predictor of metacognition, which, in turn, leads to new research topics. So much so that empirical research is needed to determine whether the metacognitive awareness of students with science anxiety has changed. It is also necessary to emphasize the fact that there is a meaningful difference in terms of the size of the class and gender. Accordingly, it can be suggested investigating the effect that components such as teachers, the exam system and the family have on metacognitive awareness, as these may be external factors that influence students' science anxiety.

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