Math Anxiety, Math Achievement and Math Motivation in High School Students: Gender Effects[1]

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Abstract

According to the results of previous research, math anxiety is an important determinant of lower math achievement among high school students. Although math anxiety affects both genders, some findings indicate that girls are more prone to its manifestation, but do not explain how the contribution of different math anxiety dimensions to the math achievement depends on the interaction of students' gender and manifestations of math motivation. The aim of this research was to examine the moderation effect of gender in the relation between math anxiety and math achievement mediated by math motivation in high school students. The sample consisted of 514 high school students (45.3 % male), aged 15 to 19, from Serbia. The instruments used in the research were the Math Anxiety Questionnaire and Students Motivation to Learn Mathematics Scale, while math achievement was measured with the average grade in mathematics at the end of the first term and at the end of the school year. The results of the moderated mediation analysis pointed out a negative contribution of math anxiety to achievement in both genders, with full mediation of satisfaction among boys, and partial mediation of satisfaction and usefulness among girls. Based on the analysis of the obtained results, it can be concluded that it is necessary to apply different motivating strategies in order to overcome math anxiety, which depends on students' gender.

Key words: *gender differences; high school; math achievement; math anxiety; math motivation*

Introduction

Math anxiety is defined as a negative behavioural response during contact with math content, and represents a risk factor for lower math achievement on all educational levels (Ashcraft, 2002; Ma & Xu, 2004; Maloney & Beilock, 2012; Ramirez et al., 2013). This type of anxiety is manifested regardless of the math skills level (Prevatt et al., 2010; Wu et al., 2012; Tsui & Mazzocco, 2007) and can already be detected at early elementary school age (Jameson 2013; Milovanović, 2018; Milovanović & Branovački, 2020; Ramirez et al., 2013). It also has the characteristics of a construct which is stable throughout time (Cargnelutti et al., 2016; Ma & Xu, 2004). The effect of this type of anxiety on math achievement grows with age and peaks in high school (Hembree, 1990; Townsend & Wilton, 2003); certain authors claim that math anxiety is present in 6-30 % of high school students (Ashcraft, 2002; Chinn, 2009; Johnston-Wilder et al., 2014). Although, some research results imply that high school boys achieve higher grades in math than girls (e.g. Hedges & Nowell, 1995; Hyde, Fennema & Lamon, 1990), and girls feel higher levels of anxiety in regards to math competencies (Else-Quest et al., 2010; Primi et al, 2014). The results of some contemporary meta-analytic studies suggested smaller effects of gender differences on math performances (Hyde, Lindberg et al., 2008; Lindberg et al., 2010; Voyer & Voyer, 2014). If we add some conclusions about gender differences in math motivation in favour of high school boys (Samuelsson & Samuelsson, 2016; Skaalvik & Skaalvik, 2004), these findings could open new questions about connective mechanisms between the dimensions of math anxiety, math motivation and math achievement, depending on the students' gender.

Math Anxiety: A Short Definition

Math anxiety is defined as a negative behavioural reaction in situations which include the expression of math learning abilities or the evaluation of math knowledge, during which it causes stress, discomfort and avoidance (Ashcraft, 2002; Ma & Xu, 2004). It affects children and adults in daily as well as in academic situations (Richardson & Suinn, 1972). In his meta-analysis, Hembree (Hembree, 1990) claimed that math anxiety could exist in behaviour regardless of test anxiety or anxiety in general; results of some research in the field of neuroscience support this claim (see Lyons & Beilock, 2012; Mattarella-Micke et al., 2011). Despite speculations about hereditary and environmental (Hart et al., 2009; Kovas et al., 2005; Wang et al., 2014), as well as neural (Young et al., 2012) correlates of math anxiety, the specific cause of its development, after 70 years of research, still remains an open question of scientific discussion (Geist, 2010).

The results in most studies of math anxiety have shown the importance of the interaction of cognition and emotion for its development (Prevatt et al., 2010; Putwain et al., 2010). The cognitive component of math anxiety refers to worrying about achievement in math and about the consequences of underachieving (Wigfield & Mecce, 1988), because of attention hyper-tenacity which the individual focuses toward

ruminating thoughts in these situations. Ruminations about math competency causes a decrease in productivity and working memory capacity, consequently resulting in failing to solve math tasks. The affective component of math anxiety refers to the emotional and physiological discomfort and tension in situations of learning math content or in situations of math knowledge evaluation (Wigfield & Mecce, 1988). It most commonly manifests as general physiological body tension or via individual physiological symptoms. Even though the manifestation of math anxiety can be described as a dominantly cognitive or emotional response during contact with math content, an interaction of these factors could usually be detected. Results of some research also point to this conclusion, supporting the claim that math anxiety dimensions are in moderate or high positive correlation (Milovanović & Kodžopeljić, 2018; Wigfield & Meece, 1988).

The affective and cognitive component of math anxiety contribute negatively to math achievement on all educational levels (e.g. Hembre, 1990; Ma & Hu, 2004; Wu et al., 2014), but the affective component has a somewhat stronger effect during high school (Ho et al., 2000; Wigfield & Meece, 1998). When discussing the strength of relation between math anxiety and math achievement, research suggests that this correlation could be described in terms of low to moderate correlation coefficients (Ho et al., 2000; Ma, 1999). Even though specific causes of math anxiety cannot be determined with certainty (Geist, 2010), high school students consider gender and gender related differences as the most common causes (Arambašić et al., 2005; Beilock et al., 2011; Steffens & Jelenec, 2011).

Relations of Math Anxiety, Math Achievement and Math Motivation

Previous research of relations between math anxiety and math achievement resulted in the formation of three groups of general theories. According to the Deficit Theory (Hembree, 1990; Tobias, 1986), low academic abilities cause a high level of anxiety. Math anxiety could be caused by a history of failure in solving math problems. This theory finds its application in research of students with developmental problems or problems with studying (Passolunghi, 2011; Rubinsten & Tannock, 2010), which decreases the possibility of generalization to students of typical development. On the other hand, the Theory of Cognitive Interference postulates the viewpoint that a high level of anxiety results in unsuccessful problem solving. According to this theory, math anxiety, mediated by working memory, interferes with the abilities to solve math problems, which results in low math achievement or avoidance of math content (Ashcraft & Krause, 2007; Morsanyi et al., 2014). By redirecting attention from solving a math problem to ruminating thoughts about the inadequacy of one's own competency, the student most often fails to solve the task. Regardless of the development of reciprocal models as well, researches mostly support the Theory of Cognitive Interference, due to a small number of findings of experimental and longitudinal studies which would support the reciprocal models or the Deficit theory.

Motivation for learning math is defined as investment in solving math problems, positive evaluation of math abilities and math in general, as well as the degree of success in solving math problems (Gottfried et al., 2007). Previous studies on high school students had shown that math anxious students manifested lower motivation for learning math (Hembree, 1990; Zakaria & Nordin, 2008), more negative attitudes towards math, and greater avoidance of math in context of choosing the future profession (Ashcraft, 2002; Hembree, 1990). High school students who have positive attitudes towards math are inclined to seek help in solving tasks, to test a large number of solving strategies, and to invest in solving more complex mathematical tasks (Wigfield, Eccles & Rodriguez, 1998). Bearing in mind the results of the previous research, it seems that the motivation for learning math is partly a consequence of the students' math anxiety, but at the same time it represents an important determinant of math achievement, which confirms its mediating character (Hong et al., 2005). Modern prevention programs recommend motivating students in order to improve mathematical achievement (e.g. Jitendra et al., 2016), so it is clear that motivation for learning math deserves an important place in research of the relationship between math anxiety and math achievement. Given the tendency of students to express the lowest motivation for learning math at high school (Wigfield, Eccles, Yoon et al., 1997), the examination of these relations in high school students seems important for future educational outcomes in the field of mathematics. Some students may even profit motivationally from math anxiety, whereas others are handicapped (Pekrun, Frenzel et al., 2007). According to Wang, Shakeshaft et al. (2018), who found eight distinct profiles of high school students characterized by various combinations of dimensions of math anxiety and math motivation, there is a need for more examination of the complexity in the emotion-motivation interplay in math learning. Wang, Lukowski et al. (2015) concluded that adolescents who had low math motivation showed a negative association between math anxiety and math performance at all levels of math achievement. Influence of math anxiety grows and peaks in high school (Hembree, 1990), when students tend to learn math merely for school marks, evaluate mathematics as less fun (Middleton & Spanias, 1999) and less important (Wigfield, Eccles, Yoon et al., 1997), and have a lack of motivation in learning math (Benček & Marenić, 2006), which additionally contributes to the importance of current research of the mediating role of math motivation in the relation between math anxiety and math achievement.

Gender Differences in Math Anxiety, Achievement and Motivation on the High School Stage

Traditionally, mathematics has long been viewed as a typically 'male' domain. Results of older meta-analyses suggested that boys achieve better scores in math than girls during high school (Hedges & Nowell, 1995; Hyde et al., 1990). More contemporary meta-analyses dispute these traditional viewpoints, suggesting small or insignificant

gender differences in math abilities (Else-Quest et al., 2010; Lindberg et al., 2010; Voyer & Voyer, 2014). Additionally, it would seem that during the last decade girls achieved better grades in math than boys in both primary and secondary school (Brown & Kanyongo, 2010; Jugović et al., 2012; Robinson & Lubienski, 2011; von Maurice et al., 2014), which makes previous results questionable. This conclusion could also be applied in the case of scores on individual tests and school grades till the end of high school (Fryer & Levitt, 2010; Guiso et al., 2008; Kenney-Benson et al., 2006; Pope & Snydor, 2010; Puklek Lepuvšček et al., 2012). In various research on the high school stage girls manifested lower performance-avoidance goals (Shim et al., 2008), more mastery in learning math materials (Pekrun, Elliot & Maier, 2006), and greater involvement in their own math schoolwork (Gherasim et al., 2013) in comparison to boys, which can be connected with girls' better school marks in math. Still, there is a need for more studies on gender differences in order to answer the questions about explaining gender math gaps and mechanisms that are conducive to math performances.

Results of meta-analyses of gender differences in math anxiety (e.g. Else-Quest et al., 2010; Hembree, 1990), and other studies (Devine et al., 2012; Hill et al., 2016; Jain & Dowson, 2009; Luo et al., 2009; Sadiković et al., 2018), mostly suggest that female gender was more prone to its manifestation during high school. Explanations of these findings were based on the opinions that female students were more self-critical and worried about their achievement, and had a lower math self-concept, which leads to worry and consequently to negative emotional reactions concerning math achievement (Goetz, Frenzel et al., 2008; Goetz, Bieg et al., 2013). Other authors had been focused on the external and contextual causes of these differences, and considered less support girls receive in studying math an explanation (Eccles, 2011), or the effect of prejudice of math being a typically 'male' domain (Arambašić et al., 2005; Steffens & Jelenec, 2011). The results of previous research (Bieg et al., 2014; Goetz et al., 2013) had suggested that girls achieved higher results on scales of math anxiety as a state and a trait, and that gender differences were least manifested when math anxiety was viewed as a state. The mentioned conclusion could be explained with the fact that female gender is more prone to anxiety in general (Chapman et al., 2007; Costa et al., 2001), while the male gender manifests anxiety symptoms more as a consequence of situational factors. In the period of adolescence, gender differences in math anxiety are more based on the differences in self-perception of personal competencies and concern about achievement (Egger et al., 2003; Osborne, 2001), which is more manifested in female adolescents. It can be concluded that girls and boys express math anxiety differently, and that certain gender differences are noticeable in the effects of math related anxiety on math achievement, causing it to be lower.

Anxiety could also be seen as the variable that regulates the manifestation and development of motivation (Catsambis, 1994; Hannula, 2012). By high school, girls show less interest in math and report higher levels of math anxiety (Lupart et al., 2004;

Skaalvik & Skaalvik, 2004). Gender related differences in motivation (i.e. expectancy and value) in turn predict later differences in academic achievement (Leaper et al., 2012). This suggests that gender differences in academic motivation may in part be modified by differences in anxiety (Pajares & Valiante, 2002). Boys' relationship with math could be understood as if they have realized the necessity for 'knowing' and 'handling' math in order to be able to work in professions which are seen as more 'male' (Samuelsson & Samuelsson, 2016). According to National Science Foundation (2012), boys are more likely to take physics and engineering in high school as an elective math-courses in a lot of countries (e.g. France, Italy, Norway, Portugal, Sweden, Slovenia etc.). Having in mind a slight increase of female participation in math-related high school courses, but also math-related jobs (Beede et al., 2011; Noonan, 2017), there is need for considering differences in student math motivation in the context of interaction with gender and anxiety. Because various kinds of motivation might be important, and various underlying factors could lead to similar patterns of results, studies of gender differences in math achievement must be interpreted with caution, especially when they are conducted in high schools where math is not main and central subject or course.

Research Goals

During high school, math anxiety represents a very important vulnerability factor of math achievement. However, previous literature has provided somewhat conflicting findings about the role of gender in relations between these variables. Keeping in mind that gender stands out as one of the most dominant factors of math achievement, and that there are gender differences in math anxiety, there is a need for analysing the relations between math anxiety and math achievement in the context of gender differences. Besides that, interaction of math anxiety and motivation improves prediction of math behaviors and achievement, compared with either one alone (Lyons & Beilock, 2012; Wang et al., 2015).

Therefore, the aim of this research was to examine the relationship of math anxiety and math achievement among high school students through the effects of math motivation and a moderating effect of gender. These relations are not so straightforward, bearing in mind the multidimensional nature of math anxiety and the mediating role of math motivation. It can be expected that the negative affective dimension will have a higher contribution in explaining math achievement than cognitive aspects of math anxiety. Therefore, this study was aimed to examine the contribution of both dimensions of math anxiety in predicting math achievement, depending on students' gender and motivation. It is expected that both dimensions of math anxiety will have a negative relation with mathematical achievement among girls. Boys are less concerned about their achievement in the field of math, and they are not as prone as girls to anxiety as a trait. With regard to the aforementioned, it is assumed that anxiety will completely influence math achievement through negative impacts on math motivation among boys, also partially and independently among girls.

Methods
Participants and the Procedure

The participants were 514 high school students (45.3 % males) from grammar (45.7 %) and secondary vocational schools in Serbia. The age of the participants ranged from 15 to 19 years, with 32.9 % attending the second, 34 % attending the third, and 33.1 % attending the fourth grade. In order to explain the purpose of this study and ask for help, researches made personal visits to school principals. Managements of all schools approved the research. During a regular school class, trained students administered the instruments to the participants. It was made sure that the chosen classes contained a proportionately approximate number of male and female students from different educational profiles and different grades. All participants were informed about the purpose of the research and about ensuring data anonymity before administration. Minors' parents have also signed an information consent before the administration of the questionnaires.

Instruments and Measures

Math Anxiety Questionnaire (MAQ: Wigfield & Meece, 1988; for translated and adapted version see: Milovanović & Kodžopeljić, 2018) contains 11 items on a seven-point Likert scale (from 1 - *strongly disagree* to 7 - *strongly agree*). MAQ consisted of two subscales: Worry (α = .86) and Negative Affective Reactions (α = .85). Items determining negative affective reactions measure negative emotional states during math activities in school (*Taking math tests scares me*), and items focused on worry measure students' concerns about their performance in mathematics (*I am worried about how well I am doing in math*).

Student Motivation to Learn Mathematics (SMOT: Githua & Mwangi, 2003) is a scale which is intended to measure different motivational factors of math learning and consists of 28 items. The scale has already been adapted and evaluated for Serbian students (Milovanović, 2016). Answers to the items were given on a five-point Likert scale (of 1 - *I generally disagree*, to 5 - *I completely agree*). The factor structure suggests there are 4 main components of this scale: interest (*I am highly motivated to learn mathematics*, α = .82), satisfaction (*I am satisfied with the way I learn mathematics*, α = .83), demotivation (*I rarely expect to perform well in mathematics-related subjects*, α = .79), and usefulness (*Learning mathematics gives me opportunities for educational advancement*, α = .85).

Mathematics achievement is measured by math school grades which were collected from school registries at the end of the school year. The overall math achievement was calculated for each student by computing the average of his/her grades in math at the half-term and at the end of the school year.

Results
Correlations and Gender Differences

Gender differences in math achievement and negative affective reactions were significant, while differences in worry were not (Table 1).

Table 1

Descriptive statistics, correlations and gender differences among variables

	Math Achievement	Worry	Negative Affective Reactions	Boys (n = 233)		Girls (n = 281)		t(513)
				M	SD	M	SD	
Math Achievement	1			3.13	0.94	3.50	0.80	-3.38**
Worry	-.29**	1		28.75	9.06	29.31	9.77	-0.68
Negative Affective Reactions	-.36**	.64**	1	17.03	6.22	18.21	6.25	-1.97*
Interest	.41**	-.17**	-.40**	10.27	4.68	10.20	4.81	0.17
Satisfaction	.64**	-.33**	-.51**	18.49	5.89	18.47	5.98	0.05
Demotivation	-.39**	.36**	.56**	21.67	6.95	22.11	7.22	-0.70
Usefulness	.31**	-.11*	-.33**	26.05	7.79	25.12	7.87	1.33

Note. ** $p < .01$. * $p < .05$.

Girls scored higher on math achievement and also experienced more negative emotional states during math activities in school than boys. Math achievement was significantly and negatively correlated to both facets of math anxiety, while dimensions of math anxiety were positively correlated with each other. Skewness and kurtosis (respectively) for math achievement (-0.14, -1.08), worry (0.06, -0.96), and negative affective reactions (0.24, -0.84), were in a satisfactory range of values, according to Tabachnick & Fiddel (2013).

Table 1 also shows that all correlations between math motivation, math achievement and math anxiety were significant. All correlations of the MAQ with the dimensions of motivation were low to moderate and negative, except those with demotivation. Correlations between math achievement and dimensions of math motivation were moderate and positive, except in the case of demotivation, where the correlations were negative. There were no detected gender differences on dimensions of math motivation. Skewness and kurtosis for math motivation subscales were also in a satisfactory range of values.

Table 2 shows correlation coefficients between math motivation, math achievement and math anxiety, depending on students' gender. There was a similar path of relations to those obtained on the whole sample (Table 1). Differences were detected in relation between interest and worry among boys, as well as in relation between usefulness and negative affective reactions, were these correlations hadn't been statistically significant.

Due to different forms of relations between these constructs among genders, it can be expected that math motivation could be a significantly distinguishing factor of relations between math anxiety and math achievement among boys and girls.

Table 2

Relations of math motivation, math achievement and math anxiety in the gender context

	Math Achievement	Worry	Negative Affective Reactions
	boys/girls	boys/girls	boys/girls
Interest	.37**/.45**	-.04/-.49**	-.30**/-.26**
Satisfaction	.60**/.68**	-.22**/-.42**	-.45**/-.56**
Demotivation	-.32**/-.45**	.57**/.40**	.31**/.65**
Usefulness	.32**/.33**	-.26**/-.17**	-.02/-.38**

Note. ** $p < .01$.

Path Analysis – Moderated Mediation

In order to test the moderated mediation effect of gender in relation between math anxiety, math motivation and math achievement, structural model was conducted through path analysis (Figure 1).
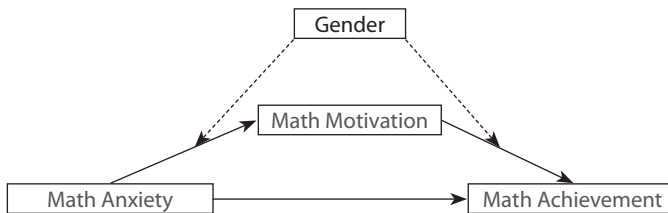

Figure 1. Structural model of moderated mediation effect of gender in the relation between math anxiety, math motivation and math achievement

This kind of model allows conclusions about relations of variables, depending on the moderator level. Level of moderator could change relations between the independent and mediator variable, as well as between the mediator and dependent variable. There are two effects which can be observed in this kind of model: direct effect of the independent variable and the total effect, which includes indirect effects through mediation. Model evaluation was conducted based on the Akaike Information Criterion (AIC: Akaike, 1973), Bayesian Information Criterion (BIC; Schwarz, 1978), comparative fit index, and the Tucker–Lewis Index (CFI and TLI – optimal values higher than .95, acceptable higher than .90), the root mean square error of approximation (RMSEA - optimal values lower than .05, acceptable lower than .08), and the quotient $\chi 2/df$ (recommended < 2) (Kline, 2010).
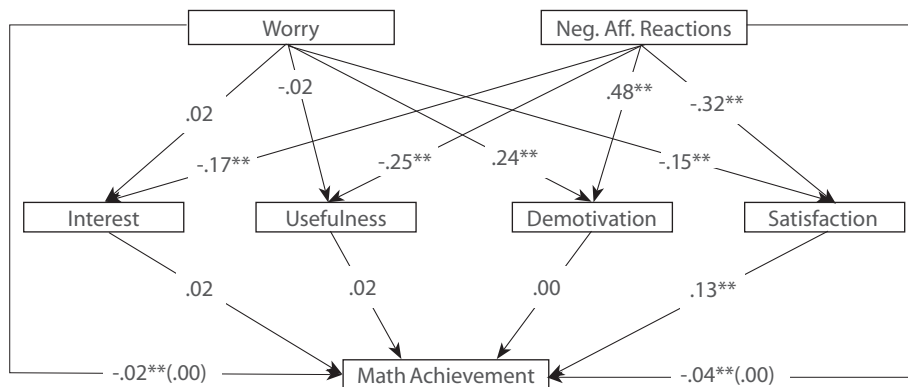
Figure 2. Structural model for boys

Notes. Residuals of variables were ommited in order to simplify the figure. Direct effects of independent variables are presented in parentheses, while total effects are presented in front of parentheses. ** p < .01.

By testing different models of relations between gender, math motivation, math achievement, and math anxiety, it was found that the model had good fit indices ($\chi^2(140)$ = 271.03, CFI = .93, TLI = .92, RMSEA = .06, AIC = 99.95, BIC = 7001.5).

In the case of boys, Figure 2 shows negative affective reactions on math achievement and a significant effect of worry. However, the direct effect of worry was insignificant. Only satisfaction had a significant indirect effect on math achievement. It can be concluded that both manifestations of math anxiety contribute to math achievement indirectly, through negative impact on satisfaction.
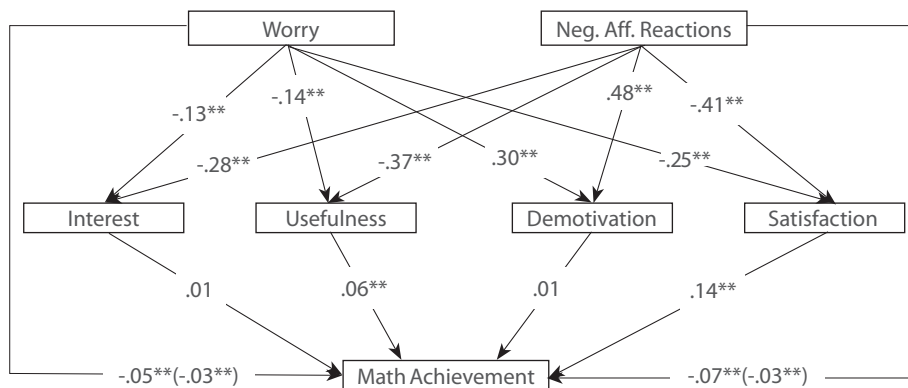

Figure 3. Structural model for girls

Notes. Residuals of variables were ommited in order to simplify the figure. Direct effects of independent variables are presented in parentheses, while total effects are presented in front of parentheses. ** *p* < .01.

Figure 3 shows a significantly negative and direct overall effect of worry and negative affective reactions on math achievement among girls. Both dimensions of

math anxiety contribute independently and negatively to girls' math achievement, but also indirectly thorugh the negative impact on satisfaction and usefulness. It is clear that math anxiety plays an important role in math achievement in both genders. This study has additionaly stressed the importance of partial mediation role of math motivation in the group of girls, and full mediation role in the group of boys.

Discussion and Conclusions

The goal of this research was to determine the moderating role of gender in relation between dimensions of math anxiety and math achievement in high school students, mediated by math motivation, as well as to examine the contributions of math anxiety dimensions to math achievement. The research results suggested that negative affective reactions and worry contribute significantly and negatively to math achievement in both genders, but that math motivation had mediated those relations partly among girls, but fully among boys.

The contribution of negative emotional reactions to math achievement has proven to be significant in both genders. At the same time, this contribution was larger than contribution of worry, which is in concurrence with results of previous research (Ho et al., 2000; Wigfield & Meece, 1998). It seems that conceptual difference between the cognitive and affective dimension of math anxiety consists in the fact that worry manifests for a longer period of time prior to the test situation, while negative affective reactions are most evidently manifested during knowledge evaluation situations (e.g. *When I am taking a math test, I usually feel nervous and uneasy* or *When the teacher asks me math questions, I worry that I will do poorly*). It's possible that precisely this causes a stronger effect of the affective component of math anxiety on math achievement, in comparison to cognitive component.

Gender differences, first detected by *t*-test, were in favour of girls achieving higher scores on the dimension of negative affective reactions, as well as in favour of them having higher achievement in math. During the last few decades, it has been shown that girls have better grades than boys in math during high school (Brown & Kanyongo, 2010; Robinson & Lubienski, 2011). The trend of decrease in traditional gender differences could be spotted in the results of contemporary meta-analyses of gender differences in math achievement during high school (e.g. Voyer & Voyer, 2014). A stronger expression of negative emotional reactions in girls could be explained by gender differences in manifesting anxiety, which is more strongly expressed in adolescence girls (see Dowker et al., 2016). Emotionality is more expressed in girls, and girls are more prone to express anxiety as a trait. Therefore, it would seem that this finding, in combination with girls perceiving their math abilities as lower during high school (Goetz, Frenzel et al., 2008; Goetz, Bieg et al., 2013), results in higher manifestation of negative emotional and physiological symptoms in girls, especially during concrete knowledge evaluation situations.

The results of this research pointed out that math anxiety dimensions contribute negatively to math achievement in both boys and girls, with twice as strong effect in the case of girls. In general, it seems the main difference is that students of both genders experience manifestations of anxiety on the physiological and emotional level, but girls are more inclined to express them and worry openly, which further increases the negative contribution to math achievement in the period of adolescence (Beilock et al., 2011). As already mentioned, some students may have motivational benefit from math anxiety, whereas others are handicapped (Pekrun et al., 2007). It seems that some manifestations of math motivation undermines math anxiety effects in both genders. Satisfaction, as a facet of motivation, refers to enjoyment and pleasure during the process of learning math. It may be that students who are more intrinsically focused on the math learning process than on the final math achievement are resistant to math anxiety influences. This conclusion could especially be applied to the group of boys, due to the fact that anxiety in girls also has independent and direct effects on math achievement, regardless of motivation. Considering boys have more confidence in their own math abilities (Goetz, Frenzel et al., 2008; Goetz, Bieg et al., 2013), it seems their high motivation and satisfaction in learning math have a protective role in regards to manifesting less worry and negative feelings about their math achievement. The most obvious finding of this research, which confirms previous conclusions, is that worry didn't play an important role in the interest of boys.

This study detected partial mediation by math motivation in the relationship between math anxiety and math achievement in the group of girls. As in the group of boys, the indirect effects of math anxiety ensued form satisfaction and usefulness. In previous research of the high school stage, girls manifested lower performance-avoidance goals (Shim et al., 2008), more mastery of learning math materials (Pekrun, Elliot & Meier, 2006), and greater involvement to their own math schoolwork (Gherasim et al., 2013), which could lead to better achievement. Considering that this research is conducted in Serbian high schools, where mathematics is not main and central subject, usefulness may play an important role for girls in terms of better global achievement and later opportunity for better higher education. It seems that perception of math's usefulness might play an important role as a manifestation of extrinsic motivation, which could be connected with future educational or personal successes of girls. According to these results, there is an implicit conclusion about different kinds of female students in the context of math success: those who are motivated by math itself, and those who have high motivation for achieving, but not specifially in the field of math. However, such a claim requires further investigation. In addition to previous findings, it is also very important to notice math anxiety in girls had also played an important independent role in contibution to math achievement. Explanations of these findings could be based on the opinion of Goetz et al. (2013) that female students are more worried about their math achievement, which could be accelerated with negative emotional reactions. Moreover, female gender is more prone to anxiety in general (Chapman

et al., 2007; Costa et al., 2001); so it seems that math anxiety plays an important role for girls in shaping achievement, regardless of motivation. If generalized anxiety had been controlled in the actual sample, previous conclusions could be more applicable. It has already been mentioned that girls perceive their mathematical abilities as lower during high school education. This kind of self-handicapping evaluation of one's own efficacy in the area of math probably contributes to the manifestation of greater worry and, partially, lower math motivation and achievement.

Limitations of the Study, Further Recommendations and Importance for Practice

It's important to notice this research was realized with certain limitations. The main limitation of the study is that math achievement wasn't measured directly by evaluating knowledge via standardized achievement tests, but by calculating an average math grade based on individual grades taken from school registries. Even though the measure of math achievement was shown to be a reliable measure by type of internal consistency, future research of this type should include a more adequate and more reliable measure of math achievement. Even though the sample was adequate in structure and size, and the used instruments were reliable and valid, the conclusions about the identified causal relationship between math anxiety, motivation and achievement cannot be confirmed due to the correlational and transversal nature of the study. The realization of a longitudinal study, the incorporation of remaining significant variables (math self-concept, math self-efficacy) into the research, as well as promoting an international character of the research would additionally contribute to a better understanding of the topic. For more reliable conclusions, it would be good to control generalized anxiety in further studies, but also to consider relations between math anxiety and motivation by levels of math achievement. In this study, this was not feasible due to small number of students who had poor math achievement.

As a general conclusion of the research, the author would state the finding that girls in high school are more sensitive to the manifestation of anxiety than boys, as the vulnerability is manifested on both cognitive and affective level. On the other hand, a very important role of motivation is detected among boys. Being familiar with gender differences in the context of overcoming certain educational themes and areas is a very important instance for realizing prevention and intervention programs in schools, with the goal of improving educational outcomes. Considering the difference in math anxiety in relation to dispositional factors such as gender, prevention and intervention, programs of overcoming math anxiety should be designed taking into consideration these specificities. In regards to that, programs that a school psychologist would realize with the students should include activities directed not only at overcoming symptoms of anxiety through increased motivation for both genders, but also at interventions focused especially on reducing math anxiety in girls.

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control, 19*(6), 716-72. https://doi.org/10.1109/TAC.1974.1100705

Arambašić, L., Vlahović-Štetić, V., & Severinac, A. (2005). Je li matematika bauk? Stavovi, uvjerenja i strah od matematike kod gimnazijalaca [Is Math Something Scary? Attitudes and Beliefs toward Math and Math Anxiety in Secondary School Students]. Društvena istraživanja: časopis za opća društvena pitanja, 14(6(80)), 1081-1102.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. Current Directions in Psychological Science, 11(5), 181-185. https://doi.org/10.1111/1467-8721.00196

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. Psychonomic Bulletin & Review, 14(2), 243-248. https://doi.org/10.3758/BF03194059

Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). Women in STEM: A gender gap to innovation. *Economics and Statistics Administration Issue Brief*, 4-11. https://doi.org/10.2139/ssrn.1964782

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academies of Science of the United States of America, 107*, 1860-1863. https://doi.org/10.1037/e634112013-097

Benček, A., & Marenić, M. (2006). Motivacija učenika osnovne škole u nastavi matematike [Motivation of elementary school students in math teaching]. *Metodički obzori, 1*(1), 104-117.

Bieg, M., Goetz, T., & Lipnevich, A. A. (2014). What students think they feel differs from what they really feel-Academic self-concept moderates the discrepancy between students' trait and state emotional self-reports. *PloS ONE, 9*(3). https://doi.org/10.1371/journal.pone.0092563

Brown, L. I., & Kanyongo, G. Y. (2010). Gender Differences in Mathematics Performance in Trinidad and Tobago: Examining Affective Factors. *International Electronic Journal of Mathematics Education, 5*(3), 115-124.

Cargnelutti, E., Tomasetto, C., & Passolunghi, M. C. (2016). How is anxiety related to math performance in young students? A longitudinal study of Grade 2 to Grade 3 children. *Cognition and Emotion 31*(4), 1-10. https://doi.org/10.1080/02699931.2016.1147421

Catsambis, S. (1994). The path to math: Gender and racial-ethnic differences in mathematics participation from middle school to high school. *Sociology of Education, 67*(3), 199-215. https://doi.org/10.2307/2112791

Chapman, B. P., Duberstein, P. R., Sörensen, S., & Lyness, J. M. (2007). Gender differences in Five Factor Model personality traits in an elderly cohort. *Personality and Individual Differences, 43*(6), 1594-1603. https://doi.org/10.1016/j.paid.2007.04.028

Chinn, S. (2009). Mathematics anxiety in secondary students in England. *Dyslexia, 15*(1), 61-68. https://doi.org/10.1002/dys.381

Costa Jr, P. T., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits across cultures: robust and surprising findings. *Journal of Personality and Social Psychology, 81*(2), 322-331. https://doi.org/10.1037//0022-3514.81.2.322

Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and Brain functions, 8*(1), 33. https://doi.org/10.1186/1744-9081-8-33

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: what have we learned in 60 years? *Frontiers in Psychology, 7*, Article 508. https://doi.org/10.3389/fpsyg.2016.00508

Eccles, J. (2011). Gendered educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *International Journal of Behavioral Development, 35*(3), 195-201. https://doi.org/10.1177/0165025411398185

Egger, H. L., Costello, J. E., & Angold, A. (2003). School refusal and psychiatric disorders: A community study. *Journal of the American Academy of Child* & *Adolescent Psychiatry, 42*(7), 797-807. https://doi.org/10.1097/01.CHI.0000046865.56865.79

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. *Psychological Bulletin, 136*(1), 103-127. https://doi.org/10.1037/a0018053

Fryer Jr, R. G., & Levitt, S. D. (2010). An empirical analysis of the gender gap in mathematics. *American Economic Journal: Applied Economics, 2*(2), 210-40. https://doi.org/10.1257/app.2.2.210

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom. Journal of Instructional Psychology, 37(1), 24-31 /online/. http://wendyharp73.wiki.westga.edu/file/view/MATH+anxiety+article.pdf/383363058/MATH+anxiety+article.pdf

Gherasim, L. R., Butnaru, S., & Mairean, C. (2013). Classroom environment, achievement goals and maths performance: Gender differences. *Educational Studies, 39*(1), 1-12. https://doi.org/10.1080/03055698.2012.663480

Githua, N. B., & Mwangi, G. J. (2003). Students' mathematics self-concept and motivation to learn mathematics: relationship and gender differences among Kenya's secondary-school students in Nairobi and Rift Valley provinces. *International Journal of Educational Development, 23*(5), 487-499. https://doi.org/10.1016/S0738-0593(03)00025-7

Goetz, T., Bieg, M., Lüdtke, O., Pekrun, R., & Hall, N. C. (2013). Do girls really experience more anxiety in mathematics? *Psychological Science, 24*(10), 2079-2087. https://doi.org/10.1177/0956797613486989

Goetz, T., Frenzel, A. C., Hall, N. C., & Pekrun, R. (2008). Antecedents of academic emotions: Testing the internal/external frame of reference model for academic enjoyment. *Contemporary Educational Psychology, 33*(1), 9-33. https://doi.org/10.1016/j.cedpsych.2006.12.002

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., Oliver, P. H., & Guerin, D. W. (2007). Multivariate latent change modeling of developmental decline in academic intrinsic math motivation and achievement: Childhood through adolescence. International *Journal of Behavioral Development, 31*(4), 317-327. https://doi.org/10.1177/0165025407077752

Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Culture, gender, and math. *Science, 320*(5880), 1164-1165. https://doi.org/10.1126/science.1154094

Hannula, M. S. (2012). Exploring new dimensions of mathematics-related affect: embodied and social theories. *Research in Mathematics Education, 14*(2), 137-161. https://doi.org/10.1080/14794802.2012.694281

Hart, S. A., Petrill, S. A., Thompson, L. A., & Plomin, R. (2009). The ABCs of math: A genetic analysis of mathematics and its links with reading ability and general cognitive ability. Journal of Educational Psychology, 101(2), 388-418. https://doi.org/10.1037/a0015115

Hedges, L. V., & Nowell, A. (1995). Sex differences in mental test scores, variability, and numbers of high-scoring individuals. *Science, 269*(5220), 41-45. https://doi.org/10.1126/science.7604277

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. Journal for Research in Mathematics Education, 21(1), 33-46. https://doi.org/10.2307/749455

Hill, F., Mammarella, I. C., Devine, A., Caviola, S., Passolunghi, M. C., & Szűcs, D. (2016). Maths anxiety in primary and secondary school students: gender differences, developmental changes and anxiety specificity. *Learning and Individual Differences, 48*, 45-53. https://doi.org/10.1016/j.lindif.2016.02.006

Ho, H. Z., Senturk, D., Lam, A. G., Zimmer, J. M., Hong, S., Okamoto, Y., Chiu, S. Y., Nakazawa, Y., & Wang, C. P. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education*, 362-379. https://doi.org/10.2307/749811

Hong, E., O'Neil, H. F. Jr., & Feldon, D. F. (2005). Gender effects on mathematics achievement: Mediating role of state and trait self regulation and test anxiety. In A. M. Gallagher, & J. C. Kaufman, (Eds.) *Gender differences in mathematics: An integrative psychological approach* (pp. 264-293). Cambridge University Press. https://doi.org/10.1017/CBO9780511614446.014

Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: a meta-analysis. *Psychological Bulletin, 107*(2), 139-155. https://doi.org/10.1037//0033-2909.107.2.139

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science, 321*(5888), 494-495. https://doi.org/10.1126/science.1160364

Jain, S., & Dowson, M. (2009). Mathematics anxiety as a function of multidimensional self-regulation and self-efficacy. *Contemporary Educational Psychology, 34*(3), 240-249. https://doi.org/10.1016/j.cedpsych.2009.05.004

Jameson, M. M. (2013). The development and validation of the Children's Anxiety in Math Scale. *Journal of Psychoeducational Assessment, 31*(4), 391-395. https://doi.org/10.1177/0734282912470131

Jitendra, A. K., Nelson, G., Pulles, S. M., Kiss, A. J., & Houseworth, J. (2016). Is mathematical representation of problems an evidence-based strategy for students with mathematics difficulties? *Exceptional Children, 83*(1), 8-25. https://doi.org/10.1177/0014402915625062

Johnston-Wilder, S., Brindley, J., & Dent, P. (2014). A *survey of Mathematics Anxiety and Mathematical Resilience among existing apprentices.* Coventry: University of Warwick

Jugović, I., Baranović, B., & Marušić, I. (2012). Uloga rodnih stereotipa i motivacije u objašnjenju matematičkog uspjeha i straha od matematike [The role of gender stereotypes and motivation in the explanation of mathematics achievement and anxiety]. *Suvremena psihologija, 15*(1), 65-78.

Kenney-Benson, G. A., Pomerantz, E. M., Ryan, A. M., & Patrick, H. (2006). Sex differences in math performance: The role of children's approaches to schoolwork. *Developmental Psychology, 42*(1), 11-26. https://doi.org/10.1037/0012-1649.42.1.11

Kline, R. B. (2010). *Principles and practice of structural equation modeling.* Guilford.

Kovas, Y., Harlaar, N., Petrill, S. A., & Plomin, R. (2005). 'Generalist genes' and mathematics in 7-year-old twins. *Intelligence, 33*(5), 473-489. https://doi.org/10.1016/j.intell.2005.05.002

Leaper, C., Farkas, T., & Brown, C. S. (2012). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of youth and adolescence, 41*(3), 268-282. https://doi.org/10.1007/s10964-011-9693-z

Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in gender and mathematics performance: a meta-analysis. *Psychological Bulletin, 136*(6), 1123-1135. https://doi.org/10.1037/a0021276

Luo, X., Wang, F., & Luo, Z. (2009). Investigation and analysis of mathematics anxiety in middle school students. *Journal of Mathematics Education, 2*(2), 12-19 /online/. https://educationforatoz.net/images/_9734_2_Xinbin_Lou.pdf

Lupart, J. L., Cannon, E., & Telfer, J. A. (2004). Gender differences in adolescent academic achievement, interests, values and life-role expectations. *High Ability Studies, 15*, 25- https://doi.org/10.1080/1359813042000225320

Lyons, I. M., & Beilock, S. L. (2012). When math hurts: math anxiety predicts pain network activation in anticipation of doing math. *PloS ONE, 7*(10), e48076. https://doi.org/10.1371/journal.pone.0048076

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education, 30*(5), 520-540. https://doi.org/10.2307/749772

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: a longitudinal panel analysis. *Journal of Adolescence, 27*(2), 165-179. https://doi.org/10.1016/j.adolescence.2003.11.003

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences, 16*(8), 404-406. https://doi.org/10.1016/j.tics.2012.06.008

Maloney, E. A., Waechter, S., Risko, E. F., & Fugelsang, J. A. (2012). Reducing the sex difference in math anxiety: The role of spatial processing ability. *Learning and Individual Differences, 22*(3), 380-384. https://doi.org/10.1016/j.lindif.2012.01.001

Mattarella-Micke, A., Mateo, J., Kozak, M. N., Foster, K., & Beilock, S. L. (2011). Choke or thrive? The relation between salivary cortisol and math performance depends on individual differences in working memory and math-anxiety. *Emotion, 11*(4), 1000-1005. https://doi.org/10.1037/a0023224

Middleton, J. A., & Spanias, P. A. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the research. *Journal for Research in Mathematics Education, 30*(1), 65-88. https://doi.org/10.2307/749630

Milovanović, I. (2016). Implicitne teorije inteligencije i motivacija za učenje matematike kod učenika srednjih škola [Implicit theories of intelligence and motivation for learning mathematics in high school students]. *Nastava i vaspitanje, 65*(3), 509-524. https://doi.org/10.5937/nasvas1603509M

Milovanović, I. (2018). Matematička anksioznost i postignuće na ranom osnovnoškolskom uzrastu: uloga uključenosti roditelja u podučavanje [Math anxiety and achievement at early elementary stage: The role of parental involvement in teaching]. *Godišnjak Filozofskog fakulteta u Novom Sadu, XLIII*(1), 271-287. https://doi.org/10.19090/gff.2018.1.271-287

Milovanović, I., & Kodžopeljić, J. (2018). Faktorska struktura i konvergentna validnost upitnika matematičke anksioznosti za učenike srednjih škola [Factor structure and

convergent validity of the Math Anxiety Questionnaire for high school students]. *Nastava i vaspitanje, 67*(1), 113-128. https://doi.org/10.5937/nasvas1801113M

Morsanyi, K., Busdraghi, C., & Primi, C. (2014). Mathematical anxiety is linked to reduced cognitive reflection: a potential road from discomfort in the mathematics classroom to susceptibility to biases. *Behavioral and Brain Functions, 10*(1), 31. https://doi.org/10.1186/1744-9081-10-31

National Science Foundation. (2012). Science and engineering indicators 2012 www.nsf.gov/statistics/seind12/

Noonan, R. (2017). Women in STEM: 2017 Update. *ESA Issue Brief*, 6-17. https://files.eric.ed.gov/fulltext/ED590906.pdf

Osborne, J. W. (2001). Testing stereotype threat: Does anxiety explain race and sex differences in achievement? *Contemporary Educational Psychology, 26*(3), 291-310. https://doi.org/10.1006/ceps.2000.1052

Passolunghi, M. C. (2011). Cognitive and emotional factors in children with mathematical learning disabilities. *International Journal of Disability, Development and Education, 58*(1), 61-73. https://doi.org/10.1080/1034912X.2011.547351

Pekrun, R., Elliot, A. J., & Maier, M. A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology, 98*(3), 583-597. https://doi.org/10.1037/0022-0663.98.3.583

Pekrun, R., Frenzel, A. C., Goetz, T., & Perry, R. P. (2007). The control-value theory of achievement emotions: An integrative approach to emotions in education. In P. A. Schutz, & R. Pekrun (Eds.), *Emotion in Education* (pp. 13-36). Academic Press. https://doi.org/10.1016/B978-012372545-5/50003-4

Pope, D. G., & Sydnor, J. R. (2010). Geographic variation in the gender differences in test scores. *Journal of Economic Perspectives, 24*(2), 95-108. https://doi.org/10.1257/jep.24.2.95

Prevatt, F., Welles, T. L., Li, H., & Proctor, B. (2010). The contribution of memory and anxiety to the math performance of college students with learning disabilities. *Learning Disabilities Research* & *Practice, 25*(1), 39-47. https://doi.org/10.1111/j.1540-5826.2009.00299.x

Primi, C., Busdraghi, C., Tomasetto, C., Morsanyi, K., & Chiesi, F. (2014). Measuring math anxiety in Italian college and high school students: validity, reliability and gender invariance of the Abbreviated Math Anxiety Scale (AMAS). *Learning and Individual Differences, 34*, 51-56. https://doi.org/10.1016/j.lindif.2014.05.012

Puklek Lepuvšček, M., Zupančič, M., & Sočan, G. (2013). Predicting achievement in mathematics in adolescent students: The role of individual and social factors. The *Journal of Early Adolescence, 33*, 523-551. https://doi.org/10.1177/0272431612450949

Putwain, D. W., Connors, L., & Symes, W. (2010). Do cognitive distortions mediate the test anxiety-examination performance relationship? *Educational Psychology, 30*(1), 11-26. https://doi.org/10.1080/01443410903328866

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development, 14*(2), 187-202. https://doi.org/10.1080/15248372.2012.664593

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554. https://doi.org/10.1037/h0033456

Robinson, J. P., & Lubienski, S. T. (2011). The development of gender achievement gaps in mathematics and reading during elementary and middle school: Examining direct cognitive assessments and teacher ratings. *American Educational Research Journal, 48*(2), 268-302. https://doi.org/10.3102/0002831210372249

Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions, 6*(1), 46. https://doi.org/10.1186/1744-9081-6-46

Sadiković, S., Milovanović, I., & Oljača, M. (2018). Another psychometric proof of the Abbreviated Math Anxiety Scale usefulness: IRT analysis. *Primenjena psihologija, 11*(3), 301-323. https://doi.org/10.19090/pp.2018.3.301-323

Samuelsson, M., & Samuelsson, J. (2016). Gender differences in boys' and girls' perception of teaching and learning mathematics. *Open Review of Educational Research, 3*(1), 18-34. https://doi.org/10.1080/23265507.2015.1127770

Shim, S. S., Ryan, A. M., & Anderson, C. J. (2008). Achievement goals and achievement during early adolescence: Examining time-varying predictor and outcome variables in growth-curve analysis. Journal of Educational Psychology, 100, 655-671. https://doi.org/10.1037/0022-0663.100.3.655

Schwarz, G. (1978). Estimating the Dimension of a Model. *The Annals of Statistics, 6*(2), 461-464. https://doi.org/10.1214/aos/1176344136

Skaalvik, S., & Skaalvik, E. M. (2004). Frames of Reference for Self-Evaluation of Ability in Mathematics. *Psychological Reports, 94*(2), 619-632. https://doi.org/10.2466/pr0.94.2.619-632

Steffens, M. C., & Jelenec, P. (2011). Separating implicit gender stereotypes regarding math and language: Implicit ability stereotypes are self-serving for boys and men, but not for girls and women. *Sex Roles, 64*(5-6), 324-335. https://doi.org/10.1007/s11199-010-9924-x

Tabachnick, B. G., & Fidell, L. S. (2013). Using Multivariate Statistics, 6th ed. Boston: Pearson.

Tobias, S. (1986). Anxiety and cognitive processing of instruction. In S. Schwarzer (Ed.), *Self-related Cognition in Anxiety and Motivation* (pp. 35-54). Oxford: Psychology Press.

Townsend, M., & Wilton, K. (2003). Evaluating change in attitude towards mathematics using the 'then-now' procedure in a cooperative learning programme. *British Journal of Educational Psychology, 73*(4), 473-487. https://doi.org/10.1348/000709903322591190

Tsui, J. M., & Mazzocco, M. M. (2006). Effects of math anxiety and perfectionism on timed versus untimed math testing in mathematically gifted sixth graders. *Roeper Review, 29*(2), 132-139. https://doi.org/10.1080/02783190709554397

Von Maurice, J., Dörfler, T., & Artelt, C. (2014). The relation between interests and grades: Path analyses in primary school age. *International Journal of Educational Research, 64*, 1-11. https://doi.org/10.1016/j.ijer.2013.09.011

Voyer, D., & Voyer, S. D. (2014). Gender differences in scholastic achievement: A meta-analysis. *Psychological Bulletin, 140*(4), 1174-1205. https://doi.org/10.1037/a0036620

Wang, Z., Hart, S. A., Kovas, Y., Lukowski, S., Soden, B., Thompson, L. A., Plomin, R., McLoughlin, G., Bartlett, C. W., Lyons, I. M., & Petrill, S. A. (2014). Who is afraid of math? Two sources of genetic variance for mathematical anxiety. *Journal of Child Psychology and Psychiatry, 55*(9), 1056-1064. https://doi.org/10.1111/jcpp.12224

Wang, Z., Lukowski, S. L., Hart, S. A., Lyons, I. M., Thompson, L. A., Kovas, Y., Mazzocco, M. M., Plomin, R., & Petrill, S. A. (2015). Is math anxiety always bad for math learning?

The role of math motivation. *Psychological science, 26*(12), 1863-1876. https://doi.org/10.1177/0956797615602471

Wang, Z., Shakeshaft, N., Schofield, K., & Malanchini, M. (2018). Anxiety is not enough to drive me away: A latent profile analysis on math anxiety and math motivation. *PloS one, 13*(2), e0192072. https://doi.org/10.1371/journal.pone.0192072

Wigfield, A., & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology, 80*(2), 210-216. https://doi.org/10.1037/0022-0663.80.2.210

Wigfield, A., Eccles, J. S., & Rodriguez, D. (1998). The development of children's motivation in school context. *Review of Research in Education, 23*, 73-118. https://doi.org/10.3102/0091732X023001073

Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbreton, A., Freedman-Doan, K., & Blumenfeld, P. C. (1997). Changes in children's competence beliefs and subjective task values across the elementary school years: A three-year study. *Journal of Educational Psychology, 89*, 451-469. https://doi.org/10.1037/0022-0663.89.3.451

Wu, S., Amin, H., Barth, M., Malcarne, V., & Menon, V. (2012). Math anxiety in second and third graders and its relation to mathematics achievement. *Frontiers in Psychology, 3*, 162-173. https://doi.org/10.3389/fpsyg.2012.00162

Young, C. B., Wu, S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science, 23*(5), 492-501. https://doi.org/10.1177/0956797611429134

Zakaria, E., & Nordin, N. M. (2008). The Effects of Mathematics Anxiety on Matriculation Students as Related to Motivation and Achievement. *Eurasia Journal of Mathematics, Science & Technology Education, 4*(1), 27-30. https://doi.org/10.12973/ejmste/75303

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Matematička anksioznost, matematičko postignuće i motivacija za učenje matematike u srednjoj školi: učinci spola

Sažetak

Prema rezultatima prethodnih istraživanja, matematička anksioznost je važna odrednica nižeg postignuća iz matematike među srednjoškolcima. Iako matematička anksioznost utječe na oba spola, neki nalazi govore da su djevojke sklonije njezinom pokazivanju, ali ne objašnjavaju kako doprinos različitih dimenzija anksioznosti ovisi o interakciji spola učenika i manifestacija motivacije za učenje matematike. Cilj ovoga istraživanja bio je ispitati učinak spola između matematičke anksioznosti i matematičkoga postignuća posredovanih motivacijom za učenje matematike kod srednjoškolaca. Uzorak je činilo 514 srednjoškolaca iz Srbije (45,3 % učenika), u dobi od 15 do 19 godina. Instrumenti koji su korišteni u istraživanju bili su Upitnik matematičke anksioznosti i Ljestvica motivacije za učenje matematike, dok je matematičko postignuće mjereno kao prosjek ocjena iz matematike na kraju prvog polugodišta i na kraju školske godine. Rezultati moderirane analize medijacije ukazali su na negativan doprinos matematičke anksioznosti postignuću kod oba spola, uz potpuno posredovanje zadovoljstva kod učenika i djelomičnim posredovanjem zadovoljstva i korisnosti kod učenica. Na temelju analize dobivenih rezultata može se zaključiti da je nužno primijeniti različite strategije motivacije za prevladavanje matematičke anksioznosti, što ovisi o spolu učenika.

Ključne riječi: *matematička anksioznost, matematičko postignuće, motivacija za učenje matematike, spolne razlike, srednja škola*

Uvod

Matematička anksioznost definirana je kao negativan bihevioralni odgovor tijekom kontakta s matematičkim sadržajem i predstavlja čimbenik rizika za niže matematičko postignuće na svim obrazovnim razinama (Ashcraft, 2002; Ma i Xu, 2004; Maloney i Beilock, 2012; Ramirez, Gunderson, Levine, i Beilock, 2013). Ova vrsta anksioznosti očituje se bez obzira na razinu matematičkih vještina (Prevatt, Welles, Li i Proctor, 2010; Wu, Barth, Amin, Malcarne i Menon, 2012; Tsui i Mazzocco, 2007) i može se otkriti već na početku osnovnoškolske dobi (Jameson, 2013; Milovanović, 2018;

Milovanović i Branovački, 2020; Ramirez i sur., 2013). Također, ova vrsta anksioznosti ima karakteristike konstrukta koji je stabilan u vremenu (Cargnelutti, Tomasetto i Passolunghi, 2016; Ma i Xu, 2004). Njezin učinak na matematičko postignuće raste s godinama, ima vrhunac u srednjoj školi (Hembree, 1990; Townsend i Wilton, 2003), a neki autori tvrde da je prisutna u 6 – 30 % srednjoškolaca (Ashcraft, 2002; Chinn, 2009; Johnston-Wilder, Brindley i Dent, 2014). Iako neki rezultati istraživanja pokazuju da tijekom srednje škole mladići postižu više ocjene iz matematike u odnosu na djevojke (npr. Hedges i Nowell, 1995; Hyde, Fennema i Lamon, 1990), a djevojke osjećaju višu razinu anksioznosti u odnosu na matematičke kompetencije (Else-Quest, Hyde i Linn 2010; Primi, Busdraghi, Tommasetto, Morsanyi i Chiesi, 2014), rezultati suvremenih metaanalitičkih studija upućuju na manje učinke rodnih razlika u matematičkim performansama (Hyde, Lindberg, Linn, Ellis i Williams, 2008; Lindberg, Hyde i Petersen, 2010; Voyer i Voyer, 2014). Ako dodamo neke zaključke o rodnim razlikama u motivaciji za učenje matematike u korist mladića (Samuelsson i Samuelsson, 2016; Skaalvik i Skaalvik, 2004), ovi bi nalazi mogli otvoriti nova pitanja o mehanizmima povezanosti između dimenzija matematičke anksioznosti, motivacije za učenje matematike i matematičkoga postignuća ovisno o spolu učenika.

Matematička anksioznost: kratko definiranje

Matematička anksioznost definirana je kao negativno emocionalno reagiranje u situacijama koje uključuju izražavanje matematičkih sposobnosti, učenje matematike ili ocjenjivanje matematičkih znanja tijekom kojih nastaje stres, nelagoda i izbjegavajuće ponašanje (Ashcraft, 2002; Ma i Xu, 2004). Ova vrsta anksioznosti utječe na djecu i odrasle, u svakodnevnim i akademskim situacijama (Richardson i Suinn, 1972). U svojoj metaanalizi Hembree (Hembree, 1990) je utvrdio da matematička anksioznost može postojati u ponašanju bez obzira na ispitnu i generaliziranu anksioznost, a rezultati nekih istraživanja u području neuroznanosti podupiru ovu tvrdnju (vidjeti Lyons i Beilock, 2012; Mattarella-Micke, Mateo, Kozak, Foster i Beliock, 2011). Unatoč nagađanjima o nasljednim i vanjskim (Hart, Petrill, Thompson i Plomin, 2009; Kovas, Harlaar, Petrill, i Plomin, 2005; Wang i sur., 2014), kao i neuralnim (Deheane, Piazza, Pinel i Cohen , 2003; Young, Wu i Menon, 2012) korelatima matematičke anksioznosti, specifični uzrok njezina razvoja, nakon 70 godina istraživanja i dalje ostaje otvoreno pitanje znanstvene rasprave (Geist, 2010).

Rezultati u većini studija matematičke anksioznosti ukazali su na važnost interakcije kognicije i emocija za njezin razvoj (Prevatt i sur., 2010; Putwain, Connors i Symes, 2010). Kognitivna komponenta matematičke anksioznosti odnosi se na zabrinutost zbog postignuća u matematici i posljedica podbacivanja (Wigfield i Mecce, 1988), zbog hipertenaciteta pažnje koju pojedinac usredotočuje na ruminirajuće misli u tim situacijama. Ruminacije o kompetenciji iz područja matematike utječu na smanjenje produktivnosti radne memorije, što rezultira neuspjehom u rješavanju matematičkih zadataka. Afektivna komponenta matematičke anksioznosti odnosi se na emocionalnu

i fiziološku nelagodu i napetost u situacijama učenja matematičkoga sadržaja ili u situacijama vrednovanja matematičkoga znanja (Wigfield i Mecce, 1988). Najčešće se manifestira kao opća fiziološka napetost tijela ili kroz pojedinačne fiziološke simptome. Iako se manifestacija matematičke anksioznosti može opisati kao dominantno kognitivni ili emocionalni odgovor tijekom kontakta s matematičkim sadržajem, najčešće se može detektirati interakcija ovih čimbenika. Rezultati nekih istraživanja također upućuju na ovaj zaključak, podupirući tvrdnju da se dimenzije matematičke anksioznosti nalaze u pozitivnom, umjerenom ili snažnom odnosu (Milovanović i Kodžopeljić, 2018; Wigfield i Meece, 1988).

Afektivna i kognitivna komponenta matematičke anksioznosti negativno pridonose matematičkom postignuću na svim obrazovnim razinama (npr. Hembre, 1990; Ma i Hu, 2004; Wu i sur., 2014), ali afektivna komponenta ima nešto jači učinak tijekom srednje škole (Ho i sur., 2000; Wigfield i Meece, 1998). Kada se govori o jačini veze između matematičke anksioznosti i matematičkoga postignuća, istraživanja upućuju na da bi se ta povezanost mogla opisati u rasponu od niskih do umjerenih koeficijenata korelacije (Ho i sur., 2000; Ma, 1999). Iako se konkretni uzroci matematičke anksioznosti ne mogu sa sigurnošću utvrditi (Geist, 2010), srednjoškolci smatraju spolne razlike njenzim najčešćim uzrocima (Arambašić, Vlahović-Štetić, i Severinac, 2005; Beilock, Gunderson, Ramirez, i Levine, 2011; Steffens i Jelenec, 2011).

Odnosi matematičke anksioznosti, matematičkoga postignuća i motivacije za učenje matematike

Prethodna istraživanja odnosa matematičke anksioznosti i matematičkih postignuća rezultirala su formiranjem tri skupine općih teorija. Prema *teoriji deficita* (Hembree, 1990; Tobias, 1986), niske akademske sposobnosti izazivaju visoku razinu anksioznosti. Matematička anksioznost mogla bi stoga biti uzrokovana poviješću neuspjeha u rješavanju matematičkih problema. Ova teorija nalazi svoju primjenu u istraživanjima kod učenika s poteškoćama u razvoju ili problemima u učenju (Passolunghi, 2011; Rubinsten i Tannock, 2010), što smanjuje mogućnost generaliziranja na učenike urednoga razvoja. S druge strane, *teorija kognitivne interferencije* postulira gledište da visoka razina anksioznosti rezultira neuspješnim rješavanjem problema. Prema ovoj teoriji, matematička anksioznost posredovana radnom memorijom, ometa sposobnost rješavanja matematičkih problema, što rezultira niskim postignućem iz matematike ili izbjegavanjem matematičkih sadržaja (Ashcraft i Krause, 2007; Morsanyi, Busdraghi, i Primi, 2014). Preusmjeravanjem pozornosti s rješavanja matematičkoga problema na vlastite misli o neadekvatnosti osobnih kompetencija, učenik najčešće ne uspijeva riješiti zadatak. Bez obzira na razvoj teorija uzajamnih utjecaja, istraživanja uglavnom podržavaju *teoriju kognitivne interferencije*, zbog malog broja nalaza eksperimentalnih i longitudinalnih studija koji bi podržali recipročne modele ili *teoriju deficita*.

Motivacija za učenje matematike definirana je kao ulaganje u rješavanje matematičkih problema, pozitivno vrednovanje matematičkih sposobnosti i matematike općenito,

kao i stupanj uspješnoga rješavanja matematičkih zadataka (Gottfried, Marcoulides, Gottfried, Oliver i Guerin, 2007). Prethodna istraživanja srednjoškolske populacije pokazale su da učenici koji su zabrinuti u vezi s matematičkim postignućima pokazuju nižu motivaciju za učenje matematike (Hembree, 1990; Zakaria i Nordin, 2008), negativniji stav prema matematici i veće izbjegavanje matematike u kontekstu odabira buduće profesije (Ashcraft, 2002; Hembree, 1990). Srednjoškolski učenici koji imaju pozitivan stav prema matematici skloni su tražiti pomoć u rješavanju zadataka, testiranju velikoga broja strategija rješavanja matematičkih problema i ulaganju u rješavanje složenijih matematičkih zadataka (Wigfield, Eccles, & Rodriguez, 1998). Imajući u vidu rezultate prethodnih istraživanja, čini se da je motivacija za učenje matematike dijelom posljedica matematičke anksioznosti učenika, ali istovremeno predstavlja važnu odrednicu u postignuću iz matematike što potvrđuje njegov posrednički karakter (Hong, O'Neal, i Feldon, 2005). Suvremeni preventivni programi preporučuju motiviranje učenika radi poboljšanja matematičkih postignuća (npr. Jitendra, Nelson, Pulles, Kiss i Houseworth, 2016), tako da je jasno da motivacija za učenje matematike zaslužuje važno mjesto u istraživanju odnosa između matematičke anksioznosti i matematičkoga postignuća. S obzirom na sklonost učenika da pokazuju najnižu motivaciju za učenje matematike u srednjoj školi (Wigfield i sur., 1997), ispitivanje tih odnosa u srednjoškolaca čini se važnim za buduće obrazovne rezultate u području matematike. Neki učenici čak mogu motivacijski profitirati od matematičke anksioznosti, dok kod drugih anksioznost djeluje demotivirajuće (Pekrun, Frenzel, Goetz i Perry, 2007). Prema Wangu i suradnicima (Wang i sur., 2018), koji su pronašli 8 različitih profila srednjoškolaca koji su karakterizirani različitim kombinacijama dimenzija matematičke anksioznosti i motivacije za učenje matematike, potrebno je više ispitati složenost emocionalno-motivacijske interakcije u učenju matematike. Wang i suradnici (2015) zaključili su da je kod adolescenata koji su imali nisku motivaciju za učenje matematike, ustanovljena negativna povezanost između matematičke anksioznosti i matematičkih performansi na svim razinama matematičkih postignuća. Utjecaj matematičke anksioznosti raste i dostiže vrhunac u srednjoj školi (Hembree, 1990) kada učenici teže učiti matematiku samo zbog školskih ocjena, matematiku ocjenjuju kao manje zabavnu (Middleton i Spanias, 1999) i manje važnu (Wigfield i sur., 1997) i imaju nedostatak motivacije za učenje matematike (Benček i Marenić, 2006), što dodatno doprinosi važnosti aktualnoga istraživanja posredničke uloge motivacije za učenje matematike između matematičke anksioznosti i matematičkoga postignuća.

Razlike između spolova u matematičkoj anksioznosti, matematičkom postignuću i motivaciji za učenje kod učenika srednjih škola

Tradicionalno se na matematiku gleda kao na tipično „muško područje". Rezultati starijih metaanaliza sugeriraju da mladići postižu bolje rezultate u matematici u odnosu na djevojke tijekom srednje škole (Hedges i Nowell, 1995; Hyde i sur., 1990),

dok suvremene metaanalize osporavaju ta tradicionalna stajališta, upućujući na male ili beznačajne rodne razlike u matematičkim sposobnostima (Else-Quest i sur., 2010; Lindberg i sur., 2010; Voyer i Voyer, 2014). Osim toga, čini se da su djevojke tijekom posljednjega desetljeća postizale bolje ocjene iz matematike od mladića u osnovnoj i srednjoj školi (Brown i Kanyongo, 2010; Jugović, Baranović i Marušić, 2012; Robinson i Lubienski, 2011; von Maurice, Dörfler i Artelt, 2014), zbog čega su prethodni rezultati upitni. Ovaj se zaključak može primijeniti i u slučaju bodova na pojedinačnim testovima i školskim ocjenama na kraju srednje škole (Fryer i Levitt, 2010; Guiso i sur., 2008; Kenney-Benson, Pomerantz, Ryan i Patrick, 2006; Pope i Snydor, 2010; Puklek Lepuvšček, Zupančič i Sočan, 2012). U raznim istraživanjima na na uzorku srednjoškolske populacije, djevojke su, u usporedbi s mladićima, pokazivale nižu razinu izbjegavanja učenja (Shim, Ryan i Anderson, 2008), višu razinu svladavanja matematičkih materijala za učenje (Pekrun, Elliot i Maier, 2006) i veću uključenost u rješavanje zadataka iz matematike (Gherasim, Butnaru i Maieran, 2013), što se može povezati s boljim ocjenama djevojaka. Ipak, potrebno je više istraživanja kako bi se odgovorilo na pitanja o mehanizmima spolnih razlika u matematici koje pridonose uspješnom rješavanju matematičkih zadataka.

Rezultati metaanaliza rodnih razlika u matematičkoj anksioznosti (npr. Else-Quest i sur., 2010; Hembree, 1990), ali i drugih studija (Devine, Fawcett, Szűcs, i Dowker, 2012; Hill i sur., 2016; Jain & Dowson, 2009; Luo, Wang, i Luo, 2009; Sadiković, Milovanović i Oljača, 2018) većinom su upućivale na to da su djevojke sklonije njezinom očitovanju tijekom srednje škole. Objašnjenja tih nalaza temeljila su se na mišljenju da su učenice više samokritične i zabrinute zbog postignuća i da imaju niže matematičko samopoimanje, što vodi u zabrinutost i, prema tome, u negativne emocionalne reakcije u vezi s matematičkim postignućima (Goetz, Frenzel, Hall i Pekrun, 2008; Goetz, Bieg, Lüdtke, Pekrun i Hall, 2013). Ostali su se autori usredotočili na vanjske i kontekstualne uzroke tih razlika te su kao objašnjenje razmatrali manju potporu djevojkama u učenju matematike (Eccles, 2011) ili učinak predrasuda prema matematici kao „muškom području" (Arambašić i sur., 2005; Steffens i Jelenec, 2011). Rezultati prethodnih istraživanja (Bieg, Goetz i Lipnevich, 2014; Goetz i sur., 2013) pokazali su da djevojke postižu veće rezultate na ljestvici matematičke anksioznosti kao stanja i osobine, a da su se razlike u spolovima najmanje očitovale kada se matematička anksioznost promatrala kao stanje. Spomenuti zaključak može se objasniti činjenicom da je ženski spol općenito skloniji anksioznosti (Chapman, Duberstein, Sörensen i Lyness, 2007; Costa, Terracciano i McCrae, 2001), dok muški spol više pokazuje simptome anksioznosti kao posljedicu situacijskih faktora. U razdoblju adolescencije, razlike u spolu u matematici više se zasnivaju na razlikama u samopercepciji osobnih kompetencija i na brizi o postignućima (Egger, Costello i Angold, 2003; Osborne, 2001), što se više očituje kod adolescentica. Može se zaključiti da djevojke i mladići različito izražavaju matematičku anksioznost te da se mogu uvidjeti određene spolne razlike u konstelaciji efekata matematičkih anksioznosti na niže postignuće iz matematike.

Anksioznost se može promatrati i kao varijabla koja regulira očitovanje i razvoj motivacije (Catsambis, 1994; Hannula, 2012). U srednjoj školi djevojke pokazuju manje interesa za matematiku i pokazuju višu razinu matematičke anksioznosti (Lupart, Cannon i Telfer, 2004; Skaalvik i Skaalvik, 2004). Spolne razlike u motivaciji (npr. očekivanja, vrijednosti), zauzvrat, predviđaju kasnije razlike u akademskim postignućima (Leaper, Farkas i Spears Brown, 2012). Ovo sugerira da se razlike u spolovima u akademskoj motivaciji mogu dijelom modificirati razlikama u anksioznosti (Pajares i Valiante, 2002). Odnos mladića prema matematici mogao bi se razmotriti u kontekstu da mladići imaju potrebu za „znanjem" i „rukovanjem" matematikom kako bi mogli raditi u zanimanjima koja se smatraju više „muškim" (Samuelsson i Samuelsson, 2016). Prema Nacionalnoj zakladi za znanost (2012), mladići češće pohađaju fiziku i inženjerstvo u srednjoj školi kao izborni „matematički" predmet u mnogim zemljama (npr. Francuska, Italija, Norveška, Portugal, Švedska, Slovenija itd.). Imajući u vidu lagani porast sudjelovanja djevojaka u srednjoškolskim tečajevima vezanim uz matematiku, ali i u poslovima vezanih uz matematiku (Beede i sur., 2011; Noonan, 2017), potrebno je razmotriti razlike u motivaciji učenika za učenje matematike u kontekstu interakcije spola i anksioznih tjeskoba. Budući da bi različite vrste motivacije mogle biti važne te da bi različiti temeljni čimbenici mogli dovesti do sličnih obrazaca rezultata, studije rodnih razlika u matematičkim postignućima moraju se tumačiti s oprezom, posebno ako se provode u srednjim školama u kojima matematika možda nije glavni i središnji predmet.

Ciljevi istraživanja

Tijekom srednje škole matematička anksioznost predstavlja vrlo važan faktor slabijih matematičkih postignuća. No, prethodna literatura pružila je donekle oprečne nalaze o ulozi spola u odnosima tih varijabli. Imajući na umu da se spol ističe kao jedan od najvažnijih čimbenika matematičkoga postignuća i da u matematičkoj anksioznosti postoje spolne razlike, postoji potreba za detaljnijom analizom odnosa između anksioznosti i matematičkoga postignuća u kontekstu spolnih razlika. Pored toga, interakcija matematičke anksioznosti i motivacije za učenje poboljšavaju predviđanje matematičkoga ponašanja i postignuća u usporedbi s njihovim samostalnim utjecajima (Lyons i Beilock, 2012; Wang i sur., 2015).

Stoga je cilj ovoga istraživanja bio ispitati odnos matematičke anksioznosti i matematičkoga postignuća među srednjoškolcima kroz učinke matematičke motivacije i moderirajućega učinka spola. Ti odnosi nisu tako jednostavni imajući u vidu višedimenzionalnu prirodu matematičke anksioznosti i posredničku ulogu motivacije za učenje matematike. Može se očekivati da će afektivna dimenzija imati veći doprinos u objašnjenju matematičkoga postignuća od kognitivnih aspekata matematičke anksioznosti. Stoga je cilj provedenoga istraživanja ispitati doprinos obje dimenzije matematičke anksioznosti u predviđanju postignuća iz matematike, ovisno o spolu učenika i motivaciji za učenje. Očekuje se da će obje dimenzije matematičke anksioznosti

imati negativan odnos s matematičkim postignućem kod djevojaka. Mladići su manje zabrinuti za svoja postignuća u području matematike i nisu tako skloni anksioznosti kao osobini u usporedbi s djevojkama. Zbog toga se pretpostavlja da će anksioznost u potpunosti doprinijeti matematičkim postignućima kroz negativne utjecaje na motivaciju za učenje matematike kod mladića, ali dijelom, neovisno, i kod djevojaka.

Metoda
Sudionici i procedura

U istraživanju je sudjelovalo 514 srednjoškolaca (45,3 % muškoga spola) iz gimnazija (45,7 %) i srednjih strukovnih škola u Srbiji. Starost sudionika kretala se u rasponu od 15 do 19 godina. Ukupno je bilo 32,9 % učenika drugog, 34 % trećeg i 33,1 % četvrtog razreda. Kako bi se objasnila svrha ove studije i zatražila suglasnost, obavljeni su osobni posjeti ravnateljima škola. Uprave svih škola odobrile su istraživanje. Tijekom redovne školske nastave, educirani studenti distribuirali su instrumente sudionicima. Brinulo se o tome da odabrani razredi imaju razmjerno približan broj učenika i učenica različitih obrazovnih profila. Svi su sudionici bili upoznati sa svrhom istraživanja i osiguravanjem anonimnosti podataka prije primjene instrumenata. Roditelji maloljetnika također su prije provođenja upitnika potpisali informativni pristanak za sudjelovanjem njihove djece u istraživanju.

Instrumenti i mjere

Upitnik matematičke anksioznosti (MAQ: Wigfield i Meece, 1988; za prevedenu i prilagođenu verziju vidi: Milovanović i Kodžopeljić, 2018) sadrži 11 čestica koje se ocjenjuju na Likertovoj skali od sedam bodova (od 1 - *izrazito se ne slažem* do 7 - *u potpunosti se slažem*). MAQ se sastojao od dvije podskale: zabrinutost (α = .86) i negativne afektivne reakcije (α = .85). Čestice koje su usredotočene na negativne afektivne reakcije, mjere negativna emocionalna stanja tijekom matematičkih aktivnosti u školi (*Testovi iz matematike me plaše*), a čestice usredotočene na brigu mjere zabrinutost učenika o njihovoj uspješnosti u matematici (*Brinem se za to koliko mi dobro ide matematika*).

Ljestvica motivacije učenika za učenje matematike (SMOT: Gitno i Mwangi, 2003) je ljestvica koja je namijenjena mjerenju različitih motivacijskih faktora učenja matematike i sastoji se od 28 čestica. Ljestvica je već prilagođena i provjerena za srpske učenike (Milovanović, 2016). Odgovori na čestice dani su na Likertovoj skali s pet bodova (od 1 - *uglavnom se ne slažem*, do 5 - *u potpunosti se slažem*). Faktorska struktura upućuje na to da postoje 4 glavne komponente ove ljestvice: motivacija (*Izrazito sam motiviran za učenje matematike*, α = .82), zadovoljstvo (*Zadovoljan sam načinom na koji učim matematiku*, α = .83), demotivacija (*Rijetko očekujem da ću biti uspješan u predmetima koji se tiču matematike*, α = .79) i korisnost (*Učenje matematike pruža mi mogućnosti za napredovanje u obrazovanju*, α = .85).

Postignuće iz matematike mjerilo se ocjenama koje su prikupljene iz školskih dnevnika na kraju školske godine. Ukupni matematički uspjeh izračunao se za svakog

učenika računanjem prosjeka njegovih ocjena iz matematike na polugodištu i na kraju školske godine.

Rezultati

Korelacije i spolne razlike

Razlike između spolova u postignuću iz matematike i u negativnim afektivnim reakcijama bile su značajne, dok razlike u zabrinutosti nisu (tablica 1).

Tablica 1.

Djevojke su postigle veće matematičko postignuće i također su doživjele više negativnih emocionalnih reakcija tijekom matematičkih aktivnosti u školi u usporedbi s mladićima. Matematičko postignuće bilo je značajno i negativno povezano s obje vrste matematičke anksioznosti, dok su dimenzije matematičke anksioznosti bile međusobno pozitivno povezane. Mjere zakošenosti i spljoštenosti distribucije (respektivno) za matematičko postignuće (-0.14, -1,08), brigu (0.06, -0.96) i negativne afektivne reakcije (0.24, -0.84) bile su u zadovoljavajućem rasponu vrijednosti, prema preporukama Tabachnick i Fiddel (2013).

Tablica 1 također pokazuje da su sve korelacije između motivacije za učenje matematike, matematičkoga postignuća i matematičke anksioznosti bile značajne. Sve korelacije MAQ-a s dimenzijama motivacije bile su niske do umjerene i negativne, osim onih s *demotivacijom*. Korelacije između matematičkoga postignuća i dimenzija matematičke motivacije bile su umjerene i pozitivne, osim u slučaju *demotivacije*, gdje su korelacije bile negativne. Nisu utvrđene spolne razlike u dimenzijama motivacije za učenje matematike. Mjere zakošenosti i spljoštenosti distribucije za dimenzije motivacije za učenje matematike također su bile u zadovoljavajućem rasponu vrijednosti.

Tablica 2.

Tablica 2 prikazuje koeficijente korelacije između motivacije za učenje matematike, matematičkoga postignuća i matematičke anksioznosti ovisno o spolu učenika. Utvrđen je sličan odnos u usporedbi s odnosima koji su dobiveni na cijelom uzorku (tablica 1). Otkrivene su razlike između *motivacije* i *brige* među mladićima, kao i u odnosu *korisnosti* i *negativnih afektivnih reakcija*. Zbog različitih odnosa tih konstrukcija među spolovima može se očekivati da bi motivacija za učenje matematike mogla biti značajan faktor koji razlikuje odnose između matematičke anksioznosti i matematičkih postignuća kod mladića i djevojaka.

Analiza putanje – moderirana medijacija

Kako bi se testirao moderacijski učenik spola u medijacijskom odnosu motivacije za učenje matematike između matematičke anksioznosti i matematičkoga postignuća, proveden je strukturni model analizom putanje (slika 1).

Slika 1.

Ova vrsta modela omogućava donošenje zaključaka o odnosima varijabli ovisno o razini moderatora. Razina moderatora mogla bi promijeniti odnose između neovisne varijable i varijable medijatora, kao i između varijable medijatora i ovisne varijable. U ovom se modelu mogu primijetiti dva učinka: izravni učinak neovisne varijable i ukupni učinak koji uključuje posredne učinke. Procjena modela provedena je na temelju Akaikeova informacijskoga kriterija (AIC; Akaike, 1973.), Bayesova informacijskoga kriterija (BIC; Schwarz, 1978.), komparativnoga indeksa fita i Tucker-Lewisova indeksa (CFI i TLI - optimalne vrijednosti veće od .95, prihvatljiva veća od .90), aproksimacije korijenske srednje vrijednosti (RMSEA - optimalne vrijednosti niže od .05, prihvatljive niže od .08) i kvocijent χ2/*df* (preporučeno <2) (Kline, 2010). Ispitivanjem različitih modela odnosa između spola, motivacije za učenje matematike, matematičkoga postignuća i matematičke anksioznosti utvrđeno je da model imao dobre indekse fita (χ^2(140) = 271.03, CFI = .93, TLI = .92, RMSEA = .06, AIC = 99.95, BIC = 7001.5).

Slika 2.

Slika 2 pokazuje da je u slučaju mladića bio značajan negativan ukupan, ali neznačajan izravan učinak brige i negativnih afektivnih reakcija na matematičko postignuće. Samozadovoljstvo imalo je značajan neizravan učinak na matematičko postignuće. Može se zaključiti da obje manifestacije matematičke anksioznosti neizravno pridonose matematičkim postignućima, putem negativnoga utjecaja na zadovoljstvo tijekom učenja matematike.

Slika 3.

Slika 3 pokazuje da je došlo do značajnoga i negativnog ukupnoga i izravnoga učinka brige i negativnih afektivnih reakcija na matematičko postignuće kod djevojaka. Obje dimenzije matematičke anksioznosti doprinose neovisno i negativno postignućima iz matematike, ali također posredno i negativno utječu na zadovoljstvo i korisnost. Jasno je da matematička anksioznost igra važnu ulogu za matematičko postignuće kod oba spola, ali ova je studija također označila važnost djelomične medijacijske uloge motivacije za učenje matematike u skupini djevojaka, ali punu medijacijsku ulogu u skupini mladića.

Rasprava i zaključci

Cilj ovoga istraživanja bio je utvrditi moderirajuću ulogu spola u odnosu na dimenzije matematičke anksioznosti i matematičkih postignuća kod srednjoškolaca, posredovanih motivacijom za učenje matematike, kao i ispitati doprinos dimenzija matematičke anksioznosti postignućima iz matematike. Rezultati istraživanja pokazuju da negativne afektivne reakcije i briga značajno i negativno doprinose matematičkom postignuću kod oba spola, ali da je motivacija za učenje matematike uz navedene odnose djelomično utjecala na dobivene rezultate kod djevojaka i u potpunosti kod mladića.

Doprinos negativnih emocionalnih reakcija matematičkim postignućima pokazao se značajnim kod oba spola. U isto vrijeme, ovaj je doprinos bio veći od doprinosa

zabrinutosti, što se podudara s rezultatima prethodnih istraživanja (Ho i sur., 2000; Wigfield i Meece, 1998). Čini se da se konceptualna razlika između kognitivne i afektivne dimenzije matematičke anksioznosti sastoji u činjenici da se zabrinutost očituje tijekom dužega razdoblja prije ispitne situacije, dok se negativne afektivne reakcije najočitije manifestiraju u situacijama evaluacije znanja (npr. *Kad radim test iz matematike, obično se osjećam nervozno i nelagodno* ili *Kada mi nastavnik postavi pitanja iz matematike, brinem se da ću loše raditi*). Moguće je da zbog toga afektivna komponenta matematičke anksioznosti ima jači učinak na matematičko postignuće u odnosu na kognitivnu komponentu.

Spolne razlike išle su u korist djevojaka koje postižu bolje rezultate u dimenziji negativnih afektivnih reakcija, kao i u korist toga da imaju veće postignuće u matematici u usporedbi s mladićima. Tijekom posljednjih nekoliko desetljeća pokazalo se da djevojke tijekom srednje škole imaju bolje ocjene iz matematike od mladića (Brown & Kanyongo, 2010; Robinson i Lubienski, 2011). Trend smanjenja tradicionalnih rodnih razlika mogao bi se uočiti u rezultatima suvremenih metaanaliza u matematičkim postignućima tijekom srednje škole (npr. Voyer i Voyer, 2014). Jači izraz negativnih emocionalnih reakcija kod djevojaka može se objasniti spolnim razlikama u očitovanju anksioznosti, što je snažnije izraženo kod djevojaka u adolescenciji (vidjeti Dowker, Sarkar, i Looi, 2016). Emocionalnost je izraženija kod djevojaka, a djevojke su istovremeno sklonije izražavati anksioznost kao osobinu. Stoga bi se činilo da ovaj nalaz, u kombinaciji s nalazom da djevojke svoje matematičke sposobnosti promatraju kao niže izražene tijekom srednje škole (Goetz i sur., 2008; Goetz i sur., 2013.), rezultira višom manifestacijom negativnih emocionalnih i fizioloških simptoma kod djevojaka, posebno tijekom konkretnih situacija ocjenjivanja znanja.

Rezultati ovoga istraživanja pokazali su da dimenzije matematičke anksioznosti negativno doprinose matematičkim postignućima i kod mladića i kod djevojaka, s dvostruko jačim učinkom u slučaju djevojaka. Općenito, čini se da je glavna razlika u tome što učenici oba spola doživljavaju manifestacije anksioznosti na fiziološkoj i emocionalnoj razini, ali su djevojke sklonije otvorenom izražavanju brige, što dodatno povećava negativan doprinos matematičkim postignućima u tom razdoblju adolescencije (Beilock i sur., 2011). Kao što je već spomenuto, neki učenici mogu imati motivacijsku korist od matematičke anksioznosti, dok drugi ne mogu (Pekrun i sur., 2007). Čini se da neke manifestacije motivacije za učenje matematike narušavaju učinke matematičke anksioznosti kod oba spola. Zadovoljstvo kao aspekt motivacije odnosi se na uživanje tijekom procesa učenja matematike. Može biti da su učenici koji su više usredotočeni na proces učenja matematike nego na završno matematičko postignuće, otporni na utjecaj matematičke anksioznosti. Ovaj zaključak posebno se može primijeniti na skupinu mladića zbog činjenice da anksioznost kod djevojaka ima i neovisne, izravne učinke na matematičko postignuće, bez obzira na motivaciju. S obzirom da mladići imaju više povjerenja u vlastite matematičke sposobnosti (Goetz i sur., 2008; Goetz i sur., 2013.), čini se da njihova visoka motivacija i zadovoljstvo u učenju matematike

imaju zaštitničku ulogu s obzirom na to da pokazuju manju zabrinutost i negativnih osjećaja o svojem matematičkom postignuću. Najočitiji nalaz ovoga istraživanja, koji potvrđuje prethodne zaključke, jest da zabrinutost nije igrala važnu ulogu u slučaju motivacije mladića

Ovom studijom otkrivena je djelomična medijacija motivacije za učenje matematike u odnosu između matematičke anksioznosti i matematičkoga postignuća u skupini djevojaka. Neizravni učinci matematičke anksioznosti postignuti su zadovoljstvom, kao i u skupini mladića, i korisnosti. U prethodnim istraživanjima na uzorku srednjoškolske populacije djevojke su pokazale niže izbjegavanje manifestacije performansi (Shim i sur., 2008.), višu razinu svladavanja matematičkih materijala za učenje (Pekrun i sur., 2006.) i veću uključenost u školske zadatke iz matematike (Gherasim i sur. ., 2013). S obzirom na to da se ovo istraživanje provodilo u srpskim srednjim školama u kojima matematika nije uvijek glavni i središnji predmet, korisnost može imati važnu ulogu za mlade u smislu boljeg općeg uspjeha i kasnije mogućnosti za bolje visoko obrazovanje. Čini se da bi percepcija korisnosti matematike mogla igrati važnu ulogu kao manifestacija vanjske motivacije koja bi se mogla povezati s budućim obrazovnim ili osobnim uspjesima djevojaka. Prema tim rezultatima, može se izvesti implicitni zaključak o različitim učenicama u kontekstu uspjeha iz matematike: postoje učenice koje motivira sama matematika i one koje imaju visoku motivaciju za postignuća, ali ne specifično u području matematike. Međutim, takva tvrdnja zahtijeva daljnje istraživanje. Uz prethodne rezultate, vrlo je važno primijetiti i da je matematička anksioznost kod djevojaka igrala i važnu, neovisnu ulogu u postizanju matematičkih postignuća. Objašnjenja ovih nalaza mogla bi se temeljiti na mišljenju Goetza i suradnika (2013) da su učenice više zabrinute zbog svojega matematičkog postignuća čemu pridonose negativne emocionalne reakcije. Štoviše, ženski spol je skloniji anksioznosti općenito (Chapman i sur., 2007; Costa i sur., 2001), pa se čini da matematička anksioznost igra važnu ulogu za djevojke u oblikovanju postignuća, bez obzira na motivaciju. Da je generalizirana anksioznost bila kontrolirana u ovome istraživanju, prethodni zaključci mogli bi biti primjenjiviji. Već je spomenuto da djevojke svoje matematičke sposobnosti percipiraju kao niže tijekom srednjoškolskoga obrazovanja. Ovakva vrsta samohendikepirajućega ponašanja u kontekstu procjene vlastite učinkovitosti u području matematike, vjerojatno pridonosi iskazivanju veće anksioznosti i, djelomično, niže motivacije i postignuća iz matematike.

Ograničenja studije, daljnje preporuke i praktični učinak

Važno je primijetiti da je ovo istraživanje provedeno s određenim ograničenjima. Glavno ograničenje studije je da se matematički uspjeh ne mjeri izravno vrednovanjem znanja standardiziranim testom postignuća, već izračunavanjem prosječne ocjene iz matematike na temelju pojedinačnih ocjena uzetih iz školskih dnevnika. Iako se pokazalo da se mjera postignuća iz matematike može smatrati pouzdanom mjerom, buduća istraživanja ove vrste trebala bi uključivati prikladniju mjeru matematičkoga

postignuća. Iako je uzorak bio odgovarajuće strukture i veličine, a korišteni instrumenti pouzdani i valjani, zaključci o utvrđenoj uzročno-posljedičnoj vezi između matematičke anksioznosti, motivacije i postignuća ne mogu se potvrditi zbog korelacijske i transverzalne prirode studije. Realizacija longitudinalne studije, uključivanje preostalih značajnih varijabli (matematičko samopoimanje, matematička samoučinkovitost) u istraživanje, kao i promicanje međunarodnoga karaktera istraživanja, dodatno bi pridonijeli boljem razumijevanju teme. Za pouzdanije zaključke bilo bi dobro kontrolirati generaliziranu anksioznost u daljnjim studijama, ali i uzeti u obzir odnose između matematičke anksioznosti i motivacije prema stupnjevima matematičkih dostignuća. U ovome istraživanju to nije bilo izvedivo zbog malog broja učenika koji su imali loša matematička postignuća.

Kao opći zaključak istraživanja, može se navesti nalaz da su djevojke u srednjoj školi osjetljivije na manifestaciju anksioznosti od mladića, jer se ranjivost očituje i na kognitivnoj i na afektivnoj razini. S druge strane, detektirana je vrlo važna uloga motivacije. Poznavanje rodnih razlika u kontekstu promatranja određenih obrazovnih tema i područja vrlo je važna instanca za realizaciju programa prevencije i intervencija u školama s ciljem poboljšanja obrazovnih rezultata. S obzirom na razlike u matematičkoj anksioznosti u odnosu na dispozicijske čimbenike kao što je spol, prevencija i intervencijski programi prevladavanja matematičke anksioznosti trebaju biti osmišljeni uzimajući u obzir ove specifičnosti. S tim u vezi, programi koje bi provodio školski psiholog sa srednjoškolcima trebali bi sadržavati aktivnosti koje bi bile usmjerene na prevladavanje simptoma anksioznosti povećanom motivacijom za oba spola, ali i na intervencije koje bi se mogle usredotočiti posebno na smanjenje matematička anksioznost kod djevojaka.