한국초등수학교육학회지 23(4) 383-403.
2019. 11. 30
Journal of Elementary Mathematics Education in Korea 23(4) 383-403.
November 30. 2019.

The Relationship Between Students' Perception Toward Mathematics Teachers' Instructional Practices and Attitude toward Mathematics: A Mediation Role of Self-Efficacy Beliefs

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The purpose of this study was to examine how students' perception of their mathematics teachers' instructional practices is associated with students' attitude toward mathematics, taking into account their self-efficacy in mathematics. The sample contained 4669 Korean fourth graders who participated in Trends in International Mathematics Science Study 2015. We used exploratory factor analysis and confirmatory factor analysis to explore the factor structure of three latent variables and conducted structural equation modeling to examine the hypothesized model. The results revealed that when students positively perceived their teachers' instructional practices, they tended to have a positive attitude toward mathematics. We also found that students' self-efficacy beliefs in mathematics positively mediated the relationship between perceived teachers' instructional practices and personal attitude toward mathematics. We discuss the practical and methodological implications of these findings and offer directions for future studies.

Key words: mathematics teachers' instructional practices, attitude toward mathematics, self-efficacy beliefs, student perception, structural equation modeling

Ⅰ. Introduction

Students' attitude toward mathematics has attracted a great deal of attention from researchers and educators over the past few decades (Hannula, 2002; McLeod, 1992; Zan, Brown, Evans, & Hannula, 2006). Research has shown that students' attitude toward mathematics is related to not only their academic outcomes and classroom engagement but also their future careers (Eshun, 2004; Ma & Kishor, 1997; Zan et al., 2006). Students

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who have a positive attitude toward mathematics are highly committed to studying mathematics, which leads to their increased achievement and motivation in mathematics. Although many factors influence students' attitude toward mathematics, researchers have found that teachers' instructional practices play a critical role in the development of students' attitude toward mathematics (McLeod, 1992; Philipp, 2007). Teachers decide how to teach mathematics topics (Schoenfeld, 2014). They might focus on specific elements in mathematics textbooks and implement them differently. For example, studies have reported that while Korean elementary school teachers use the same mathematics curricula and textbooks, they implement them differently based on their mathematical knowledge and beliefs (Hwang, 2018; Shin & Lee, 2004). In turn, the instructional practice influences how students learn mathematics (Schoenfeld, 2014). These learning experiences may affect the development of students' attitude toward mathematics (Ifamuyiwa & Akinsola, 2008; McLeod, 1992).

Previous studies evaluated teachers' instructional practices from teachers' and researchers' perspectives (Mayer, 1999). Using teachers' self-reported survey and researchers' observation data, these studies examined the characteristics of teachers' instructional practices and then determined their influences on student outcomes (Hannula, 2002; Mayer, 1999). Although these studies provided meaningful information, they neglected to explore students' perceptions of their teachers' mathematics teaching. Hence, these methods may not be enough to properly describe teachers' general instructional practices regarding students' mathematics learning experiences (Borko, Stecher, Alonzo, Moncure, & McClam, 2005; Clarke, Keitel, & Shimizu, 2006; Shimizu, 2006). Attending to students' voices may help researchers more extensively examine teachers' teaching practices from students' perspectives (Arthur, Tubré, Paul, & Edens, 2003). More importantly, previous studies have demonstrated that students' ratings of their teachers' instructional practices are strongly related to their attitude toward mathematics (De Jong & Westerhof, 2001; Vandecandelaere, Speybroeck, Vanlaar, De Fraine, & Van Damme, 2012). In the current study, therefore, we focus on students' perception toward teachers' instructional practices to examine their characteristics.

Moreover, we examine the meditating effect of students' self-efficacy in mathematics on this relationship between teachers' instructional practices and students' attitude toward mathematics. Self-efficacy is related to students' mathematics achievement and confidence in mathematics learning (Zimmerman, 2000). Hence, students with a high level of sense of efficacy tend to have a positive attitude toward mathematics (Kundu & Ghose, 2016). Although many studies have examined students' self-efficacy in mathematics (Pajares, 1996), few have paid attention to the mediating effect of self-efficacy on the relationship between teachers' instructional practices and students' attitude toward mathematics. However, such understanding is necessary to accurately describe the relationship between them. Therefore, the current study examines how students' perception of their mathematics teachers' instructional practices is associated with students' attitude toward mathematics, taking into account their self-efficacy in mathematics.

Ⅱ. Literature Review

1. Evaluating Mathematics Teachers' Instructional Practices

Surveys and observations are the most widely used methods of collecting data on teachers' instructional practices (Borko et al., 2005). The strength of a survey is that it can be used to obtain the characteristics of a population using questionnaires. Hence, it is convenient and useful for collecting general information on teachers' instructional practices. The advantage of observation is that it can provide in-depth information on teachers' instructional practices. Researchers can observe a small number of teachers over a relatively long period, allowing them to thoroughly analyze teachers' instructional practices and obtain holistic impressions of them (Fraenkel, Wallen, & Hyun, 1993; Mayer, 1999). However, these methods are not enough to determine whether teachers' instructional practices are effective for students' mathematical learning (Borko et al., 2005).

Researchers have reported that teachers' responses to questions about their mathematics instructional practices are not always aligned with their actual practices (Spillane & Zeuli, 1999). Because some teachers cannot properly comprehend and evaluate their instructional practices from students' perspectives, their interpretations of the practices tend to be different from students' actual learning experiences (Fraenkel et al., 1993; Shimizu, 2006; Spillane & Zeuli, 1999). In a study comparing perceptions of mathematics teachers and their students in Japanese classrooms, Shimizu (2006) found that students interpreted classroom events differently from their teachers. Because teachers were occupied with other activities, they sometimes did not notice important moments in students' learning during the lessons. Regarding the limitations of researchers' observations, studies have reported that researchers' interpretation of a teacher's instructional practices might have validity issues because researchers try to generalize teachers' instructional practices based on observations of only a few lessons (Borko et al., 2005; Mayer, 1999). Similar to the Hawthorne effect, in which individuals tend to modify their usual behavior when they notice they are being observed, when teachers are aware that their instructions are being evaluated by outsiders, they may use nonstandard mathematical practices (Fraenkel et al., 1993). As such, Borko et al. (2005) cautioned that researchers cannot generalize teachers' overall instructional practices based on little observation data.

To overcome these limitations, studies have suggested using students' ratings of their teachers' instructional practices (Arthur et al., 2003; De Jong & Westerhof, 2001). Researchers have stated that while students' ratings are not perfect, they can provide reliable information on teachers' instruction because they are well aware of classroom norms and teachers' behaviors (De Jong & Westerhof, 2001). In their study analyzing the relationship between fourth graders' ratings of their teachers' instructional practices and teachers' actual instructional practices, conducted with 9,967 students across six countries, Kyriakides et al., (2014) found that elementary students' ratings of the quality of their teachers' teaching are generally reliable. With regard to the value of using students' ratings, studies have reported that students' feelings and thoughts about instruction are directly related to their learning outcomes. Because students' personal evaluations reveal their corresponding behavior and thoughts, their perception toward teachers' instructional practices influence their academic attitude and achievements (Kyriakides et al., 2014; Vandecandelaere et al., 2012). Given the above, some studies have used students' ratings to examine mathematics teachers' instructional practices based on the assumption that this would provide researchers with integrated and comprehensive information of mathematics teachers' instructional practices (Ampadu, 2012; Kyriakides et al., 2014; Shimizu, 2006; Vandecandelaere et al., 2012). For example, Trends in International Mathematics Science Study (TIMSS, Martin, Mullis, & Hooper, 2016) uses questions about students' perception of their teachers' instructional practices, such as "How much do you agree with the statement about your mathematics lessons? My teacher is good at explaining mathematics," to evaluate teachers' instructional practices.

2. Dimensions of Mathematics Teachers' Instructional Practices

Several scholars have proposed a set of dimensions to examine mathematics teachers' instructional practices. Based on qualitative data, Carpenter and Lehrer (1999) suggested tasks and activities for students, classroom tools, and mathematical norms regulating student engagement to understand the characteristics of teachers' instructional practices. Similarly, Franke, Kazemi, and Battey (2007) suggested that the analysis of classroom discourse, classroom norms, and the relationship between teacher and students and students and mathematics could help researchers understand teachers' instructional practices. More recently, Munter (2014) discussed the roles of teachers, classroom discourse, mathematical tasks, and student engagement in classroom activity based on extensive interviews with more than 900 mathematics educators.

In their quantitative study of 1,084 elementary students' (aged 12–13 years) ratings of their mathematics teachers, De Jong and Westerhof (2001) claimed that motivation, clarity, and teaching skills were the most important factors for determining instructional effectiveness from students' perspective. They explained that although mathematical investigation and independent reasoning are important, young children cannot easily perform these activities without teachers' guidance. In their study exploring the relationship between learning environment and students' attitude toward mathematics with survey data, Vandecandelaere et al. (2012) also found a positive association between students' ratings of teachers' helpful feedback and coach and their attitude toward mathematics. Because young students' learning usually begins with teachers' guidance, teachers' clear answers and explanations helped students acquire mathematical knowledge and conduct individual investigations, leading to the development of a positive attitude toward mathematics. In sum, it is reasonable to analyze the following elements when using young students' perception toward their teachers' instructional practices to examine teachers' instructional practices: (a) tasks and activities used in the class; (b) students' roles and participation; and (c) teachers' roles, clarity of instruction, and feedback.

3. Students' Attitude Toward Mathematics

Students' attitude toward mathematics has received a great deal of attention (McLeod, 1992; Philipp, 2007; Zan et al., 2006). McLeod (1992) claimed that emotion, attitude, and beliefs are sub-domains of the affective domain and that attitude is more cognitive than emotion and less cognitive than beliefs. Based on an extensive literature review, Philipp (2007) explained the differences among the three affective elements. According to Philipp (2007), beliefs are related to one's worldview; they are "psychologically held understandings, premises, or propositions about the world that are thought to be true" (p. 259). Hence, belief domains include questions about what mathematics is and how to learn mathematics. Meanwhile, attitude is concerned with one's feelings about and preference for a certain subject. Philipp (2007) described attitude as people's "manners of acting, feeling, or thinking that show one's disposition or opinion" (p. 259). Emotion is spontaneous response and feeling (e.g., joy and panic) to a certain event and situation, so it is rapidly changing and unstable. Unlike beliefs, peoples' attitude and emotions are usually described as positive or negative.

Researchers have proposed different components of attitude. The Mathematics Attitude Scales (Fennema & Sherman, 1976), one of the most widely used attitude measurement scales, contain a group of components, including attitude toward success in mathematics, teachers' and parents' attitude, mathematics as a male domain, confidence in learning mathematics, mathematics anxiety, motivation, and mathematics usefulness. However, an increasing number of studies have raised questions about the reliability and integrity of the Mathematics Attitude Scales and claimed that some components should be excluded from the scale (Mulhern & Rae, 1998). After analyzing 545 high school students in the United States, for example, Tapia and Marsh (2004) suggested a revised Mathematics Attitude Scales that included self-confidence, value, enjoyment, and motivation dimensions. Recently, Di Martino and Zan (2010) discussed three dimensions: emotional disposition, vision of mathematics, and perceived competence. They explained that these three dimensions can be examined as positive/negative, relational/instrumental, and high/low, respectively.

Meanwhile, many studies have suggested differentiating self-efficacy beliefs (self-competence) from attitude (e.g., Hannula et al., 2016). Whereas students' confidence in mathematics affects their attitude toward mathematics, self-efficacy is more strongly related to their perceived mathematical abilities such as their competence to perform a certain task (Bandura, 1977, 1996; Nicolaidou & Philippou, 2003). Zimmerman (2000) argued that self-efficacy is related to one's performance capabilities, rather than one's psychological status. Based on Philipp's (2007) study, the current study examines students' attitude toward mathematics by focusing on emotional disposition, including whether they like studying mathematics (mathematics as a subject) and are willing to engage in mathematics classrooms (mathematics lessons). Additionally, students' confidence is evaluated as a different construct.

4. Teachers' Instructional Practices and Students' Attitude Toward Mathematics

Attitude is constructed using situational experiences with objects, people, and environments (Zimbardo & Leippe, 1991). Similarly, students' attitude toward mathematics are formed using various experiences in mathematics classroom (Philipp, 2007). Classroom activities that teachers design affect students' temporal emotions, and the accumulation of similar emotions result in the development of students' attitude toward mathematics (McLeod, 1992). For example, a student who feels discomfort and illness in a drill-based classroom tends to develop a negative attitude toward mathematics over time.

Studies have reported that when teachers construct mathematics classrooms to promote students' participation, students tend to develop a positive attitude toward mathematics (Ifamuyiwa & Akinsola, 2008; Jennison & Beswick, 2010; Papanastasiou, 2008). Ifamuyiwa and Akinsola (2008) found that encouraging students to demonstrate what they have learned and listening to what they have to say help them develop a positive attitude toward mathematics. These activities provide students with opportunities to reflect on and articulate their ideas, understand mathematical concepts accurately, and develop an interest in learning mathematics. This in turn leads to the development of their positive attitude toward mathematics. Papanastasiou (2008) found a positive association between teachers' explanations (e.g., showing students how to do mathematics problems) and mathematical activities (e.g., learning interesting and new topics) and students' attitude toward mathematics based on an analysis of TIMSS 1999 data of Cyprus students. Moreover, Jennison and Beswick (2010) demonstrated that providing hands-on activities and tools positively influenced students' attitude toward mathematics. Furthermore, based on an analysis of TIMSS 2003 data of Belgium students, Vandecandelaere et al. (2012) stressed the influence of mathematical activities, classroom structure, and teachers' feedback and coaching on the development of students' positive attitude toward mathematics.

5. Students' Self-Efficacy

The sense of efficacy refers to one's evaluation of one's abilities to bring about expected outcomes (Bandura, 1996). People's beliefs in their capabilities are context specific, so students with a high level of self-efficacy in mathematics might have a low level of self-efficacy in other subjects (Zimmerman, 2000). Because domain-specific questions have more explanatory and predictive power than omnibus ones, Pajares (1996) stressed that the mathematics self-efficacy scale should focus on students' confidence in mathematics itself, such as "I am certain I can understand the math presented in this class" (p. 550). Self-efficacy is constructed through four types of experiences (Bandura, 1977): mastery experiences (previous successful and failed experiences), vicarious experiences (observing and learning from peers' behavior and thoughts), verbal persuasion (verbal feedback from teachers), and physiological states (by means of reduced stress). Because classrooms provide these experiences, students' self-efficacy beliefs tend to change depending on teachers' instruction. In particular, when students successfully accomplish tasks, observe peers' success, receive positive feedback, and feel they are in a positive atmosphere, they tend to develop a high level of self-efficacy (Zimmerman, 2000).

In mathematics education, studies have claimed that teachers' and students' roles and mathematical activities in the classroom affect the construction of students' self-efficacy (Hannula et al., 2016). Siegle and McCoach (2007) examined changes in fifth graders' mathematical self-efficacy, finding that the levels of self-efficacy were positively enhanced when teachers provided clear feedback. This is because the feedback helped students become aware of their performance and modify them. The authors also highlighted the importance of letting students show what they learned in the classroom because such experiences encouraged them to observe and learn from their peers' thoughts and behaviors. Similarly, after analyzing 2003 Program for International Student Assessment (PISA) U.S. data, Cheema and Kitsantas (2014) found a significantly positive association between students' perception of the climate of their mathematics classrooms and their self-efficacy (r = .16). Other studies on Korean elementary students' self-efficacy beliefs obtained similar findings: encouraging student participation, providing feedback, and using interesting activities helped students enhance their self-efficacy in mathematics (Shin, Wang, & Kim, 2007; Yoon & Kim, 2011)

Studies have reported positive associations for the relationship between self-efficacy and mathematical attitude (Hannula et al., 2016; Kundu & Ghose, 2016; Pajares, 1996; Zimmerman, 2000). They claimed that students' self-efficacy positively influences their academic motivation and emotion, which in turn helps them develop a positive attitude toward mathematics. In a study examining 983 Japanese middle school students, Shiomi (1992) found that students who have a high level of mathematics self-efficacy are inclined to have a positive attitude toward mathematics than students with a low level of self-efficacy. Although Shiomi (1992) did not explain the reason for this association, it is likely that when students believe in their efficacy in a subject, they tend to spend more time and effort pursuing it and persevering in the face of adversity (Bandura, 1996), and they are likely to develop a positive attitude toward the subject (Zimmerman, 2000).

6. Current Study

Although studies have found an association between teachers' instructional practices and students' attitude toward mathematics, many studies have failed to account for students' voices. As stated above, the influence of teachers' instructional practices is strongly related to how students perceive them. Additionally, self-efficacy can positively mediate the association. The objective of this study, therefore, is to determine whether Korean elementary students' perception toward their teachers' mathematics instructional practices are positively related to their attitude toward mathematics. Also, the purpose of this study is to examine the association between students' perception toward their teachers' mathematics teaching and their attitude toward mathematics by considering the mediation effects of self-efficacy in mathematics. The two research questions are as follows: How does students' perception toward their teachers' mathematics instructional practices relate to their attitude toward mathematics? And how does students' self-efficacy toward mathematics mediate the relationship? On the basis of a literature review, we hypothesize that when students positively perceive their teachers' mathematics instructional practices, they tend to develop a positive attitude toward mathematics, and self-efficacy positively mediates this relationship.

Ⅲ. Methods

1. Participants

Korean fourth graders' TIMSS 2015 data set was used in this study. Students were selected using a two-stage stratified cluster sample design. First, schools were selected from nationally represented samples based on demographic characteristics, and then classrooms in the schools were selected (Martin et al., 2016). There were 4,669 fourth graders in 188 classes: 2,258 girls (48.4%) and 2,411 (51.6%) boys, respectively. Missing data were not deleted; instead, they were handled using the default setting of Mplus to ensure all available information was used (Muthén & Muthén, 2017).

2. Variables

Three latent variables were selected from the TIMSS 2015 data set: (a) students' perception toward mathematics teachers' instructional practices, (b) students' attitude toward mathematics, and (c) students' self-efficacy in mathematics. Cronbach's alpha of the three latent variables was greater than .80, indicating a high level of reliability.

A. Perception toward teachers' instructional practices

Seven items asked students to report how much they agreed with statements about their mathematics teachers' instructional practices. The statements were as follows: My teacher gives me interesting things to do (PR1), My teacher has clear answers to my questions (PR2), My teacher is good at explaining mathematics (PR3), My teacher lets me show what I have learned (PR4), My teacher does a variety of things to help us learn (PR5), My teacher tells me how to do better when I make a mistake (PR6), and My teacher listens to what I have to say (PR7). We assume that these seven items represent the three dimension of mathematics teaching described in the literature: (a) tasks and activities; (b) students' roles and participation; and (c) teachers' roles, clarity of instruction, and feedback. Items used a four-point Likert-type scale from 1 (agree a lot) to 4 (disagree a lot). The variables were reverse coded from 1 (disagree a lot) to 4 (agree a lot). Hence, high scores indicated high-quality mathematics teaching from students' perspective. Cronbach's alpha value was .879.

B. Attitude toward mathematics

Four items were used to measure students' attitude toward mathematics. All items began with the following question: "How much do you agree with these statements about learning mathematics?" The four items were as follows: I enjoy learning mathematics (AT1), I like any schoolwork that involves numbers (AT2), I look forward to mathematics lessons (AT3), and Mathematics is one of my favorite subjects (AT4). Responses were given on a 4-point scale from 1 (agree a lot) to 4 (disagree a lot) The variables were reverse-coded, indicating disagree a lot (1) to agree a lot (4). Thus, high scores indicated a positive attitude toward mathematics. Cronbach's alpha value was .899.

C. Self-efficacy in mathematics

Six items asked students to rate the degree of their self-efficacy in mathematics. The items were as follows: I usually do well in mathematics (SE1), Mathematics is harder for me than for many of my classmates (SE2), I am just not good at mathematics (SE3), I learn things quickly in mathematics (SE4), Mathematics makes me nervous (SE5), and I am good at working out difficult mathematics problems (SE6). All items used a four-point Likert-type scale from 1 (agree a lot) to 4 (disagree a lot). Three items (SE1, SE4, and SE6) were reverse coded from 1 (disagree a lot) to 4 (agree a lot) for easy interpretation. The high scores indicated a high level of self-efficacy in mathematics. Cronbach's alpha value was .836.

3. Data Analysis

In Korea, little research has examined the relationships among the three latent variables used in the study, so we first conducted exploratory factor analysis (EFA) to examine the independence of three factors in a randomly selected half of the data set. Then, we conducted confirmatory factor analysis (CFA) with the other half of the data set to estimate the measurement model fit. Next, bivariate correlations of latent variables were examined for the entire data set. Last, structural equation modeling (SEM) was conducted to examine the hypothesized factor structures. We used the weighted least square mean and variance (WLSMV) as an estimator and oblique GEOMIN rotation for analyzing categorical variables (Muthén & Muthén, 2017). All the analyses in this study were conducted using Mplus 8.3 (Muthén & Muthén, 2017). To evaluate goodness of fit to the hypothesized model, we used x^2 statistic. Because x^2 statistic is sensitive to sample size (Fan, Thompson, & Wang, 1999), we also used other fit indices to examine the model fit. Although there is no golden role, it is typically accepted that comparative fit index (CFI) values exceeding .95 are indicative of good fit and root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) values of less than .08 and .06 are considered to indicate a good model fit, respectively (Hu & Bentler, 1999).

Ⅳ. Results

1. Factor Analysis

The EFA was conducted to confirm the hypothesized three-factor structure of students' perception toward their teachers' instructional practices, attitude toward mathematics, and self-efficacy in mathematics. Except for SE5, all items showed high loading scores (>.50). After excluding SE5, the second EFA was administered. The final EFA model showed good model fit (x^2 [120, N = 2348] = 57730.61, p <.001, RMSEA = .072, CFI = .98, and SRMR = .022) with high loading scores. Table 1 shows factor scores with 17 items. Next, we conducted CFA with the other half of the data set to examine all items in the model. The analysis revealed a good degree of model-data fit; x^2 (120, N = 2269) = 53576.14, p <.001, RMSEA = .074, CFI = .977, and SRMR = .042.

<Table 1> Rotated Factor Analysis of All Items

	First Administration			Second Administration		
	1	2	3	1	2	3
AT1	0.813*			0.815*		
AT2	0.857*			0.856*		
AT3	0.956*			0.957*		
AT4	0.934*			0.937*		
PT1		0.584*		0.318*	0.586*	
PT2		0.801*			0.804*	
PT3		0.776*			0.780*	
PT4		0.569*			0.570*	
PT5		0.799*			0.803*	
PT6		0.833*			0.836*	
PT7		0.843*			0.847*	
SE1			0.850*			0.855*
SE2			0.815*			0.807*
SE3			0.851*			0.848*
SE4			0.711*			0.715*
SE5			0.299*			-
SE6			0.754*			0.760*

Note. Factor scores below .25 are not listed. AT = attitude toward mathematics, PT = perception toward teachers' instructional practices, SE = self-efficacy in mathematics. *p < .05 (two-tailed tests).

2. Bivariate Correlation Analysis

Correlations between the three factors were analyzed with the whole data set. Table 2 shows the results of bivariate correlations. Students' attitude toward mathematics was positively but weakly correlated with their perception toward teachers' instructional practices (r = .352, $p < .05$). Further, the correlation between students' attitude toward mathematics and self-efficacy in mathematics were significantly positive and moderate (r = .625, $p < .05$). With regard to the correlation between students' perception toward teachers' instructional practices and self-efficacy in mathematics, there was significantly positive and very weak correlations (r = .169, $p < .05$). Hence, we can conclude that the three latent variables were positively correlated but different constructs.

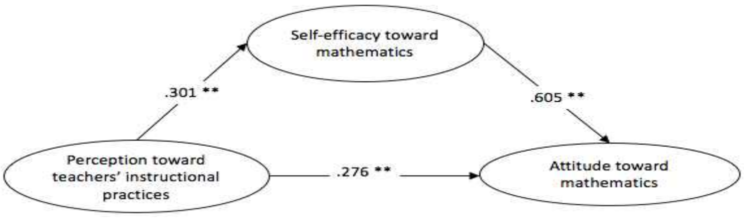
<Table 2> Bivariate Correlation Between Attitude Toward Mathematics, Perception Toward Teachers' Instructional Practices, and Self-Efficacy

	1	2	3
1. Attitude toward mathematics	-		
2. Perception toward teachers' instructional practices	0.352*	-	
3. Self-efficacy in mathematics	0.625*	0.169*	-
M	2.619	3.119	2.816
(SD)	(.274)	(.259)	(.214)

Note. *p < .05 (two-tailed tests).

3. Structural Equation Modeling

We hypothesized that students' self-efficacy would mediate the influence of their perception toward teachers' instructional practices on their attitude toward mathematics. The SEM analysis results concurred with our hypothesis. Table 3 shows unstandardized and standardized coefficients and coefficients of determination of all items. The fit indices show good fit with the overall sample: x^2 (120, N = 4667) = 112514.834, p <.001, RMSEA = .074, CFI = .977, and SRMR = .042. Figure 1 and Table 4 represent unstandardized and standardized total, direct, and indirect path coefficients. In terms of the total effect, Korean fourth graders showed a significant positive relationship between perceived teachers' instructional practices and attitude toward mathematics (β = .458, $p < .01$). Regarding direct effect, there were significant positive associations between perceived teachers' instructional practices and self-efficacy (β = .301, $p < .01$), self-efficacy and attitude toward mathematics (β = .605, $p < .01$), and perceived teachers' instructional practices and attitude toward mathematics (β = .276, $p < .01$). As indicated in the indirect analysis, self-efficacy significantly mediated the relationship between perceived teachers' instructional practices and attitude toward mathematics (β = .182, $p < .01$). Hence, the results indicated that students' positive perception toward their teachers' instructional practices directly and positively improved their attitude toward mathematics. Additionally, students' perception toward their teachers' instructional practices was positively and indirectly associated with their increased attitude toward mathematics via self-efficacy.



[Figure 1] Structural equation model for students' perception toward teachers' instructional practices, self-efficacy, and attitude toward mathematics.

<Table 3> Unstandardized and Standardized Coefficients and Coefficients of Determination

Scale	Item	B	SE of B	β	R^2
Attitude toward mathematics	AT1	1fixed**	-	0.895**	0.802
	AT2	0.982**	0.006	0.879**	0.773
	AT3	0.982**	0.006	0.879**	0.773
	AT4	0.997**	0.006	0.893**	0.797
Perception toward teachers' instructional practices	PR1	1fixed**	-	0.787**	0.619
	PR2	1.041**	0.011	0.819**	0.671
	PR3	1.077**	0.012	0.847**	0.717
	PR4	0.742**	0.014	0.584*	0.341
	PR5	1.074**	0.011	0.845**	0.714
	PR6	1.038**	0.011	0.817**	0.667
	PR7	1.068**	0.011	0.840**	0.706
Self-efficacy	SE1	1fixed**	-	0.894**	0.799
	SE2	0.864**	0.010	0.772**	0.596
	SE3	0.872**	0.009	0.780**	0.608
	SE4	0.876**	0.009	0.782**	0.612
	SE6	0.961**	0.007	0.859**	0.738

Note: B, β, and R^2 refer to unstandardized coefficients, standardized coefficients, and the coefficient of determination, respectively. $^{*}p < .05$ (two-tailed tests), $^{**}p < .01$ (two-tailed tests)

<Table 4> Direct, Indirect, and Total Effects Between Latent Variables

	B	β	SE of B
Direct effects			
Perceived teachers' instructional practices → self-efficacy	.342**	.301**	0.016
Self-efficacy → attitude toward mathematics	.606**	.605**	0.011
Perceived teachers' instructional practices → attitude toward mathematics	.314**	.276**	0.014
Indirect effects			
Perceived teachers' instructional practices → self-efficacy → attitude toward mathematics	.207**	.182**	0.010
Total effects			
Perceived teachers' instructional practices → attitude toward mathematics	.521**	.458**	0.015

Note. B and β refer to unstandardized and standardized coefficients. $^{**}p < .01$ (two-tailed tests)

V. Discussions and Conclusion

1. Discussion

In this study, we modeled the relationships among students' perception toward mathematics teachers' instructional practices, attitude toward mathematics, and self-efficacy in mathematics. The EFA and CFA confirmed the expected factor structure. Similar to previous studies, our study reveals that teachers' instructional practices are positively related to students' attitude toward mathematics and self-efficacy positively mediates this relationship.

A. Perceived instructional practices and attitude toward mathematics

The noteworthy finding of this study is that how students perceive their teachers' instructional practices is statistically related to students' attitude toward mathematics. When they have a positive attitude toward their teachers' mathematics teaching, they tend to like to study mathematics more and look forward to being in a mathematics classroom. This finding is consistent with previous research (McLeod, 1992; Papanastasiou, 2008). In the classroom, students observe and interpret their teachers' mathematics teaching, which explicitly and implicitly influences their evaluation of the teachers' instruction (De Jong & Westerhof, 2001). When students perceive that their teachers do not use interesting mathematical tools and activities, do not encourage students' participation, and do not provide clear explanations and feedback, they dislike learning mathematics (Kyriakides et al., 2014; Vandecandelaere et al., 2012). Conversely, when they assume that their teachers' instruction is valuable, they pay attention to it and look forward to studying with the teachers (Vandecandelaere et al., 2012). Because students within these classroom environments have more opportunities to investigate mathematics problems using tools and activities and to acquire accurate mathematics knowledge with teachers' guidance, they have positive emotions and experiences in the classroom, which result in the development of a positive attitude toward mathematics (Ifamuyiwa & Akinsola, 2008; Jennison & Beswick, 2010). In short, students' personal experiences and evaluations of teachers' instructional practices lead to positive and negative attitude toward mathematics (McLeod, 1992; Philipp, 2007).

B. Mediation effects of self-efficacy

The results of SEM analysis support the partial mediation effect of self-efficacy on the relationship between students' perception toward mathematics teachers' instructional practices and their attitude toward mathematics. The positive relationship between self-efficacy in mathematics and students' perception toward teachers' instructional practices confirms our hypothesis that high-quality mathematics instruction can help students develop confidence in mathematics (Cheema & Kitsantas, 2014; Siegle & McCoach, 2007). As Bandura (1996) and Pajares (1996) stated, students' self-efficacy is related to their learning experiences in classrooms. When teachers provide clear feedback (verbal persuasion), students are able to acquire accurate mathematical understanding and experience success in mathematics learning (mastery experiences). Additionally, when teachers encourage students to demonstrate their knowledge with peers, students can understand peers' ideas and observe their success (vicarious experiences). Consequently, these positive learning experiences help students develop self-efficacy beliefs.

Regarding the relationship between self-efficacy beliefs and attitude toward mathematics, this study found a positive relationship in line with previous research (Kundu & Ghose, 2016; Shiomi, 1992). Students are likely to spend more time and effort on a subject they feel confident about (Bandura, 1977; Zimmerman, 2000). Because students with a high level of self-efficacy beliefs in mathematics have more positive mathematics-related experiences (e.g., acquire accurate mathematical understanding and success in mathematics learning) than students with a low level of self-efficacy, they tend to have greater commitment to studying mathematics. As a result, they are willing to study mathematics more and to develop a positive attitude toward mathematics. In sum, teachers who are perceived as high-quality teachers can achieve greater success at improving students' attitude toward mathematics via self-efficacy than those who are perceived as low-quality teachers. With these findings, this study lends support to the argument that specific teaching practices, including organization of students' and teacher' roles and the use of interesting mathematical tools and activities, are helpful for the improvement of students' attitude toward mathematics.

C. Practical implications

In this section we discuss the implications of the findings for researchers, teachers, and mathematics educators. The first implication pertains to using students' ratings to examine teachers' instructional practices. Although much attention has been paid to analyses of teachers' instructional practices, students' perception toward their teachers' instructional practices has generally been neglected. This study follows the TIMSS (Martin et al., 2016) approach and considers students' ratings of their teachers' instructional practices. An evaluation of the ratings confirms the relationship between perceived teachers' instructional practices and attitude toward mathematics. Researchers can thus use students' perception toward their teachers' instructional practices to understand which instructional practices students deem trustworthy. Second, teachers should be aware of their critical roles in students' mathematics learning. In view of the positive association between perceived teachers' instructional practices and students' attitude toward mathematics, teachers should review their instructional practices and modify them to align them with students' expectations. In particular, teachers should use interesting mathematical tools and activities, encourage students' participation, and provide clear explanation and support (Kyriakides et al., 2014; Vandecandelaere et al., 2012). These improved instructional practices can help students develop positive attitudes toward mathematics. Third, given the mediating effect of self-efficacy, classroom environments that can enhance students' self-efficacy should be constructed. Teachers should put more effort into promoting students' confidence in mathematics by providing positive mathematics learning experiences (mastery experiences). They should also provide authentic feedback (verbal persuasion) to encourage the development of a high level of self-efficacy. Regarding the second and third implications, teacher education programs should provide professional training to mathematics teachers to help them acquire appropriate practical knowledge and skills. As indicated in this study, students' attitude is influenced not only by teachers' clear explanation and support but also by their engagement and investigation experiences. Therefore, mathematics teacher educators should design professional development programs to provide teachers with more meaningful learning experiences that will improve their instructional skills and, in turn, enhance students' mathematical attitude.

2. Conclusion

This study has three critical limitations. First, all the data were collected from students' self-reported surveys. Hence, the results may have reliability issues. Even when students anonymously complete questionnaires, they may deliberately rate teachers' instructional practices to create a good impression on teachers. Therefore, further research should be conducted with additional data sources (e.g., interviews and observations) to validate our findings. Second, students' data have nested structure. Whereas students in the same classroom may share similar characteristics, this study treated individual students as individual-level data. We did not conduct multilevel analyses by clustering students within their classrooms. Therefore, the findings of this study should be interpreted with caution. Future studies should use multilevel analyses to corroborate the findings of this study. Last and most important, we did not measure individual students' development of their attitude toward mathematics over time. Students with a positive attitude toward mathematics might have developed such an attitude in their previous years of mathematics learning. Because individual students' attitude toward mathematics may not be entirely aligned with teachers' instructional practices, additional longitudinal research should be conducted to explain how students' attitude toward mathematics can change based on teachers' instructional practices.

This study examined the relationship between students' perception toward their teachers' instructional practices and attitude toward mathematics, taking into account their self-efficacy in mathematics. The results revealed that when students positively perceive their teachers' instructional practices, they tend to have a positive attitude toward mathematics. Moreover, self-efficacy positively mediates these relationships. These findings indicate that to enhance students' attitude toward mathematics, teachers should construct the mathematics classroom by considering (a) implantation of mathematical tasks and activities; (b) students' roles and participation; and (c) teachers' roles, clarity of

instruction, and feedback. This study provides insights for improving students' attitude toward mathematics through the influence of teachers' instructional practices.

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<국문초록>

학생의 수학 수업에 대한 인식과 수학적 태도의 관계 분석: 자기효능감의 매개를 중심으로

황성환[2)]

본 연구는 수학 수업의 중요성을 인식하면서, 교사의 수업에 대한 학생들의 인식이 학생들의 수학적 태도에 미치는 직접효과와 자기효능감의 매개효과를 분석하는 것을 목적으로 한다. 이를 위해 TIMSS 2015에 참여한 4669명의 초등학교 4학년 자료를 탐색적 요인분석과 확인적 요인분석을 통해 변수들 간의 관계를 탐색하고, 구조방정식을 통해 잠재변인 간의 관계를 분석하였다. 분석결과, 학생들이 교사의 수학 수업을 긍정적으로 인식할 때, 학생들은 수학에 대한 긍정적인 태도를 갖는 것으로 나타났다. 또한 학생들의 수학에 대한 자기효능감이 교사의 수업에 대한 학생들의 인식과 학생들의 수학적 태도 사이의 관계를 매개함이 나타났다. 이러한 연구 결과를 바탕으로 실질적인 그리고 방법론적인 시사점과 후속 연구의 방향을 제안하였다.

주제어: 수학 교사의 수업, 수학 태도, 자기효능감, 학생 인식, 구조방정식

논문접수: 2019. 10. 16
논문심사: 2019. 11. 04
게재확정: 2019. 11. 12

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