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# Effect of teaching on reducing mathematics anxiety in university statistics class

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# 대학 통계 수업에서 가르치기가 수학 불안 감소에 미치는 영향

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**Abstract** The benefits of teaching learning materials to others have been shown on learning achievement. Anxiety is one of the obstacles in learning and it has been shown that math anxiety is strongly associated with math achievement. Thus, the aim of this study was to investigate whether teaching others benefits math anxiety when university students learn statistics. 59 students who enrolled in statistics class participated and 30 students performed group assignment of teaching peer in a group and 29 students did not. Other than group assignments, the instructor, lectures, assignment of solving the problems, and exams were all the same. The results showed that the math anxiety of students who did group assignments of teaching was decreased at the end the semester. Increased math anxiety yielded negative attitudes toward learning statistics, resulting in poor learning performance. Furthermore, the relationship between math anxiety and the attitudes toward leaning statistics was moderated by teaching others. The results suggest that teaching others has an effect on reducing math anxiety and thus, possibly yield persistent learning gains.

**Key Words :** Teaching effect, Math anxiety, Statistics, Learning achievement, Learning method, Convergence

**요 약** 다른 사람에게 학습 자료를 가르치는 것의 이점은 학업 성취도에서 나타났다. 불안은 학습을 방해하는 요인 중 하나이고 수학 불안은 수학 성취도와 밀접한 관련이 있음이 밝혀졌다. 따라서 본 연구의 목적은 대학생들이 통계를 학습할 때 다른 사람을 가르치는 것이 수학 불안에 도움을 주는지 알아보는 것이다. 통계수업에 등록한 학생들 59명이 참여했고 30명의 학생은 그룹 안에서 다른 학생을 가르치는 그룹 과제를 수행했고, 29명의 학생은 수행하지 않았다. 그룹 과제를 제외하고 강사, 강의, 문제 풀이 과제와 시험은 모두 동일했다. 그 결과, 가르치는 그룹 과제를 수행한 학생들의 수학 불안은 학기 말에 감소하였다. 수학 불안이 증가하면 통계 학습에 대한 태도가 부정적으로 나타나고 그 결과 학습 성취도가 저하되었다. 또한, 수학 불안과 통계 학습에 대한 태도의 관계는 다른 사람을 가르치는 것으로 조절되었다. 이러한 결과는 가르치기는 수학 불안을 감소시키는 데 영향을 미쳐 지속적인 학습 이득을 얻을 수 있음을 시사한다.

**주제어 :** 가르치기 효과, 수학 불안, 통계, 학업 성취도, 학습법, 융복합

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## 1. Introduction

It has been shown that explaining experiences enhance learning[1-4] and this is known as teaching effect or learning by teaching. It is powerful learning strategy to explain learned materials to others[1,4] or to oneself[3] and teaching even fictitious others(i.e., those not present without interaction) was more effective than repetition of study[2]. Cohen, Kulik, and Kulik performed a meta-analysis from evaluations of school tutoring programs and found that peer tutoring yielded better understanding of the subjects they taught[5].

How can we explain the benefits of this teaching effect? Roscoe and Chi suggested that teaching others is an interactive process to construct knowledge, in which a result of knowledge building derived positive learning benefits[4]. Furthermore, it has been shown that the act of teaching itself has benefits on learning other than preparing to teach[6]. In the second experiment of Hoogerheide et al., for instance, participants were asked to study a material of syllogistic reasoning problems and were then randomly assigned to three groups. Participants in the control group had to restudy the learning materials. Others had to either explain the material in writing or record explanations on a videotape. As a result, participants who explained learning materials via a video learned better than did those who explained in writing or simply repeated studying materials[2].

On the contrary to the finding that the act of teaching itself is important to earn benefits of teaching effect, it has shown that benefits of the teaching effect possibly engage in retrieving rather than the act of teaching itself. It is required to retrieve learning materials with a considerable amount of time and effort when preparing teaching. To investigate this possibility, Koh, Lee, and Lim had participants study learning material first and randomly be assigned to one of four conditions. Participants in the first condition as a control group solved arithmetic problems and those in the second condition taught learning material without aids from teaching notes. Participants in the third condition taught learning material using teaching notes and those in the fourth condition retrieved the material without teaching. The second condition was different from the third condition in that teaching included active retrieval of learning material. One week later, participants performed a comprehension test explaining main concepts of the material they learned. It was shown that participants who taught the material without using teaching notes as well as those who retrieved the material performed better than those taught with teaching notes and those in the control group. The results indicated that benefits of teaching others might be due to retrieval practice[7].

In fact, recent studies argued that the learning pyramid in which retention of learning is varied by different learning strategies and teaching others has the highest retention of learning does not exist[8-10]. Baer found that lectures were underrated in the learning pyramid and there was no difference between lectures and peer teaching in retention of learning[8]. Although it has been argued that learning by teaching is actually better than other learning strategies as it is claimed in the learning pyramid theory, teaching others possibly helps learning somehow.

It has been known that anxiety is one of the obstacles in learning. Anxiety is a process involving a series of cognitive, emotional, and behavioral responses that occur in response to some form of tension[11]. Richardson and Suinn defined mathematics(math) anxiety as “feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations(p. 551)”[12]. Kim and Heo classified the factors of math

anxiety into math subject factor(e.g., prejudicial anxiety about math, abstraction, lack of basic functions, language and structure), math achievement factor(e.g., tests, grades, self-concept), cognitive factors/negative thoughts(e.g., anxiety about numbers in daily life, cognitive styles, parental attitude), attitudes toward math(e.g., math learning motivation, practicality), and teacher factor(e.g., authority, teacher)[13]. It has been found that even university students taking math classes have high math anxiety in general[14]. It is also suggested that students with math anxiety have shown a tendency for negative attitudes towards math and avoiding the math subject resulting in poor math achievement[15]. It is, thus, important to note that math anxiety is negatively related to math achievement in learning process. Meta analysis of 26 research showed that math anxiety was negatively correlated with academic achievement[16] and university students also showed a negative relationship between math anxiety and math achievement[17,18]. In particular, math achievement was more related to the score of math anxiety conducted at the end of the semester than that conducted at the beginning of the semester[17].

It has been shown that teaching others is an effective strategy of learning and the learning benefits of teaching can be explained by the result of knowledge building, the act of teaching interactively, retrieval practice and so on but it is needed to be further investigated from various perspectives. Since math anxiety is strongly associated with math achievement, it is possible that reduction of math anxiety results in better math achievement. Hence, the question of whether teaching strategy can also be effective in learning math and actually reduce math anxiety was investigated.

### 1.1 The present study

Although it is important to learn statistics in social sciences, many students have shown anxiety about learning statistics, resulting in poor learning achievement. Since it has been found that teaching others is effective strategy of learning achievement, the purpose of this study was to investigate whether teaching has benefits on learning achievement by reducing math anxiety in statistics class.

## 2. Methods

### 2.1 Participants

Participants were 59 university students enrolled in the statistics course of psychology department of university located in Cheonan. Due to the purpose of this study, students who did surveys prior to and following the semester only were selected and students who enrolled in the same class twice were excluded. There were two classes for this course but the instructor, curriculum of the class and tests were the same. 30 students (9 males and 21 females) were in the class 1 and 29 students (8 males and 21 females) were in the class 2. Since this class was for the freshmen, the majority of participants were freshmen. There were 20(66.7%) first-year students, 3(10%) second-year students, 5(16.7%) third-year students, and 2(6.7%) fourth-year students in the class 1. There were 17(58.6%) first-year students, 5(17.2%) second-year students, 5(17.2%) third-year students, and 2(6.9%) fourth-year students in the class 2.

### 2.2 Measurements

#### 2.2.1 Korean mathematics anxiety scale(KMAS)

To measure mathematics anxiety level of university students, we used Korean mathematics anxiety scale(KMAS) which Chang and Cho[19] developed. For the development of KMAS, the reliability and validity of the scale were verified by performing basic item analysis, exploratory

factor analysis, reliability analysis, and confirmatory factor analysis. As a result, a total of 20 items consisted of four factors; 6 items of lack of confidence in math("I easily lose confidence in math when encountered with something that seems even just a little bit difficult"), 5 items of math test anxiety("I was nervous and anxious during math exams"), 5 items of abstraction and language("Math makes me nervous because its terminology is more abstract"), and 4 items of math learning anxiety("When I was studying math, I was worried about my competence"). Participants had to respond to each item from 1(strongly disagree) to 7(strongly agree). Since the purpose of the study was to investigate whether math anxiety would reduce by teaching materials, overall math anxiety score was used rather than separating four factors of anxiety.

Participants responded to this scale at the beginning and the end of the semester. Overall reliability of the scale was Cronbach's $\alpha$ coefficient of 0.95 when surveyed at the beginning of class and 0.96 when surveyed at the end of class, respectively.

#### 2.2.2 Questionnaire about statistics

For the second survey performed at the end of the semester, self-reported questions regarding opinions of statistics learning were asked. Some of the questions were adopted from the survey of Moon[20]. A total of 14 items questionnaire consisted of three parts: (1) 9 items of attitudes in learning statistics("The contents of statistics were difficult in general"), (2) 3 items of general opinion of statistics("Statistics is thought to a unit that focuses on formulas and calculations"), (3) 2 items of thought of assignments("Assignments were helpful to learn statistics"). Since students in class 1 had group assignments, two more questions about group assignments were added("Group assignments were helpful to learn statistics"). All students in both classes had to respond to each item ranging from 1(strongly disagree) to 5(strongly agree). Overall reliability of the nine items of how s/he felt while studying statistics was Cronbach's $\alpha$ coefficient of 0.89.

#### 2.2.3 Demographic Information

The questionnaire included questions regarding gender, age, school year, and major. Moreover, some questions regarding statistics and mathematics were included as follows: whether any statistics class was taken before, whether s/he majored science at the high school, how much s/he thinks competence of mathematics is from 1(very low) to 7(very high), and how important s/he thinks to learn statistics from 1(strongly disagree) to 7(strongly agree). For the second survey performed at the end of the semester, the question of how much s/he thinks competence of mathematics is was only included. Lastly, final two digits of student identification number were collected both at the beginning and the end of the semester for pre-post analysis.

### 2.3 Procedures

Students who took statistics class were taught 11 chapters of statistics for the behavioral and social sciences in 15 weeks. In both classes, assignments of solving problems were given at the end of each chapter (except a week before mid-term and final exam). Since the instructor was the same, the lectures, teaching materials, assignments, and exams were all same. One exception was that students in the class 1 had to do further assignments grouped with three students for chapter 2, 3, 4, 5, 7, 8, and 9. In the group assignment, students had to record teaching others with given problems (each student taught one question for each chapter) and present the video file. In contrast to individual assignment focusing on calculating math problems, group assignment focused on interpreting results and explaining the problem like teaching people who do not know about

statistics. Although group assignments were given only in the class 1, the instructor told students in the class 2 that teaching others is a very effective learning method and encouraged them to teach others or his/herself during the semester. Two surveys were conducted in the first week of the semester and before the final exam.

### 2.4 Statistical analysis

Jamovi 1.2.27 was used for the statistical analysis in this study. We performed descriptive analysis and Pearson's correlation analyses on research variables. To compare the reduction of math anxiety between the two classes, we performed repeated measures ANOVA. Furthermore, we performed hierarchical multiple regressions to test a mediation effect and a moderation effect.

## 3. Results

### 3.1 Descriptive Analysis

Descriptive analysis on the research variables are presented in Table 1. Due to the characteristics of the statistics course required for students majoring in Psychology, there were more female students than male students in both classes. Likewise, freshmen and students majoring in social sciences were the majority in both classes. Participants who had experiences of taking statistics class or studying statistics before were 12(40%) in the class 1 and 18(62.1%) in the class 2. Three students(10%) in the class 1 and seven students(24.1%) in the class 2 took the sciences course when attending high school. There was a tendency that both the sum of math anxiety(total of 140) and the score of math competence (from 1 to 7) were decreased in the class 1, whereas increased in the class 2 at the end of the semester compared to those at the beginning of the semester. The attitude toward learning statistics was similar in both classes and students thought difficulty or interests of studying statistics was neutral($M_{class1}$=3.03, $M_{class2}$=3.04 between 1 to 5). Students in both classes highly agreed that doing assignments was helpful studying statistics($M_{class1}$=4.33, $M_{class2}$=4.21 between 1 to 5). Students in the class 1 who performed group assignments reported that group assignments of teaching others helped studying statistics(M=3.6 between 1 to 5). Moreover, students in the class 1 reported that they also tried to teach others or themselves when studying statistics(M=3.37) compared to students in the class 2(M=3.07 between 1 to 5). The degree of increase in exam scores was greater in the class 1 than in the class 2.

**Table 1. Descriptive findings of variables**

| Variables | Sub scales | Class | |
|---|---|---|---|
| | | 1 | 2 |
| Gender | Male | 9(30%) | 8(27.6%) |
| | Female | 21(70%) | 21(72.4%) |
| School year | 1 | 20(60.7%) | 17(58.6%) |
| | 2 | 3(10%) | 5(17.2%) |
| | 3 | 5(16.7%) | 5(17.2%) |
| | 4 | 2(6.7%) | 2(6.9%) |
| Major | Foreign languages | 5(16.7%) | 4(13.8%) |
| | Social sciences | 24(80%) | 22(75.9%) |
| | Engineering | 1(3.3%) | 2(6.9%) |
| | Arts/Sports | 0 | 1(3.4%) |
| Experiences of studying statistics | yes | 12(40%) | 18(62.1%) |
| | no | 18(60%) | 11(37.9%) |
| High school sciences course | yes | 3(10%) | 7(24.1%) |
| | no | 27(90%) | 22(75.9%) |
| Math anxiety | pre | 82.4(20.7) | 75.4(27.0) |
| | post | 76.7(23.9) | 86.2(26.8) |
| Math competence | pre | 3.97(1.22) | 3.83(1.2) |
| | post | 4.17(1.09) | 3.66(1.14) |
| Attitude toward learning stats | | 3.03(.63) | 3.04(.8) |
| Attitude toward assignment | | 4.33(.8) | 4.21(.86) |
| Efforts of teaching | group assignment | 3.6(1.07) | |
| | teaching voluntarily | 3.37(1.0) | 3.07(1.16) |
| Exams | mid-term | 57.3(17.3) | 57.8(16.9) |
| | final | 67.2(16.3) | 60.5(23.0) |

### 3.2 Repeated measures ANOVA

To investigate whether teaching others had a benefit on math anxiety, repeated measures ANOVA was performed with math anxiety as a within subject factor and class as a between subject factor. Since previous knowledge of statistics or math might affect on math anxiety or learning achievement, two variables (whether having previous experience of studying statistics and whether majoring in sciences in high school) were controlled for every analysis. The results of repeated measures ANOVA showed that main effect of math anxiety was not significant ($F(1,55)=.15$, $p=.7$) and main effect of class was also not significant ($F(1,55)=.58$, $p=.45$). The interaction between math anxiety and class, however, was significant ($F(1,55)=12.64$, $p<.001$). As shown in Fig. 1, math anxiety of students in the class 1 was decreased, while that of students in the class 2 was increased. Thus, the results suggest that teaching others had a benefit on math anxiety.

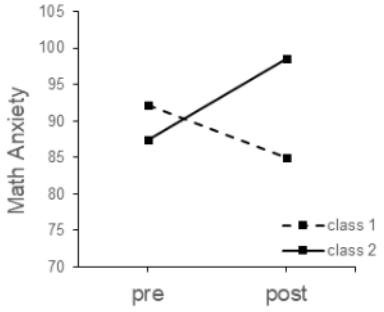


**Fig. 1. Results of a repeated ANOVA**

### 3.3 Bivariate analyses

As shown in Table 2, correlation analyses were performed for research variables combining two classes. Pre-math anxiety was positively correlated with post-math anxiety($r=.66$, $p<.001$) and pre-math competence was also positively correlated with post-math competence($r=.46$, $p<.01$). There was significantly negative correlation between post-math anxiety and post-math competence($r=-.63$, $p<.001$). As attitude toward learning statistics was negative, post-math anxiety was higher ($r=.71$, $p<.001$) and post-math competence was lower($r=-.49$, $p<.001$). Students who thought assignment of solving problems was helpful showed more positive attitude toward learning statistics($r=-.34$, $p<.01$). Also students who thought group assignment was helpful or taught others or themselves more as a tool of studying statistics showed higher post-math competence($r=.32$, $p<.05$). The score of mid-term exam was positively correlated with the score of final exam($r=.55$, $p<.01$). The relationship between mid-term exam and other variables was similar the relationship between final exam and other variables. That is, the score of exam was negatively correlated with math anxiety and attitude toward learning statistics, whereas positively correlated with math competence.

**Table 2. Pearson's correlation coefficient on research variables**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | | | | | | | |
| 2 | .66*** | 1 | | | | | | | |
| 3 | -.57*** | -.35** | 1 | | | | | | |
| 4 | -.49*** | -.63*** | .46** | 1 | | | | | |
| 5 | .49** | .71*** | -.22 | -.49*** | 1 | | | | |
| 6 | -.08 | -.15 | .12 | .21 | -.34** | 1 | | | |
| 7 | .02 | -.12 | .17 | .32* | -.12 | .21 | 1 | | |
| 8 | -.3* | -.39** | .32* | .47*** | -.36** | .19 | .15 | 1 | |
| 9 | -.22 | -.35** | .14 | .5*** | -.43*** | .3* | .12 | .55** | 1 |

*p<.05, **p<.01, ***p<.001
1: Pre-math anxiety, 2: Post-math anxiety, 3: Pre-math competence, 4: Post-math competence, 5: Attitude toward learning statistics, 6: Attitude toward assignment, 7: Efforts of teaching, 8: Mid-term exam, 9: Final exam

### 3.4 Testing relationship of math anxiety, attitude toward learning statistics, and learning achievement

To investigate whether math anxiety and attitude toward learning statistics had an effect on learning achievement, mediation effect was

performed. Since attitudes toward learning statistics were surveyed at the end of the semester, math anxiety surveyed at the end of the semester (post-math anxiety) was used to assess math anxiety and the final exam was used to assess learning achievement to assess the relationship of variables. That is, Baron & Kenny's three step analyses were performed to test whether attitude toward learning statistics mediated the relationship between post-math anxiety and the score of final exam. As shown in Table 3, post-math anxiety significantly predicted attitude toward learning statistics($\beta$ =.75, $p$<.001) after controlling previous experiences of studying statistics and whether majoring in sciences in high school. Second, post-math anxiety was shown a negative association with the score of final exam($\beta$=-.37, $p$<.01). Third, attitude toward learning statistics was also shown a negative association with the score of final exam($\beta$=-.36, $p$<.05) and post-math anxiety was not shown a predictor of the score of final exam($\beta$=-.09, $p$>.05). Thus, the results showed a complete mediation.

**Table 3. Analyzing a mediating effect**

| Steps | IVs | DVs | *B* | *β* | *F* |
|---|---|---|---|---|---|
| 1 | Post M_A | A_stats | .02 | .75*** | 20.62* |
| 2 | Post M_A | Final exam | -.29 | -.37** | 2.89* |
| 3 | Post M_A | Final exam | -.07 | -.09 | 3.35* |
| | A_stats | | -10.2 | -.36* | |

*p<.05, **p<.01, ***p<.001
Post M_A= post-math anxiety, A_stats= attitude toward learning statistics

In addition, Sobel test was performed to assess if a mediation effect is significant. As a result, a mediating effect of attitude toward learning statistics was statistically significant (Z=-1.98, $p$=.047). Thus, as math anxiety increased, attitudes toward learning statistics increased, resulting in lower learning achievement.

### 3.5 Testing a moderation effect of group assignment

To assess how teaching others had benefits on learning statistics, data of participants in class 1 were analyzed separately. Although the average score of the final exam was higher in the class 1 than that in the class 2, statistical difference between classes was not shown. Since it was shown, however, math anxiety negatively affected final achievement by mediation of attitude toward learning statistics, it was investigated whether attitude toward group assignment moderated the relationship between math anxiety and final exam score. As shown in Table 4, the interaction of post-math anxiety and attitude toward group assignment on attitude toward learning statistics was significant(t=-2.28, $p$=.03). Thus, students with higher math anxiety had a more negative attitude toward learning statistics when having a thought that group assignment of teaching others was not helpful compared to those having a thought that group assignment of teaching others was very helpful(see Fig. 2).

**Table 4. Analyzing a moderation effect**

| Step | IV | DV: Attitude toward learning statistics | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | B | SE | *β* | t | $R^2$ | $\triangle R^2$ | $\triangle F$ |
| 1 | A | .02 | .003 | .75 | 5.8*** | .82 | .62*** | 23.7 |
| | B | .11 | .14 | .08 | .84 | | | |
| 2 | A | .05 | .01 | .77 | 3.87*** | .86 | .06* | 5.2 |
| | B | .44 | .24 | -.16 | 1.81 | | | |
| | AxB | -.01 | .003 | -.28 | -2.28* | | | |

*p<.05, **p<.01, ***p<.001
A: post-math anxiety, B: attitude toward group assignment

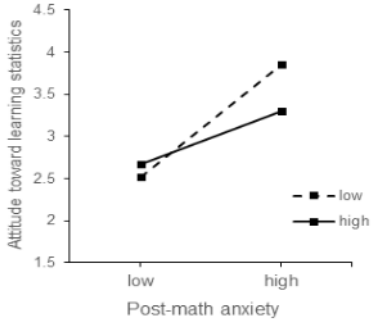


**Fig. 2. Results of a moderation effect analysis**

## 4. Discussion and Conclusion

The purpose of the study was to investigate whether teaching others has a benefit on the relationship between math anxiety and learning achievement in the statistics class of university. To test the benefits of teaching on math anxiety, students did group assignments of teaching others in one class whereas those did not in another class. The results showed that math anxiety was decreased at the end of the semester in the class with teaching, while math anxiety was increased in the class without teaching others. Thus, teaching others, in fact, is effective strategy reducing math anxiety.

In consistent with the results of Kim[17], math anxiety was negatively associated with the score of exam in statistics class and math anxiety conducted at the end of the semester was especially more related to the learning achievement. Since Núñez-Peña et al. found that while math anxiety was more stronger factor in explaining low math learning achievement, negative attitudes toward math also influenced math learning achievement[18], these two variables affected on learning achievement were analyzed in this study. The results showed attitudes toward learning statistics was completely mediated the relationship between math anxiety and math learning achievement. That is, increased math anxiety yielded negative attitudes toward learning statistics resulting of poor learning achievement. This suggests that affective factors have a negative impact on learning processes in statistics.

Then, what is the role of teaching in learning statistics? The moderation effect of attitudes toward teaching others in the relationship between math anxiety and attitude toward learning statistics showed that positive attitudes toward teaching reduced the relationship. Teaching others, therefore, possibly reduces not only math anxiety but attitudes toward learning statistics associated with math anxiety.

It has been investigated whether new learning methods, such as cooperative, blended, mentoring and flipped learning, improve leaning achievement and what factors of the learners affect on learning methods and learning achievement[21-24]. It has been found that active learning attitudes, such as self-directed learning ability, self-regulated learning ability, learning satisfaction and learning motivation, have a great effect on learning achievement in the new learning environment. Thus, learners should be encouraged to actively participate in class and teaching others could be an effective training method. Especially, teaching method could be easy to use and effective in online learning environment.

Although the results showed the benefits of teaching others even when learning statistics, there are some limitations. First, the reason that math anxiety of students who taught others was reduced is simply because students studied more due to extra assignments compared with those who did not do group assignments. To test teaching effect solely, it should be needed to control amount of assignments in further study. Second, since average score of exam was not statistically different between two classes, the benefits of teaching others on learning achievement were not clearly shown. However, size of participants in each class were small because pre-post test was conducted to assess the benefits of teaching on math anxiety. There are also many other factors could affect on learning achievement. It is important to note that the tendency of increased score of final exam was shown for students with teaching others compared with those without teaching was shown. Lastly, it is possibly argued that math anxiety is different from statistics anxiety. Baloglu suggested that statistics anxiety is related to math anxiety but the relationship between statistics anxiety and math anxiety is

moderate[25]. Yet, Fennema and Sherman proposed that math anxiety and statistics anxiety are similar because both involve similar symptoms of anxiety, fear, nervousness related to math activities[26].

Learning statistics is mandatory in studying psychology at university but many students have anxiety of learning statistics because most of them took humanities high school course and thus, had less experiences of studying math. Therefore, effective learning or teaching strategy should be needed to help students have more persistent learning gains. Recently, Hong and Im tested the effect of smart learning using smartphones and immediate feedback. Students who did smart learning showed better understanding of basic mathematical concept and academic achievement[27]. It is noteworthy that this study investigated the application of teaching strategy on learning statistics. Although it has been mostly shown that teaching others enhances learning achievement[1-4], the underneath mechanism of learning benefits of teaching on academic achievement has not widely investigated. Taken together, this study suggested that teaching others benefits learning by lower math anxiety and positive attitudes toward learning statistics.

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