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The Mediating Effect of Academic Self-Efficacy in the Relationship between Middle School Students' Perceptions of Teaching Competencies and Math Achievement : Using Multi-level Structural Equation Modeling*

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Abstract

The purpose of this study was to investigate the mediating effect of academic self-efficacy on the relationship between middle school students' perceptions of teaching competencies and math achievement. This study was based on the GEPS and used multi-level SEM to capture the hierarchical structure of the clustered data. Considering the limitations of previous empirical studies using SEM methodology to control the influences of confounding variables, this study included student and school-level covariates. Through model comparisons between two models: a model without covariates and the other model with both student and school-level covariates, the final research model was applied to analyze the effects of perceived teaching competencies and academic self-efficacy on academic achievement.

The study yielded a number of interesting results. Firstly, after controlling for student and school-level variables, the direct effect of perceived teaching competencies on academic achievement was shown to be statistically significant. The indirect effect, or the mediating influence of academic self-efficacy, was also

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statistically significant. Secondly, it was found that a model without covariates was likely to overestimate the effects of explanatory variables on academic achievement in contrast to the other model with covariates. This resulted in a huge difference in statistical significance between the models. Based on these findings, the educational implications and future research directions were discussed.

Key words: teaching competencies; academic self-efficacy; mediation effect; multi-level SEM

Ⅰ. Introduction

Teaching is a constant process of communication between teachers and learners, where under the appropriate learning situations and conditions behaviors can be adapted in a positive and desirable manner(Chi et al., 2011; Kim, 2001; Park, 2008). Teaching is recognized as an important activity which involves the internalization of subjects and changes in awareness which can have a profound impact on students. For this reason, teaching professionalism has long been emphasized in the classroom(Lee, 2002). In this educational context, it is worthwhile to examine the effect of students' perceived teaching competencies on their affective or cognitive abilities in practice, with the goal of improving professional development for teachers. Firstly, the relationships between teacher characteristics such as teacher background, affective variables, and teaching styles on the one hand, and students' learning motivations, learning strategies, learning attitudes and academic achievement on the other, have been the focus of a number of empirical studies(Kim and Cha, 2003; Lee and Chung, 2011).

Secondly, students' affective factors have been also closely connected to their academic achievement. In particular, students' academic self-efficacy among affective variables is one of the major predictors of academic achievement(Lee et al, 2015). Considering that the teaching learning process is an interaction between teachers and students, variables related to teachers may have not merely a direct impact on students' achievement, but also an indirect effect mediating students' affective variables such as academic self-efficacy. In this sense, academic self-efficacy presumably seems to have a mediation effect between teachers' teaching competency and students' academic achievement. Despite the positive influence of academic self-efficacy on academic achievement(Hong and Lee, 2012; Joo et al., 2011; Kwon et al., 2015; Lee et al., 2013; Ryou et al., 2010; Shin and Shin, 2006), there have been few

studies analyzing the relationships between teachers' teaching competence, students' academic self-efficacy, and achievement.

Roh(2009) reported that students' perceptions of teaching activities had an indirect effect on academic achievement by mediating learner characteristics such as learning strategies or concentration rather than having a direct influence on students' performance. Some studies provided evidence of the direct effects of students' perceptions of class characteristics or teaching strategies on academic achievement(Park and Kim, 2009; Roh, 2009). There were also studies that examine the direct effects of teachers' teaching styles on learners' personal characteristics including motivation, interests, concentration, learning strategies and self-directed learning attitude(Chi et al., 2011; Kim and Yang, 2009; Kwon and Min, 2004). However, there is a lack of studies investigating the mediating effect of academic self-efficacy. Accordingly, it is crucial to analyze the mediating effect of academic self-efficacy in the relationship between teaching competencies and academic achievement, as it is one of the most important characteristics of effective students. Additionally, the influence of middle schoolers' academic self-efficacy on academic achievement was likely to be larger than that of high schoolers'. Particularly, the impact of learning attitudes on students' performance in math was presented to be more considerable compared to Korean and English(Lee et al, 2015).

Methodologically, although researchers acknowledged the hierarchical structure present when taking into account the student and school-level variables, a multi-level SEM analysis was conducted in only a few studies. It was reported that employing a single-level SEM to the nested data structure might lead to underestimated standard errors and imprecise estimates of school-level variables(Ronald and Scott, 2015; Wang and Wang, 2012).

To address the limitations of the previous approaches, this study aims to investigate the mediating effect of academic self-efficacy in the relationship between middle school students' perceptions of teaching competencies and math achievement while controlling for the influences of student and school-level variables using a multi-level SEM. This study also casts a light on the importance of academic achievement development, academic self-efficacy and teachers' instructions.

This study addressed two primary research questions. First, how does the change from a model without covariates to a model with multi-level covariates lead to different conclusions about the relationship between teaching competencies perceived by students, academic

self-efficacy and math achievement? Second, what is the mediating effect of academic self-efficacy between the perceived teaching competencies and math achievement when students and school-level covariates are controlled?

Ⅱ. LITERATURE REVIEW

1. The relationship between academic self-efficacy, perceived teaching competencies and academic achievement

Academic self-efficacy is a judgment about one's ability to organize behaviors effectively in order to complete academic tasks. This includes confidence in learning abilities, the degree of preferences for specific tasks and goals and self-regulated efficacy(Bandura, 1977 cited in Shin and Shin, 2006). Recently, the influence of academic self-efficacy among student-level variables in predicting academic achievement has been the focus of numerous empirical studies.

Most research has been carried out to examine the direct and indirect relationships between academic self-efficacy and academic achievement in middle-school and high-school students (Ryou et al., 2010; Seon and Choi, 2016; Shin and Shin, 2006; Song and Yoo, 2011). However, there was a common limitation, the studies investigated these relationships without controlling variables relevant to academic self-efficacy and achievement. Previous studies showed inconsistent results regarding the relationship between academic self-efficacy and achievement. Some studies pointed out that academic self-efficacy had both direct and indirect positive effects on academic achievement when controlling for covariates such as student, family and teacher-related factors(Lee and Song, 2015; Song and Yoo, 2011; Zimmerman, Bandura and Martinez-Pons, 1992 cited in Shin and Shin, 2016). On the other hand, other studies showed that there was no relationship or negative relationship between academic self-efficacy and achievement(Joo et al., 2011; Shin and Shin, 2006).

Teachers have a strong effect on students' cognitive and affective development. Particularly teachers' teaching abilities play an important role in students' affective domain related to learning as well as academic achievement. Kim(2011) showed that perceived teaching competence had an indirect positive effect by mediating practical intelligence, learning

strategies and achievement-goal orientations as well as a direct positive effect on students' achievement. Also, perceived teaching competence had an indirect positive influence on students' achievement by mediating academic self-efficacy(Kim et al, 2017; Lim, Lee, 2016). The results indicated that students' academic achievement could be improved when teachers provided differentiated instructions based on students' proficiency levels and encouraged their cognitive activation(Hong, Kim, 2013; Lee and Song, 2015).

Teaching abilities of instructors are interwoven with the understandings of learners' proficiency level and proper instructions as well as content knowledge. If teachers provide appropriate level of instructions, students will be able to have more opportunities of success rather than failure in learning, and positive feedback by teachers can improve the conviction of being able to solve learning tasks well, that is self-efficacy(Ormrod, 2008). In this sense, the teaching competence perceived by students is likely to improve their academic self-efficacy. Concretely, the perceived teaching competency had a positive influence on academic self-efficacy in the same year and students showed the improvements in their academic self-efficacy over time(Kim et al, 2017; Lim, Lee, 2016). These previous studies showed that teachers' teaching competence had a significant impact on academic self-efficacy and achievement, and eventually academic self-efficacy could play an important role as a mediating variable in the relationship between teaching competence and academic achievement.

2. The Relationship between Student and Teacher Characteristics and Academic Achievement

A variety of studies have been conducted on the relationship between student characteristics and academic achievement, with a number of noteworthy results. Firstly, academic achievement appears to be woven into students' backgrounds. Lee and Chung (2011) and Choi(2014) all indicated that academic achievement has a positive relationship with parents' education, family income and educational expenditure.

In contrast, in the studies by Shin and Shin(2006), Lee and Song(2015), no significant relationship with the family SES was found based on the overall analysis of students' affective characteristics and family backgrounds. Secondly, most of the literature reviews focusing on the effect of private education on academic achievement reported that the private

tutoring participation, expenditure and time have positive correlations with academic achievement(Kim, 2013; Nam, 2013; Park, 2010; Park, 2012). Furthermore, Park(2012) and Kim (2013) identified that the pattern of change in academic achievement can be expected to increase linearly or quadratically, which implies that academic achievement is closely related to prior achievement.

Except for the teaching competence, teachers' characteristics still account for a considerable part of middle school and high school students' academic achievement. It was shown that teachers' self-efficacy also had an important effect on academic achievement similarly to students' academic self-efficacy(Heo, Kim, 2013). Particularly, the higher teaching efficacy teachers were likely to have, the more active coping strategies they tended to use for the underachieving students(Oh, 2011). On the other hand, a few studies demonstrated that teachers' self-efficacy did not have a significant effect on students' academic achievement (Kang, 2002; Lee et al., 2013).

Next, teachers' morale, enthusiasm and self-esteem were positively related to learners' academic achievement(Hong and Kim, 2013; Lee and Song, 2015). Specifically, Hong and Kim(2013) confirmed that there is a tendency that the teachers who work in a school with a high level of academic achievement have not only a high level of morale and enthusiasm on the instructions to students but also a high level of self-esteem and responsibility as a teacher. In addition, Lee and Song(2015) found that teachers' morale and enthusiasm have a positive relationship with academic achievement after controlling for students' factors. In particular, teacher-related factors such as morale, enthusiasm and self-esteem were shown to be positively related to students' academic achievement mediating their learning activities, extrinsic and intrinsic motivation(Kim et al, 2011; Ahn et al., 2011).

Ⅲ. METHOD

1. Subject

In this study, we used the 2014 Middle School student survey data from the GEPS (Gyeonggi Education Longitudinal Panel Survey), which was collected by Gyeonggi Education Research. The GEPS tracked samples and conducted surveys during a 4-year

period, from 2012 to 2016. The purpose was to understand cognitive and affective changes and growths of students from elementary, middle and high schools, as well as analyze the education policies and effects for school education in the Gyeonggi Province. Panel data consists of three cohorts: elementary school 4th grade, middle school 1st grade, and high school 1st grade. Data from 4,051 middle school students in the Gyeonggi Province, including students from innovation schools, was extracted by stratified cluster sampling and analyzed in the present study. The participants in this study were in 2nd grade in 2013, and accordingly, were 3rd grade middle school students in 2014.

2. Variables

The dependent variable of this study was middle school students' academic achievement measured using raw math scores. Student-level variables[1] consisted of explanatory variables and covariates. Explanatory variables included students' perceptions of teaching competencies and academic self-efficacy. More specifically, students responded to four questions regarding their math teachers' teaching competencies while academic self-efficacy was measured by relevant three questions[2] as observed variables. On the basis of findings, covariates measured at the student-level, which relate to both explanatory and dependent variables, included the socioeconomic status(SES) of the family, the participation in private tutoring and prior achievement. The family SES was calculated by the mean of z-scores of parents' level of education, which was transformed into the years of education, and the natural log value of family incomes. At the school-level, teachers' affective characteristics such as teacher efficacy, teacher morale and enthusiasm, and teaching satisfaction as well as the school mean SES were also involved as covariates. The three affective characteristics of teachers were calculated by

1) Given that prior achievement (math achievement in the 2nd grade of middle school) was considered as a covariate, it might be more adequate to use the vertical scale scores of math in 3rd grade as present achievements. However, as the GEPS does not provide the vertical scale scores, raw scores of math were used in this research.

2) According the results of correlation analysis, the correlation coefficient between two items: 'I have confidence understanding how difficult the learning contents are.' and 'I have confidence understanding lessons in which complex contents are covered.' showed more than .90. Accordingly, taking into account the multicollinearity between observed variables, which might cause the problem of non-positive definite matrix in parameter estimation (Lee, 2005), the first item was excluded in the analysis.

the means of the scores of five, three and six items respectively. The between-level variables were observed by using the aggregated values for school unit. <Table 1> summarizes the detailed content of variables in the study.

<Table 1> Research Variables

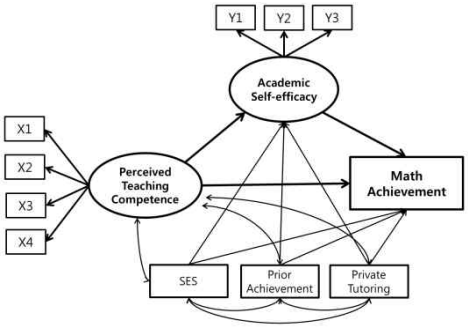
Level	Variables	Measurement Items
Dependent Variable	Math Achievement	· raw scores of math in the 3rd grade of middle school
Student Level Variables	Perceived Teaching Competence*	· Teachers have a lot of subject knowledge. · Teachers convey the lesson intelligibly. · Teachers check for students' understanding in the classroom. · Teachers teach students in accordance with their levels.
	Academic Self-Efficacy*	· I have confidence understanding lessons in which complex contents are covered. · I have confidence doing homework well. · I have confidence applying what I learn skilfully.
	SES	· z-score of transformed values from mother's level of education into years of education · z-score of transformed values from father's level of education into years of education · z-score of transformed values from family's monthly income (unit: 10,000 Won) to natural log · mean of the three z-scores
	Private Tutoring Participation	· participation in private tutoring related to math · 0: non participation, 1: participation
	Prior Achievement	· raw scores of math in the 2nd grade of middle school
School Level Variables	Teacher Efficacy*	· I can grasp the reason why students do not concentrate on lesson. · I can assess students' academic abilities. · I can change teaching methods according to the subject-matter. · I can grasp the degree of students' attention in classes. · I can analyze the reasons why students are not interested in learning.
	Teachers' Morale and Enthusiasm*	· I have a high level of morale. · I work with enthusiasm. · I take pride in my school.
	Teaching Satisfaction*	· I am satisfied with my occupation as a teacher. · I am satisfied with works as a teacher. · I will be a teacher if I have an opportunity to choose my career again. · I live with an expectation of my school everyday. · I feel proud of my school. · Teaching in my school is helpful to my personal development.
	School Mean SES	· mean of the aggregate SES at the school level

*Scale: 1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree

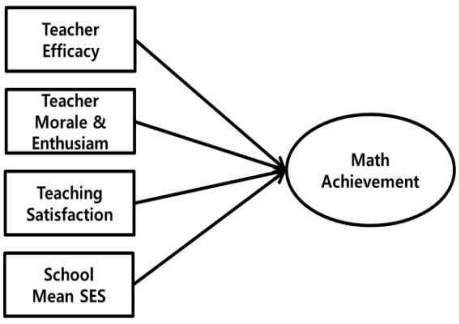
3. The research model

This study identified the indirect effect of academic self-efficacy in the relationship between teaching competencies perceived by students and their math achievement with a consideration of the multi-level data structure. Specifically, as a multi-level SEM was applied to take into account students and teachers nested within schools, a multi-level SEM method has advantages in that the variances of dependent variables are partitioned into two levels and this approach overcomes the limitation of underestimation of standard errors by a single level SEM[3](Ronald and Scott, 2015; Wang and Wang, 2012). In this study, MLR was applied to provide robust estimates for the analysis with missing data(Wang and Wang, 2012).

By taking into account these advantages, this study was designed as follows. First, We estimated the explained variance of achievement at each level and ICC(Intra Class Correlation) by using the baseline model of the multi-level SEM. Second, 'Model 1' is the model that hypothesizing the mediating effect of academic self-efficacy in the relationship between perceived teaching competencies and math achievement without covariates. Finally, 'Model 2(The final research model)' is the model adding the student and school-level covariates to 'Model 1'. In the study we tested the mediating effect of academic self-efficacy in the relationship between perceived teaching competencies and math achievement after student and school-level confounding variables were controlled. The final model can be described as [Figure 1] and [Figure 2] at the student and school-level model respectively.



[Figure 1] Student-Level Model



[Figure 2] School-Level Model

3) We compared the results of estimated standard errors between a multi-level SEM and a single level SEM in the <appendix 1>.

Ⅳ. Results

1. Correlations among main study variables and descriptive statistics

The results of correlations between the variables we observed at the student- and school-level can be seen in <Table 2> and <Table 3> respectively. All of the correlations between the student variables were shown statistically significant at the .01 level. Particularly, positive but relatively low correlations between middle school students' perceptions of teaching competencies and their math achievement were shown in contrast to the highest positive correlation with prior achievement.

<Table 2> Correlation Coefficients for the Student-Level Variables

	Academic Self-Efficacy			Math Achievement	Perceived Teaching Competence				SES	Private Tutoring Particip-ation	Prior Achieve-ment
	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	.630**	1									
3	.727**	.725**	1								
4	.383**	.317**	.347**	1							
5	.198**	.263**	.240**	.189**	1						
6	.269**	.280**	.276**	.218**	.681**	1					
7	.228**	.256**	.246**	.190**	.652**	.795**	1				
8	.263**	.278**	.282**	.214**	.634**	.811**	.798**	1			
9	.245**	.202**	.205**	.372**	.084**	.103**	.081**	.094**	1		
10	.197**	.215**	.210**	.327**	.104**	.134**	.120**	.138**	.245**	1	
11	.406**	.347**	.359**	.676**	.179**	.198**	.182**	.201**	.364**	.301**	1

** p<.01

<Table 3> Correlation Coefficients for the School-Level Variables

	Teacher Efficacy	Teacher Morale & Enthusiasm	Teaching Satisfaction	School Mean SES	Math Achievement
1	1				
2	.313**	1			
3	.240**	.842**	1		
4	.139**	.109**	−.072**	1	
5	.054**	.062**	−.017	.368**	1

** p<.01

At the school level, the results revealed the correlations to be statistically significant at the .01 level with the exception of the correlation between teaching satisfaction and math achievement. Specifically, students' math achievement had significant correlations with teacher efficacy, teacher morale and enthusiasm, and the school mean SES.

Next, according to descriptive statistics of the main study variables summarized in <Table 4>, there was a huge difference in the dependent variable, math achievement among students with respect to the mean(=45.49) and standard deviation(=24.86). In addition, teacher efficacy scores measured by teacher surveys tended to be relatively higher than their teaching competencies perceived by students.

<Table 4> Descriptive Statistics of Student-level and School-level Variables

Level	Variables	Mean	Standard Deviation	Skewness (S.E)	Kurtosis (S.E)
Student Level	Academic Self-Efficacy1	3.12	1.033	−.081(.040)	−.472(.080)
	Academic Self-Efficacy2	3.44	.978	−.337(.040)	−.101(.080)
	Academic Self-Efficacy3	3.34	.951	−.243(.040)	−.087(.080)
	Math Achievement	45.49	24.86	.479(.040)	−.839(.080)
	Perceived Teaching Competence1	4.00	0.89	−.697(.040)	.402(.080)
	Perceived Teaching Competence2	3.74	1.02	−.553(.040)	−.052(.080)
	Perceived Teaching Competence3	3.74	1.01	−.542(.040)	−.020(.080)
	Perceived Teaching Competence4	3.70	1.01	−.488(.040)	−.066(.080)
	SES	0.00	2.29	.101(.039)	.414(.077)
	Private Tutoring Participation	0.67	0.47	−.719(.040)	−1.484(.080)
	Prior Achievement	55.08	24.37	.150(.039)	−.999(.079)
School Level	Teacher Efficacy	4.10	0.15	−.273(.038)	−.577(.077)
	Teacher Morale & Enthusiasm	3.96	0.24	−.357(.038)	−.721(.077)
	Teaching Satisfaction	3.73	0.27	.032(.038)	−.672(.077)
	School Mean SES	−0.01	0.42	.705(.038)	−.144(.077)

2. Analysis Results

Before analyzing the research model, we examined ICC with its baseline model. By partitioning variance of math achievement, which is the dependent variable in this study, school-level variance and student-level variance were estimated to be 117.812 and 504.314 respectively, thus ICC was 0.189. If the ICC of a variable is above 5%, the variable is considered to have differences across groups in general(Kang et al., 2005). In this study, 19% of the total variance seemed to be explained by school-level variables.

<Table 5> Summary of Fit Results for Research Model

Model	χ^2	df	CFI	TLI	RMSEA
Model 1 (without covariates)	109.571***	18	.991	.987	.037
Model 2 (with covariates)	201.580***	36	.991	.983	.034

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

Fit indices of the model where we put variables at each level were suggested in <Table 5>. The 'model 1' where we set only teaching competencies and academic self-efficacy at the student-level and the 'model 2' where student-level covariates(SES, private tutoring participation, and prior achievement) and school-level covariates(teacher efficacy, teacher morale and enthusiasm, teaching satisfaction, and the school mean SES) were added, both models have good fit indices except for χ^2 statistic. Although χ^2 statistic is capable of testing statistical difference between a sample covariance matrix and a model covariance matrix, there is the downside that the statistic is proportional to the number of sample and therefore, the test easily rejects the null hypothesis(Anderson and Gerbing, 1984). Instead, CFI and TLI, the incremental fit indices which was calculated by comparison with the baseline model, based on the χ^2 statistic, satisfied the general standard, .90[4], and RMSEA, which means the approximate fit of a model covariance matrix, to a sample covariance matrix, also appeared to be acceptable (Kline, 2005).

4) It should be taken into account that fit indices such as CFI, TLI were suggested in the context of a single level SEM. Therefore, multi-level models which have more parameters than the identical single level models, might have lower fit indices. There is no consensus or sufficient research on the issues of fit indices for multi-level models at the present time.

<Table 6> Unstandardized and Standardized Coefficients of Models

Level	Path		Model 1 (without covariates)				Model 2 (with covariates)			
			Unstandardized		Standardized		Unstandardized		Standardized	
			Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Student Level	Perceived Teaching Competence	→ Academic Self-Efficacy	0.324***	0.022	0.350***	0.022	0.239 ***	0.021	0.259 ***	0.022
	SES	→ Academic Self-Efficacy	–	–	–	–	0.032 ***	0.008	0.085 ***	0.020
	Private Tutoring Participation	→ Academic Self-Efficacy	–	–	–	–	0.157 ***	0.034	0.088 ***	0.018
	Prior Math Achievement	→ Academic Self-Efficacy	–	–	–	–	0.011 ***	0.001	0.318 ***	0.018
	Perceived Teaching Competence	→ Math Achievement	2.679***	0.527	0.110***	0.021	1.236 **	0.424	0.049 **	0.016
	Academic Self-Efficacy	→ Math Achievement	9.623***	0.532	0.366***	0.017	3.179 ***	0.500	0.115 ***	0.018
	SES	→ Math Achievement	–	–	–	–	0.709 ***	0.159	0.069 ***	0.015
	Private Tutoring Participation	→ Math Achievement	–	–	–	–	4.712 ***	0.649	0.095 ***	0.013
	Prior Math Achievement	→ Math Achievement	–	–	–	–	0.540 ***	0.024	0.560 ***	0.020
School Level	Teacher Efficacy	→ Math Achievement	–	–	–	–	2.714	4.101	0.077	0.113
	Teacher Morale & Enthusiasm	→ Math Achievement	–	–	–	–	6.776	5.492	0.265	0.213
	Teacher Satisfaction	→ Math Achievement	–	–	–	–	−6.661	5.121	−0.294	0.219
	School Mean SES	→ Math Achievement	–	–	–	–	0.382 *	0.171	0.496 **	0.180

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

Unstandardized and standardized coefficients, and corresponding standard errors of the research model were presented in <Table 6>. Firstly, the perceived teaching competence still had a statistically significant impact on the mediating variable, academic self-efficacy, even though the effect of the variable was reduced by adding student and school-covariates. In particular, as reported in the standardized result, the perceived teaching competence appeared to be more influential on academic self-efficacy than SES and private tutoring participation. The result implied that teaching competence perceived by students had a more

significant influence on their self-efficacy than students' prior characteristics such as SES and the participation in private tutoring.

A detailed explanation of other variables was elaborated with the result of direct, indirect and total effect in <Table 7>.

<Table 7> Direct Effects, Indirect Effects and Total Effects on Math Achievement

Level	Path	Model 1 (without covariates)			Model 2 (with covariates)		
		Direct Effect (S.E)	Indirect Effect (S.E)	Total Effect (S.E)	Direct Effect (S.E)	Indirect Effect (S.E)	Total Effect (S.E)
Student Level	Perceived Teaching Competence	0.110 ** (0.021)	0.128 *** (0.010)	0.238 *** (0.022)	0.049 ** (0.016)	0.030 *** (0.005)	0.079 *** (0.016)
	Academic Self-Efficacy	0.366 *** (0.017)	–	0.366 *** (0.017)	0.115 *** (0.018)	–	0.115 *** (0.018)
	SES	–	–	–	0.069 *** (0.015)	0.010 ** (0.003)	0.079 *** (0.016)
	Private Tutoring Participation	–	–	–	0.095 *** (0.013)	0.010 *** (0.003)	0.106 *** (0.014)
	Prior Math Achievement	–	–	–	0.560 *** (0.020)	0.037 *** (0.006)	0.597 *** (0.018)
School Level	Teacher Efficacy	–	–	–	0.077 (0.113)	–	0.077 (0.113)
	Teacher Morale & Enthusiasm	–	–	–	0.265 (0.213)	–	0.265 (0.213)
	Teacher Satisfaction	–	–	–	−0.294 (0.219)	–	−0.294 (0.219)
	School mean SES	–	–	–	0.496 ** (0.180)	–	0.496 ** (0.180)

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

The direct, indirect and total effects of student and school-level variables on math achievement were suggested in <Table 7>[5].

The findings of this study are summarized as follows. First, in 'model 1', the direct effects of teaching competence and academic self-efficacy on math achievement have been found positive and statistically significant(p<.001). In addition, teachers' teaching competence had an

5) Only standardized coefficients were reported in the table.

indirect positive effect with the mediating effect of academic self-efficacy and the indirect effect(.128) was larger than the direct one(.110). When comparing the two direct effects, the influence of academic self-efficacy on math achievement appeared to be approximately three-times as large as that of teachers' teaching competencies. The total effect of academic self-efficacy on math achievement was also larger than that of teachers' teaching competence.

Second, in 'model 2' where student and school-level covariates were controlled, the effects of teaching competence and academic self-efficacy on math achievement were estimated to be smaller than the effects in 'model 1'. This result implies that the effects in 'model 1' might be overestimated without controlling for covariates; therefore, it is necessary to include relevant covariates in multi-level SEM models such as multi-level linear models. Also, the direct effect of teachers' teaching competence was larger than the indirect effect, which was contrary to the result of 'model 1'. This was because the direct effect of academic self-efficacy decreased more significantly than the effect of teachers' teaching competence on students' math achievement after controlling for covariates. That is, the covariates in 'model 2' were more closely related to academic self-efficacy than teachers' teaching competence, and accordingly the mediating effect largely decreased.

In summary, the results indicated that teachers' teaching competence had an indirect effect with the mediating effect of academic self-efficacy as well as a direct effect on math achievement. In sum, with the student and school-level variables predicting math achievement controlled for, the more positively students perceived teachers' teaching competence, the higher their academic self-efficacy and performance were likely to be. We could also verify academic self-efficacy as a major mediating variable in the relationship between the perceived teaching competencies and math achievement.

V. Discussion

In this paper, we analyzed the mediating effect of academic self-efficacy in the relationship between middle school students' perceptions of teaching competencies and math achievement, using the GEPS based on a multi-level SEM methodology. The results and implications of this study are described below.

First, with regard to the effect of perceived teaching competencies on math achievement,

the indirect effect of the mediation role of academic self-efficacy as well as the direct effect were statistically significant with student and school-level variables controlled. This finding implied that the more positively middle school students perceived teachers' teaching competencies, the higher their academic self-efficacy was likely to be, which had a positive impact on math achievement.

Instructors' teaching competence has a strong influence on students' learning process and math achievement. Particularly, this study focused on math teachers' teaching ability as perceived by the students considering that the perceptions of students as an educational consumer were likely to be more objective than teachers' self-assessment. The study tried to investigate the hypothesis that teachers' teaching competence can have direct and indirect effects on math achievement mediating learners' affective factors, particularly academic self-efficacy highly correlated with math achievement(So, 2008). Results also indicated that the magnitude of the indirect effect mediated by academic self-efficacy was statistically nearly equivalent to that of the direct effect on students' math achievement. This provided a range of suggestions for an improvement of current practices, starting with the reorganization of classes and the process of teaching and learning in order to develop students' academic self-efficacy as well as math achievement. Thus, it could be argued that overall support in terms of teachers' efforts, school climates and curriculum are needed. Our findings have educational implications in terms of providing empirical evidence on the effects of learners' affective factors such as perceptions toward teachers and self-efficacy on math achievement.

Second, the direct, indirect and total effect size of perceived teaching competencies on math achievement differed between the research models in the study. A model without covariates often overestimated coefficients in comparison to the model with covariates. In addition, the indirect effect of the mediation effect of academic self-efficacy was relatively larger than the direct effect of teaching competence in this study. In contrast, the effects of perceived teaching competencies on math achievement were considerably decreased in the model with student and school-level variables controlled. The direct effect of perceived teaching competencies was larger than the indirect effect in the model. This leads to the conclusion that confounding variables in the research model were closely related to academic self-efficacy because the direct effect of academic self-efficacy on math achievement substantially decreased after controlling for the these variables.

In this regard, numerous studies using an SEM approach had the limitation that

confounding variables, which had significant impacts on dependent variables, were not considered in the model. The biases caused by the omitted variables can lead to the overestimation of coefficients(Kim et al., 2011; Lim and Lee, 2016; Park, 2012). Inconsistent with previous studies, the results of the current study revealed that the bias of estimates was considerably reduced after controlling for the student and school-level variables predicting math achievement. Indeed, differences between the total effect of teachers' teaching competence and academic self-efficacy on math achievement were reduced after controlling for covariates in the study. In comparing the effects of teaching competence and academic self-efficacy on math achievement, reduced OVB(omitted-variable bias) by including covariates in the model led to relatively smaller differences between each effect size. By the same token, it is necessary to consider covariates in an SEM approach which is prone to omit confounders in terms of controlling sources of bias(Ye and Kaskutas, 2009). Furthermore, a multi-level SEM should be applied to reflect the influences of group-level variables in the nested structure of the model more precisely.

Based on these findings, the limitations of this study and suggestions for a further research are as follows. First, due to the analysis of the cross-sectional data in the third year of middle school, there might be discrepancies in the relationship between perceived teaching competence, academic self-efficacy and achievement in the first or second grade. In this sense, further considerations in testing the serial correlations using the longitudinal data are required to more thoroughly investigate the causality and pattern of changes between the variables.

In addition, owing to the limited data set, we included general school-level variables in the final model instead of more specific variables related to math teachers or math class which have a direct effect on students' math achievement. As a result, coefficients of school level variables were not statistically significant.

We recommend that additional covariates which are closely related to academic self-efficacy and achievement such as gender, learning motivation and strategies, study time allocation, and parental support be explored(Hwang and Kim, 2010; Ju, 2011), and that future researches using a multi-level SEM methodology consider methods of controlling for these covariates to provide more precise results of analysis.

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Appendix

<Appendix 1> Comparison the Results between the Single and Multi-Level SEM

Level	Independent Variables	Multi-Level SEM			Single-Level SEM		
		Direct Effect (S.E)	Indirect Effect (S.E)	Total Effect (S.E)	Direct Effect (S.E)	Indirect Effect (S.E)	Total Effect (S.E)
Student Level	Perceived Teaching Competence	.049** (.017)	.041*** (.007)	.090*** (.017)	.052*** (.014)	.036*** (.006)	.088*** (.013)
	Academic Self-Efficacy	.114*** (.019)	–	.114*** (.019)	.102*** (.016)	–	.102*** (.016)
	SES	.072*** (.016)	–	.072*** (.016)	.107*** (.014)	–	.107*** (.014)
	Private Tutoring Participation	.099*** (.013)	–	.099*** (.013)	.110*** (.013)	–	.110*** (.013)
	Prior Math Achievement	.579*** (.019)	–	.579** (.019)	.560*** (.014)	–	.560*** (.014)
School Level	Teacher Efficacy	.078 (.113)	–	.078 (.113)	.007 (.012)	–	.007 (.012)
	Teacher Morale & Enthusiasm	.263 (.213)	–	.263 (.213)	.058* (.023)	–	.058* (.023)
	Teacher Satisfaction	−.292 (.218)	–	−.292 (.218)	−.069** (.022)	–	−.069** (.022)
	School Mean SES	.501** (.140)	–	.501** (.140)	.047 (.036)	–	.047 (.036)

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