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고등학생의 수학성취와 수학불안 간의 상관연구

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A study on the correlation between mathematics anxiety and mathematics achievement in high school students

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초록

본 연구는 고등학생의 수학불안과 수학적 성취가 성별과 학년별로 어떻게 다른지 분석하고 수학불안과 수학성취 요인 간의 상관 및 설명력을 알아보고자 실시되었다. 서울지역의 고등학생 459명을 대상으로 수학불안 검사와 수학성적을 조사하고 SPSS 24.0을 활용하여 T-test와 상관관계, 회귀 분석을 실행하였으며 분석결과 성별과 학년에 따라 수학점수 및 수학불안은 차이가 있는 것으로 나타났다. 남학생의 수학 점수는 흥미, 수학성취 요인 및 수학적 자신감 요인에 의해 의미 있게 설명되었으며 여학생의 경우 수학 성취와 흥미요인이 의미 있는 예측변인으로 나타났다. 다음으로, 수학적 불안과 수학성취는 1학년과 3학년에서 상관이 있었으며, 모든 학년에서 수학 점수를 유의하게 예측할 수 있는 변수는 수학에 대한 흥미요인이었다. 이상의 결과에 이해 교육현장에서의 시사점이 논의되었다.

Abstract

The purpose of this paper is to investigate the differences of the mathematics anxiety and mathematical achievement of high school students according to gender and grade, and to find out which mathematics anxiety causes have more influence on mathematical achievement and how much it is. The subjects of this study consist of 459 students selected for a class of unit, in high schools located in Seoul, Korea. Huh(1996)'s Mathematics Anxiety Scale was used. The collected data were analyzed by using the 24.0 SPSS program. The data were also tested by using the t-test, correlation and multiple regression. The major results of this study were as follows: Firstly, there was no difference in mathematics score according to gender, but mathematics anxiety was higher in girl students. Mathematics score and mathematics anxiety have significantly related each other. Boy students' mathematics scores were significantly explained by interest, Mathematical Achievement factor, and mathematical confidence factor. For girl students, mathematics achievement factor, interest were the significant predictors. Secondly, mathematical anxiety and mathematics scores were correlated in the first and third grades, and the variables that predict mathematics scores significantly in all grades were interest.

* 주요어 : 수학불안, 수학 성취도, 성별, 학년, 고등학생
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Ⅰ. Introduction

In Korea, mathematics score is considered to be very important for university entrance examination and it would be no exaggeration to say that many students nationwide are gripped by the fear towards mathematics learning. Currently, many students in Korea are studying mathematics mechanically in order to pass the university entrance examination without knowing why they learn the mathematics and where they can apply the knowledge. As a result, the mathematical achievement of Korean students is the highest in terms of the PISA results, but remains the lowest when the time and effort that they invest are compared with their achievement (Kwak, 2016). The new curriculum revised in 2015 emphasizes understanding the aesthetics, necessity and usefulness of mathematics, pleasure from learning the mathematics, and cultivation of interest and confidence in mathematics (Ministry of Education, 2015). However, students currently studying mathematics are compulsorily studying mathematics for the examination.

Generally, cognitive factors and affective factors need to work together in order to increase academic achievement. For students obsessed with test scores or outcomes without motivations such as affective factors, including pleasure and interest, will decrease which in return will lead the student to give upon mathematics. In addition to the perception that affective factors are as important as cognitive factors in mathematics learning, extensive research is needed to be carried out, investigating into how emotional factors would affect mathematics learning, particularly, among high school students slated to take university entrance examination.

Among the emotional factors, anxiety is a personality trait. According to Freud, anxiety is an emotion felt by humanity from birth in terms of human psychology and human beings grow feeling anxiety and continue to have anxiety related to death. Freud explains the anxiety based on inherent fear and fear.

Anxiety is one of the factors that hinder individuals from flexible and diverse thinking activities, and constraints on various thinking activities interfere with the process of extracting the appropriate clues for problem solving (Tobias & Weissbrod, 1998). As the theory that the emotion of anxiety is related to the learner's low academic achievement has been dominant, it has become the object of interest to educational psychologists(Baker & Siryk, 1984; Coleman & Webber, 2002) who want to help improve learners' achievement.

High school students in Korea are required to undergo multiple tests, and the results have a profound effect on transition to higher education and careers. Therefore, academic stress due to school classes, examination, and assignments, etc., is one of the biggest and most important stress factors. Particularly, the mathematics, perceived as a subject that has a great influence on current fierce competition and success or failure in entrance examination, gives rise to difficulties to students, such as pressure and psychological tension towards mathematics learning.

'Lazarus(1974)' found that stressful anxiety or emotion of fear was more likely to occur due to the psychological state of individual, viewpoint towards the event, and cognitive evaluation result, rather than the event itself. In the academic scene, stress is a psychological state felt by individuals such as pressure, tension, worry, fear, depression, and nervousness, etc., which are experienced for reasons of academic performance, class, examination, career paths and so forth.

Ⅱ. Theoretical background

According to a study by 'Zimmerman, Bandura & Martinez-Pons(1992)' on mathematics anxiety, students who felt less degree of mathematics anxiety used more effective learning strategy and expressed excellent

self-regulating ability. In addition, the anxiety perceived in mathematics learning may be associated with the anxiety towards examination or with students' negative self-evaluation of their behavior in group activities or presentation activities during the class.

The study by 'Goldin(2003)', 'Malmivuori(2004)', and 'Hannula(2006)' showed that the motivation factors for mathematics learning fell under the realm of affective domain of mathematics learning and that motivation was a variable correlated with mathematical achievement.

Huh(1996) and Kim(2012) defined the mathematics attitude, beliefs, and emotions, and shed light on the relationship among characteristics of affective factors in mathematics learning, emotions about mathematics, and academic achievement. Yoon and Jeon(2012) state that fear of mathematics developed into 'mathematics phobia', resulting in aversion or negative feelings toward mathematics and avoidance of learning. According to these assertions, Huh(1996) analyzed the factors of mathematics anxiety and presented 5 super-factors and 19 sub-factors. Among those factors, mathematics subject factors consisted of abstractness, teaching method, language and structure, prejudicial anxiety towards t mathematics, and lack of basic function. Mathematics achievement factors consisted of grades, self-concept, and examination. Mathematics cognitive factors were comprised of number anxiety, negative thinking, cognitive style, parental attitude, understanding, and prejudice in daily life. Mathematics attitude factors consisted of usefulness, male-dominant realm, mathematics learning motivation, while teacher factors consisted of teachers' authority and confidence.

In the preceding studies that investigated the differences in mathematics anxiety by gender and grade, Brush(1978) and Meece(1981) reported that mathematics anxiety tended to increase as grade increased in the same way as examination anxiety, and that particularly, the difference in mathematics anxiety was more significant in terms of grade than the difference in terms of gender.

Wigfield and Meece(1988) analyzed the changes in the extent of mathematics anxiety across students ranging from six graders of elementary schools to third graders of high schools. The results showed that there were significant difference in terms of school variables, and that mathematics anxiety was the highest among the third graders of middle schools and the lowest among the six graders of elementary schools.

The study by Kim & Kang(2006) and Lew(2017) on elementary school students showed that there was a difference in the extent of mathematics anxiety by grade and that there was no difference in the extent of mathematics anxiety by gender. The study by Hwang and Lew(2018) on middle school students showed that the extent of mathematics anxiety was significantly higher in the third graders of middle schools than the first graders of middle schools and that there was no difference in the extent of mathematics anxiety by gender. The study by Ko and Yi(2012) on middle and high school students showed that the extent of mathematics anxiety was higher in male students. However, the study by Oh and Lee(2000) showed that the extent of mathematics anxiety was higher in female students of elementary, middle and high schools. The study by Oh(2002) on middle school students showed that there was no difference in the extent of mathematics anxiety by gender. Therefore, the extent of mathematics anxiety by gender varied, depending on subjects. The studies that investigate the difference in the extent of mathematics anxiety by grade have been fewer than those investigating the difference by gender. In Korea, the extent of mathematics anxiety is likely to increase as the grade is higher, considering the educational phenomenon across the nation. However, there are few studies on high school students, and it is hard to find any detailed study by

gender or grade. The studies that investigated the mathematics anxiety in high school students by gender and grade would need to examine how the mathematics anxiety, a psychological factor, would affect academic performance of students.

As explained above, we set forth thee research questions as below to determine the difference in the extent of mathematics anxiety, a psychological factor, in high school students by gender and grade and to verify the extent by which the mathematics scores indicative of mathematics performance could be correlated with the extent of mathematics anxiety and to explain the mathematics performance.

Research Question 1. What is the difference and correlation between mathematical achievement(score) and mathematics anxiety by gender?

Research Question 2. What are the mathematics anxiety variables that best explain the mathematical achievement by gender?

Research Question 3. What is the difference and correlation between mathematical achievement and mathematics anxiety by grade?

Research Question 4. What are the mathematics anxiety variables that best explain the mathematical achievement by grade?

Ⅲ. Method

1. Subjects

The subjects of this study were selected from 4 high schools located in Seoul. A test-type survey that aimed to evaluate mathematics anxiety was conducted by homeroom teachers. The survey was conducted relatively freely without time constraint. Excluding those containing insincere answers or omissions, the questionnaires were collected from 459 students(male students: 124 persons, female students: 335 persons) comprised of first graders(236, 51.4%), second graders(120, 26.1%), and third graders(103, 22.4%).

2. Measurement tools

1) Mathematics anxiety test

The mathematics anxiety test tool of Huh[11] was used to measure the anxiety factors related to mathematics. The questionnaires for middle school students consisted of 65 items. The subfactors consisted of 6 factors, such as mathematics subject factor(15), mathematical achievement factor(mathematical achievement)(12), mathematics cognitive factor(mathematical confidence)(14), mathematics attitude factor(attitudes toward mathematics)(8), teacher factor(teachers)(6), and interest/attention factor(interest in mathematics)(10). The scale type was based on 5 scores ranging from 1(Not at all) to 5(Very much so). Total scores were calculated for each subfactor. The questionnaire item related to interest/attention were scored in reverse, indicating that higher score meant the higher anxiety. Reliability ranged from .94 to .95.

2) Mathematical achievement

For the mathematical achievement of students, the scores on scholastic ability test which occurred most recently in schools were recorded. Different scores were standardized using the Z score, the standardized score, for subsequent comparison.

3. Data analysis

The statistical program used for data analysis was SPSS 24.0. Technical statistics were estimated to examine the tendency of mathematics anxiety and related variables, and then t-test was performed to determine difference by gender. Analysis of variance(ANOVA) was performed to look into the differences by grade. Pearson correlation analysis and multiple stepwise regression were carried out to examine correlation and explain ability.

Ⅳ. Results and discussion

1. Mathematical achievement and mathematics anxiety by gender

1) Difference in mathematical achievement and mathematics anxiety by gender

The results of the t-test are presented in Table 1, which were performed to determine the difference in mathematics scores and mathematics anxiety factor by gender in high school students. The mathematics anxiety was significantly higher in female students than it was in male students(t=3.40, p>.01). By subfactors, a difference was found in terms of mathematical achievement factor, mathematics cognitive factor, mathematics attitude factor, and teacher factor. However, no statistically significant difference was observed in mathematics scores by gender.

2) Correlation between mathematical achievement and mathematics anxiety

We examined the correlation between mathematics anxiety and mathematics scores, and the results showed that the mathematics scores were negatively correlated with mathematics anxiety in both male and female students. Male students were found to earn lower mathematics scores when they had higher anxiety for mathematics subject factor and mathematical achievement factor and when their Interest/attention was lower. In female students, the mathematics scores were correlated with mathematical achievement factor(r=-.306, p<.001), mathematics cognitive factor(r=-.249, p<.001), interest/attention(r=-.246, p<.001), mathematics subject factor(r=-.224, p<.001), mathematics attitude factor(r=-.199, p<.001), and furthermore, higher anxiety led to lower mathematics scores.

[Table 1] Difference of variables between two gender groups

		M	SD	t
Mathematics Score	Male(124) Female(335)	.07 .11	.92 .87	.46
Mathematics subject factor	Male Female	2.37 2.52	.77 .73	1.95
Mathematics achievement factor	Male Female	2.54 3.20	.83 .83	7.60***
Mathematics cognitive factor	Male Female	2.43 2.69	.70 .70	3.51***
Mathematics attitude factor	Male Female	2.52 2.39	.56 .53	2.37*
Teacher factor	Male Female	2.34 2.56	.71 .74	2.86**
Interest/attention	Male Female	3.00 3.07	.89 .83	.80
mathematics anxiety total	Male Female	2.53 2.74	.57 .58	3.40**

*p<.05 **p<.01 ***p<.001

[Table 2] Correlation between mathematics scores and mathematics anxiety

	Gender	Mathematics subject factor	Mathematics achievement factor	Mathematics cognitive factor	Mathematics attitude factor	Teacher factor	Interest/ Attention	total
Mathematics Scores	Male	-.200*	-.186*	-.146	.021	-.091	-.484***	-.262**
	Female	-.224***	-.306***	-.249***	-.199***	-.042	-.246***	-.269***

*p<.05 **p<.01 ***p<.001

3) Regression of mathematics anxiety factors for mathematical achievement

The results of the regression analysis for the mathematics anxiety factors explaining the Mathematics score were like this: In male students, the mathematics anxiety subfactors explaining the mathematics scores were interest/attention factor accounting for 23.5%, mathematical achievement factor accounting for 2.5%, and mathematics cognitive factor accounting for 2.8%. We performed the regression analysis to determine the extent of effect that the mathematics anxiety subfactors would have on mathematics scores in female students. The results showed that the factors explaining the mathematics scores were mathematical achievement factor accounting for 9.4%, interest/attention factor accounting for 2.5%, and teacher factor accounting for 3.5%.

2. Mathematical achievement and mathematics anxiety by grade

1) Difference in Mathematical Achievement and Mathematics Anxiety by Grade

The results of ANOVA are presented in [Table 4], which was performed to examine the difference in mathematical achievement and mathematics anxiety of high school students by grade. The mathematics scores standardized by grade were -.06 in first graders, .45 in second graders, and .07 in third graders, which suggests that there was a significant difference(F=13.743, p<.01).

The mathematics anxiety was 2.74 in first graders, 2.69 in second graders, and 2.55 in third graders, and the results of post-test showed that the mathematics anxiety was significantly higher in the first and second graders.

Mathematics achievement factor was 3.25 in first graders, 3.02 in second graders, and 2.52 in third graders, which suggested that the first graders and second graders had significantly higher anxiety for mathematical achievement than the third graders(F=327.721, p<.05). In addition, the mathematics cognitive factor was found to be 2.72 in first graders, 2.57 in second graders, and 2.44 in third graders, suggesting that the anxiety was higher for mathematics cognitive factor as the grade was lower(F=6,278 p<.05). The results of post-test showed that the first graders and second graders had significantly higher anxiety for mathematics cognitive factor than third graders. Meanwhile, the teacher factor was 2.49 in first graders, 2.67 in second graders, and 2.35 in third graders, suggesting that the first graders and second graders had higher anxiety for teachers than third graders(F=5.189, p<.05).

2) Correlation between mathematical achievement and mathematics anxiety

We examined the correlation between mathematics anxiety and mathematics scores in high school students by grade. The results showed that both were negatively correlated in the first graders and third

[Table 3] Regression of mathematics anxiety factors for mathematics scores

Dependent Variables	Type	Phase	Independent Variables	β	R^2	Revised R^2	F
Mathematics Score	Male	1	Interest/attention	-.484	.235	.228	37.384***
		2	Mathematics achievement factor	-.161	.260	.248	21.294***
		3	Mathematics cognitive factor	.406	.288	.270	16.187***
	Female	1	Mathematics achievement factor	-.306	.094	.091	34.357***
		2	Interest/attention	-.167	.119	.113	22.324***
		3	Teacher factor	.230	.154	.146	20.013***

***p<.001

[Table 4] Difference in mathematics score and mathematics anxiety by grade

	Grade	M(SD)		Sum of squares	df	Mean squares	F	사후검증
Standardized score (Mathematics score)	1(236) 2(120) 3(103) total(459)	-.06(.86) .45(.80) .07(.93) .10(.89)	Intergroups	20.477	2	10.238	13.743***	2>3>1
			Within groups	339.725	456	0.745		
			Whole	360.202	458			
Mathematics Subject factor	1 2 3 total	2.55(.73) 2.41(.73) 2.38(.78) 2.48(.74)	Intergroups	2.778	2	1.389	2.528	
			Within groups	250.544	456	0.549		
			Whole	253.322	458			
Mathematics Achievement factor	1 2 3 total	3.25(.87) 3.02(.80) 2.52(.79) 3.02(.88)	Intergroups	38.482	2	19.241	27.721***	1>2>3
			Within groups	316.503	456	0.694		
			Whole	354.985	458			
Mathematics cognitive factor	1 2 3 total	2.72(.71) 2.57(.70) 2.44(.70) 2.62(.71)	Intergroups	6.220	2	3.110	6.278**	1>2>3
			Within groups	225.881	456	0.495		
			Whole	232.101	458			
Mathematics attitude factor	1 2 3 total	2.44(.50) 2.29(.57) 2.55(.55) 2.42(.54)	Intergroups	3.886	2	1.943	6.904**	
			Within groups	128.320	456	0.281		
			Whole	132.205	458			
Teacher factor	1 2 3 total	2.49(.71) 2.67(.77) 2.35(.74) 2.50(.74)	Intergroups	5.599	2	2.800	5.189**	1,2>3
			Within groups	246.050	456	0.540		
			Whole	251.649	458			
Interest/attention	1 2 3 total	2.97(.83) 3.19(.86) 3.09(.84) 3.05(.84)	Intergroups	3.854	2	1.927	2.728	
			Within groups	322.115	456	0.706		
			Whole	325.969	458			
total	1 2 3 total	2.74(.59) 2.69(.58) 2.55(.55) 2.68(.58)	Intergroups	2.443	2	1.221	3.657*	1,2>3
			Within groups	152.295	456	0.334		
			Whole	154.737	458			

*p<.05 **p<.01 ***p<.001

graders(r=-.321, p<.001/ r=-.235, p<.001). By subfactors of mathematics anxiety, it was found that interest/attention(r=-.383, p<.001), mathematics achievement factor(r=-.318, p<.001), mathematics cognitive factor(r=-.261, p<.001), mathematics subject factor(r=-.257, p<.001), attitude factor(r=-.164, p<.05), were correlated in the first graders. Meanwhile, interest/attention(r=-.449, p<.001) were correlated in the third graders. In second graders, the whole factors did not have any correlation(r=-.173, p>.05) while the interest/attention factor(r=-.200, p<.05) and mathematics achievement factor(r=-.190, p<.05) were correlated.

[Table 5] Correlation between mathematics score and mathematics anxiety

	grade	Mathematics subject factor	Mathematics achievement factor	Mathematics cognitive factor	Mathematics attitude factor	Teacher factor	Interest/ attention	total
Mathematics score	1	-.257***	-.318***	-.261***	-.164*	-0.121	-.383***	-.321***
	2	-.121	-.190*	-.153	-.111	-.022	-.200*	-.173
	3	-.178	-.154	-.136	-.005	-.061	-.449***	-.235*

*p<.05 ***p<.001

3) Regression of mathematics anxiety factor for mathematics score

We conducted a multiple regression analysis of the mathematics anxiety factors explaining the mathematics scores. The factors that explained the mathematics score of first graders were interest/attention factor accounting for 14.6% and mathematical achievement factor accounting for 3.0%. The factors that explained the mathematics score of second graders were interest/attention factor accounting for 4.0%. The factors that explained the mathematics score of third graders were interest/attention factor accounting for 20.1% and mathematics subject factor accounting for 3.5%.

[Table 6] Regression of mathematics anxiety factorsr for mathematics score

Dependent Variables	Type	Phase	Independent Variables	β	R2	Revised R2	F
Mathematics score	First grader	1 2	Interest/attention Mathematics achievement factor	-.383 -.190	.146 .176	.143 .169	40.135*** 24.925***
	Second grader	1	Interest/attention	-.200	.040	.032	4.892*
	Third grader	1 2	Interest/attention Mathematics subject factor	-.449 -.187	.201 .236	.193 .221	25.440*** 15.461***

*p<.05 ***p<.001

Ⅳ. Conclusion and Implication

The purpose of this study was to investigate the correlation and its explainability between mathematics anxiety and mathematics score by gender and grade of high school students. In this study, we tested the mathematics anxiety of 459 high school students residing in Seoul and drew the following conclusion based on the comparative analyses of mean scores and regression analyses. The mathematics score did not exhibit different by gender while mathematics anxiety was higher in female students. The results of correlation analysis suggested that female students with lower grades felt more mathematics anxiety and that lower mathematics anxiety led to higher mathematical achievement. Higher mathematics anxiety reduces the effort to achieve and decreases the understanding, and therefore has a negative impact on mathematics score.

The mathematics score of female students was correlated with mathematical achievement factor, mathematics cognitive factor, interest/attention, mathematics subject factor, mathematics attitude factor. The mathematics score of male students was correlated with interest/attention, mathematical achievement factor, and mathematics subject factor.

Regarding the factor that explained the mathematics score, female students′ mathematics score was found to be affected by the negative perception, depending on

the influence of teachers who considered the mathematics as boring and meaningless subject, while the intellectual curiosity of teacher was also transferred to students according to the attitude and feeling of teachers. It could be explained by their tendency to feel pleasure while they were involved in numerical games or handling the numbers with interest or attention towards mathematics or their tendency to plan pleasantly with their fiends good at mathematics.

Meanwhile, male students were found to be influenced by anxiety towards numbers, negative ideas towards mathematics, parental attitude, comprehension, and prejudice about mathematics in their daily lives. I was interested in or interested in mathematics and had a pleasure in dealing with numerical play or numbers. Also, it could be explained by their tendency to feel pleasure while they were involved in numerical games or handling the numbers with interest or attention towards mathematics or their tendency to plan pleasantly with their fiends good at mathematics.

By grade, he mathematics score was the highest in second graders while mathematics anxiety was higher in the first and second graders than third graders. Such results were in contrast to the results of the studies on middle school students which showed that the anxiety was higher in third graders than first and second graders among middle school students. In addition, anxiety increased in the third-grade years of middle school may be likely to continue into the first and second-grade years of high school. In particular, the high 'teacher factor anxiety' in first and second graders may be closely correlated with the attitude of teachers who converse anytime with teachers about mathematics and help students approach unknown problems easily, thus inducing the mathematical achievement. In the factor analysis of factors leading to higher mathematical achievement, it was found that the mathematics score of first graders was correlated with mathematical achievement factor, mathematics cognitive factor, interest/attention, mathematics attitude factor, and mathematics subject factor, but was not affected by teachers. The mathematics score of second graders was correlated with interest/attention and mathematical achievement factor, while the mathematics score of third graders was correlated with interest/attention in mathematics. The mathematics score of first graders was found to be affected positively by the tendency to feel pleasure while they were handling the numbers through, for example, numerical games related to mathematics with interest or attention towards mathematics. Moreover, the encouragement and support of parents and teachers, etc., may play an important role in promoting mathematical achievement, so that students with greater willingness to learn can be more motivated and continue to focus on learning for longer time in the face of difficult problems. Mathematics score of second graders was found to be affected negatively by the lack of interest or attention towards mathematics, difficulty with numerical games or numbers or their perception that they are not good at mathematics. The mathematics score of third graders was found to be best explained by the lower factor of interest/attention towards mathematics, which suggests that the interesting approach to mathematics would need to be researched.

If the emotions, such as mathematics anxiety, are left alone, it may act as a factor disrupting the mathematics learning. Therefore, it is important to identify the mathematics anxiety factor and to find suitable measures that can resolve such mathematics anxiety. Particularly, first graders of high school would need to be guided in such a way that they can be relieved of pressure related to admission to higher schools and preparation for university examination, adapt themselves well to the changed education environment, learn mathematics in a comfortable atmosphere, and maintain their interest in mathematics. To lower the anxiety factors analyzed in this study,

teachers and parents would need to discuss on measures that can promote proper learning attitude and teaching guidance at home or at class.

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