韓國數學教育學會誌 시리즈 A <數學教育>
https://doi.org/10.7468/mathedu.2018.57.4.393
2018. 11. 제 57권, 제 4호, 393-412.

J. Korean Soc. Math. Ed. Ser. A:
The Mathematical Education
November. 2018, Vol. 57, No. 4, 393-412.

The impacts of teacher education on students' academic achievement and satisfaction in mathematics lessons

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Ⅰ. Introduction

Teacher is one of the core factors that determine the quality of school education. South Korea's 2015 revised curriculum emphasizes areas that tended to receive little attention in traditional South Korea's education: creativity, character-building, and career education. It also discusses what teaching-learning method should be used to manifest these areas in classrooms. In particular, 2015 revised mathematical curriculum indicates inquiry learning, project-based learning, discussion and debate-based learning, cooperative learning, medium and instrument-based learning as a set of teaching-learning methods that should be introduced into classrooms. In addition, the curriculum asks to introduce innovative evaluation methods such as project-based evaluation, portfolio assessment, and evaluation through observation.

Needless to say, teachers' role is crucial to developing students' affective and cognitive aspects. The development can be achieved when teachers implement the methods recommended by the revised curriculum. To support teachers' aligning their teaching-learning methods with the curriculum, Ministry of Education and Metropolitan and Provincial Offices of Education have been providing numerous professional development programs. Moreover, teachers themselves worked to improve their professionalism using class improvement activities such as an open class, colleague observation, subject council activity, class consulting, participating in a research group, and the forth.

In essence, the end goal of the improvement of teacher professionalism is to provide education for the learners. Therefore, it is necessary to verify the effectiveness of the various approach used to improve teacher professionalism. To this end, this study's purpose and research questions are as below.

1. Purpose of the study

The purpose of the study is to explore how various approaches used to improve teacher professionalism impact students' achievement in mathematics and their degree of satisfaction in mathematics lessons and teacher class activity. Another purpose of the study is to suggest implications for educational policy that supports improvement of students' course satisfaction and academic achievement.

* 접수일(20180년 10월 5일), 수정일(1차: 2018년 11월 8일, 2차: 2018년 11월 28일), 게재확정일(2018년 11월 28일)
* ZDM 분류: C70
* MSC2000분류 : 97C70
* 주제어: 교사교육, 혼합분석모형, 학업성취도, 수업만족도
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* 이 논문은 2018년도 정부(미래창조과학부)의 재원으로 한국연구재단의 지원을 받아 수행된 기초연구사업임(No. 2017R1E1A1A03070637)

2. Research questions

Question 1: Do teachers' participation in class improvement activities and participation time in professional development positively influence students' academic achievement and satisfaction in mathematics lessons and mathematics teachers?

Question 2: How different are the relationships among the variables (i.e., teacher- and student-factors, students' academic achievement, and course satisfaction) across grade levels (i.e., 3rd grade in middle school, 1st and 3rd grades in high school)?

Ⅱ. Theoretical Background and Literature Review

This study aims to understand effectiveness of self- and externally-motivated efforts for improving instructional professionalism and these efforts influence students' course satisfaction and academic achievement. Therefore, in this section we discuss (1) teachers' effort for improving teaching practice, (2) teacher variable and student achievement, and (3) students' course satisfaction.

1. Efforts for improving teaching practice

Teachers have been investigating range of forms of professional developments. A professional development can be either an individual or a group activity. Action research is an example of an individual professional development (Atweh & Ochoa, 2001; Reason & Bradbury, 2001). Besides individual activity, teachers can collaborate by forming a study group with a specific purpose. Lesson study is a collaboration-based professional development that takes place in a local context (Dudley, 2013; Lewis & Perry, 2006). Because of the strong collaborative features of the process, lesson study is best for the teachers who can regularly and frequently hold meetings. More recently, educators are integrating online space to professional development (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2008; Fishman et al., 2013; Hur & Brush, 2009). In a hybrid professional development program of on-site and online communications, teachers designed educative curriculum materials that include teacher narratives and online forum (Barbosa & de Oliveira, 2014). While online forum is a simple method to integrate online space, other options such as virtual environments, augmented realities, and mental modeling from networking exists (Dede et al., 2008). These research shows that professional developments take various forms: from individual to group activity, and from school-based to web-based environment.

Across these various forms of professional developments, researchers suggest that a strong and clear focus on the content is important for a professional development to be effective (Harris & Sass, 2008). In addition, sustainability of professional developments was found to be significant (Capraro et al., 2016; Garet, Porter, Desimone, Birman, & Yoon, 2001; Han, 2013). Professional developments incorporating technology (Denton, Davis, Smith, Beason, & Strader, 2005), self-evaluation process (Duff, Brown, & van Scoy, 1995; Guskey, 2003), and teachers with distinct backgrounds (Corlu, 2012) were also found to contribute to the effectiveness of professional developments. A safe and trusting environment that allows creative dissonance among teachers, too, are crucial for a professional development to be effective (Ball & Cohen, 1999; Crespo, 2006, Males, Otten, & Herbel-Eisenmann, 2010).

The end goal of professional development is to positively impact student learning and behavior. To impact students, teachers should be open to changing their practice as needed. Some researchers asserted that change on one's belief bring changes to their practice (Camburn & Han, 2015; William, 2010). Taken

together, teacher professionalism can be examined in light of student impact, teacher practice, and teacher beliefs. In fact, some professional developments have been aiming to change teachers' belief (e.g., Timperley & Phillips, 2003), while others more directly attended to changes in practice (e.g., Bausmith & Barry, 2011). Unfortunately, only small number of research had clear focus on student impact such as their learning and/or behavior (Sedova, Sedlacek, & Svaricek, 2016; Vogt & Rogalla, 2009). Researchers have been addressing the lack of attention to the impact of professional development on student learning (Antoniou & Kyriakides, 2013; Cochran-Smith & Zeichner, 2005; Meiers & Ingvarson, 2005). This study contributes to the research that foreground the impact of teacher professional development on students, including students' class participation attitudes and degree of course satisfaction.

2. Teacher variable and student achievement

With student, teacher is an important authority of school classroom. Class situation works by the two authorities - teacher and students - interacting together (e.g., Yackel, 1996). The interaction is affected by characteristics of the two authorities. In other words, teachers' teaching-learning methods and pedagogical approach changes according to student characteristics, which in turn may impact both teacher characteristics and students' academic achievement. Therefore, education researchers and policy makers have consistently paid attention to and examined teacher characteristics' impact on students (Kim & Cha, 2003; Lee & Chung, 2011). The results show that some of the teacher variables have significant effect on students' academic achievement (Lee & Chung, 2011). Teachers' gender have statistically significant effect on students' math academic achievement (Lee & Chung, 2011), and teachers' career and teacher efficacy had indirect effect on students' academic achievement (Kim & Cha, 2003). In other words, teachers' efficacy had no direct effect on students' academic achievement, but it increased students' self-efficacy, which in turn enhanced students' academic achievement. On the other hand, teachers' level of education and their college major did not have significant effect on students' math academic achievement (Lee & Chung, 2011).

The research examined so far suggests that teacher education have no homogeneous impact on students' academic achievement. For example, Jacob and Lefgren(2004) showed that professional development on elementary school teachers has no positive effect on students' achievement. Such result was due to that the professional development was not aligned with curriculum, and the school that teachers were in was located at an area with low socio-economic status. Similar result were found in South Korea's research using the data from Trends in International Mathematics and Science Study(TIMSS). Teachers' participation in professional development for last two years had no significant effect on students' math score (Lee & Chung, 2011). On the other hand, there were research that reported positive effect of teacher professional development on students' academic achievement. For instance, in the research on teachers' professional development's effect on students' academic achievement, Siegle and McCoach(2007) showed that new teaching-learning method has positive effect on students' academic achievement.

There was also a teacher variable that brought different results depending on the research. Lee and Chung(2011) reported that teachers' degree of preparation of class has no significant effect on students' math academic achievement, but in the research by Kang(2001) and Nam and Lee(2002), it was found to have a positive effect.

To examine the impact of teacher professionalism on students, prior research used students' academic achievement and exam scores as criteria for measuring the effect. This, however, did not actually measure teachers' professionalism. Rather it regarded the effect of teachers' characteristics on students' academic achievement as an indirect effect of teachers' professionalism on students' academic achievement. For example, when analyzing the effectiveness of teachers' professional development, rather than measuring teachers' professionalism, they regard degree of increase in students' academic achievement due to teacher professional development, as improvement in teachers' professionalism. To build on prior work on this matter, this study considered teacher professionalism using the following variables: class improvement activities, time spent on professional development (both curriculum related and extra-curriculum related), and teaching methods (instructional organization, instructional activities, and encouragement activities).

3. Course satisfaction

Teachers' and students' course satisfaction can be seen as a result of course effectiveness (Sung, Leem, & Kim, 2010; Pyo, Lee, & Jeong, 2010). From the teachers' perspective, course satisfaction means the degree of their achievement of the learning goals that they set up by themselves. Therefore, teachers' course satisfaction is affected by what goals the teacher set up as well as teachers' instructional professionalism that can make them reach the goal. Students' course satisfaction means "overall degree of satisfaction from learning activities and experiences, consistent class participation rate, etc." (So, 2012, p. 69). In other words, students' satisfaction is determined by whether their interest on class material and activities planned by teachers and/or whether their cognitive curiosity is fulfilled by reaching the learning goals.

Researchers have been attempting to improve students' course satisfaction, but research on identifying specific factors on their satisfaction is extremely limited. Kang and Park(2010), in research on creative instruction, showed that teachers' effort on lesson planning, and student supporting action during the class, have effect on students' course satisfaction. Students' course satisfaction ultimately has positive effect on students' increase in creativity (Begghetto, 2010). Previous research focused on students' course satisfaction itself, but it lacked on connecting students' course satisfaction with students' achievement and understanding.

To supplement the shortcomings of previous research, this research linked the effect of teachers' efforts to improve lesson quality to teachers' and students' satisfaction as well as students' achievement and comprehension.

Ⅲ. Methods

1. Sample

This research used 3rd, 4th, and 6th years data from Seoul Educational Longitudinal Study(SELS) to analyze the effect of teachers' factors (i.e., class activity variables) on students' academic achievement and course satisfaction related to mathematics. Seoul Metropolitan Office of Education collected SELS data to track students' affective and cognitive growth longitudinally and provide it to education researchers and policy makers since 2010. The SELS survey includes about 53 items regarding students' school life, lessons, after school activities, and students' learning and psychological characteristics.

The samples were middle school students (n=2,981) who were enrolled in 240 schools located in Seoul in 2012. Of 2,981 students, 1,329 were boys (44.6%) and

1,622 were girls (54.4%) (there were 30 missing values).

2. Variables

This research used three exogenous variables, seven mediation variables, and three dependent variables. Student and teacher variables were selected based on previous studies analyzing the impact of teacher education programs on students. According to the purpose of the study, independent variables and dependent variables were set up as teachers' participation in professional development programs and students' academic achievement and satisfaction, respectively. Moreover, mediation variables were included based on the previous studies regarding students' attitudes toward mathematics lessons (Kim & Cha, 2003), teachers' instructional methods (Harris & Sass, 2008), usage of technology tools and extra learnng materials (Denton et al., 2005; Lee and Chung, 2011), and evaluation forms(Duff et al., 2005). Based on this, following variables were selected. Among exogenous variables, one variable represented mathematics teachers' participation in class improvement activity, which was calculated as a mean of the six items in six-point scale (1=Did not participate, 2=once a year, 3=twice a year, 4=three times a year, 5=four times a year, 6=More than five times a year). The other two exogenous variables indicated mathematics teachers' participation time in professional development program. Severn items were regarding how many hours mathematics teachers participated in professional development program, which were coded as 1=did not participate; 2=less than 30 hours; 3=31-45 hours; 4=46-60 hours; 5=more than 61 hours. Because there were two types of professional development program, which was drawn from EFAs and CFAs, variables representing teachers' participation time in professional development program were also divided into two: curricular related professional development (three items) and extra-curricular related professional development (four items).

Mediation variables were regarding mathematics teachers' actual class activity and students' class atmosphere and attitude. The variable representing students' attitude toward mathematics lessons was calculated as a mean of the five items, which were measured in five-point scale (1=Not at all ~ 5=Very much). Students' perception on mathematics class atmosphere was also calculated as a mean of the two items in five-point scale (1= Not at all ~ 5=Very much) and one of the items (i.e., Loud and Disordered) was oppositely coded. As the results from EFA and CFA, items regarding mathematics teachers' teaching method were grouped into three factors: instruction organization (two items), instructional activities (seven items), and student encouragement activities (four items). For each factor, means were used as composite variables. Mathematics teachers' instruction for creativity was computed as a mean of the six items in five-point scale (1=Not at all~ 5=Strongly Agree). The use of EBS[1] textbooks and materials was a mean of the two items asking about the use of textbooks and videos in four-point scale (1=Does not use at all ~ 4=Use frequently). The use of online instructional materials was calculated as a sum of the eight items in five-point scale (1=Does not use at all, 2=once a month, 3=twice a month, 4=three times a month, 5=more than four times a month). Last, the use of descriptive evaluation approach was the value representing how much of percentage teachers use for descriptive evaluation in their midterm/final tests. (0=0%, 1=1~10%, 2=11~20,

1) Educational Broadcasting System(EBS) is a broadcasting channel with an aim to enhance equity in education. Currently, Korean SAT developers have to design the tasks so that at least 70% of the SAT reflect contents from EBS.

9=81~90%, 10=100%). Medication variables such as the use of EBS textbooks and materials, online instructional materials, and descriptive evaluation were included in the analyses because these variables were regarded as critical factors influencing students' academic achievement and satisfaction, and being affected from teachers' participation in professional development programs even though these variables were not directed related to the purposes of the study.

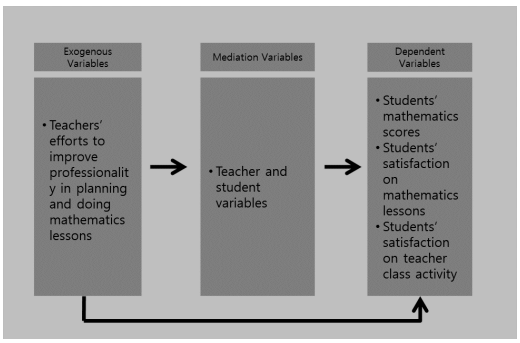
Dependent variables were students' mathematics class satisfaction and achievement. Detailed definition and explanation of variables are as following. Students' satisfaction in mathematics lessons was a mean of two items in five-point scale (1=Not at all ~ 5=Strongly agree). Students' satisfaction in teacher class activity was a mean of seven items in five-point scale (1=Not at all ~ 5=Strongly agree). Mathematics achievement was represented as a vertical scaling score, which was used to standardize students' achievement scores.

3. Analysis

This research targets to analyze the difference of school, teacher and student variable by researching causal relationship of them using three-year longitudinal data. This research used path analysis using structural equational modeling (SEM) as the main approach, but when needed, used latent profile analysis (LPA), which is a kind of mixture modeling analysis (MMA). MMA premises on mixed composition of groups from qualitatively different population and is a method that divides data into finite latent subgroups based on the similarity of groups' response variable pattern (Muthen & Muthen, 2015). Depending on characteristics of measured variable, MMA is named as latent class analysis (LCA), if the variables are categorically observed variables, and as LPA, if the variables are continuous observed variables (Villalta-Cerdas, McKeny, Gatlin, & Sandi-Urena, 2015).

When analyzing the data for 3rd grade in middle school and 1st grade in high school, Sympson's Paradox was suspected because there was a suppression effect, where in correlation analysis. That is, even though there was a positive correlation, but the path coefficient was negative in causal relationship analysis (Arah, 2008; Pearl, 2009). Sympson Paradox is a phenomenon that occurs when contradicting result occurs for third specific variable when quantitatively latent subgroups and integrated group are measured.

To resolve this, we conducted LPA for the data of 3rd grade in middle school and 1st grade in high school because the data were continuous observed variable. Suppression Effect did not occur in the data of 3rd grade high school students. Therefore, we used path analysis assuming the data is a single integrated group. Outside of that, we underwent exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) on seven items asking participation in professional development activity and 13 items asking about class method and defined the measuring variables in detail. The research model was described in Figure 1.



[Figure 1] The research model

Ⅳ. Results

1. Descriptive statistics

Descriptive statistics (minimum and maximum values, means, standard deviations) of student and teacher variables used in the research were reported in Table 1-3. The means of student and teacher variables were changed throughout the three years. Among the variables, the one that has changed the most was whether students and teachers used EBS in classes. The reason for this might be because teachers who were in charge of 3rd grade high school classes used EBS textbooks and class materials more than those in charge of 3rd grade middle school classes.

[Table 1] Descriptive statistics of the 3rd grade in middle school (2012) data

Student Variable	*N*	Minimum	Maximum	Mean	Standard Deviation
Student's attitude toward mathematics lessons	2858	1	5	3.518	0.925
Student's satisfaction in teacher class activity	2858	1	5	3.859	0.786
Student's perception on mathematics classroom atmosphere	2858	1	5	3.180	0.836
Student's mathematics course satisfaction	2858	1	5	3.126	0.935
Mathematics achievement score	2858	413	678	550.72	47.750
Teacher Variable	***N***	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Teacher's participation in class improvement activity	2858	1	5	2.403	0.744
Teacher's participation time in professional development program (curriculum related)	2858	1	5	1.603	0.599
Teacher's participation time in professional development program (extra-curriculum related)	2858	1	2.75	1.493	0.440
Teacher's teaching method -instructional organization	2858	2	5	4.019	0.543
Teacher's teaching method -instructional activities	2858	3	5	4.045	0.430
Teacher's teaching method -encouragement activities	2858	2	5	3.588	0.585
Teacher's instruction for creativity	2858	2.5	5	3.784	0.500
Use of online instructional materials	2858	8	36	14.06	4.633
Use of descriptive evaluation	2858	0	5	2.25	1.035
Use of EBS textbooks and materials	2858	0	8	0.55	1.562

[Table 2] Descriptive statistics of the 1st grade in high school (2013) data

Student Variable	*N*	Minimum	Maximum	Mean	Standard Deviation
Student's attitude in mathematics lessons	2981	1	5	3.431	0.936
Student's satisfaction in teacher class activity	2981	1	5	3.895	0.750
Student's perception on mathematics classroom atmosphere	2981	1	5	3.285	0.898
Student's mathematics course satisfaction	2981	1	5	3.131	0.946
Mathematics achievement score	2981	433	700	550.516	37.921
Teacher Variable	***N***	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Teacher's participation in class improvement activity	2981	1	5.33	2.026	0.658
Teacher's participation time in professional development program (curriculum related)	2981	1	5	1.383	0.555
Teacher's participation time in professional development program (extra-curriculum related)	2981	1	4	1.335	0.470
Teacher's teaching method -instructional organization	2981	2.5	5	3.922	0.571
Teacher's teaching method -instructional activities	2981	2.71	5	3.896	0.430
Teacher's teaching method -encouragement activities	2981	1.25	5	3.518	0.625
Teacher's instruction for creativity	2981	2	5	3.758	0.524
Use of online instructional materials	2981	2	40	11.29	3.952
Use of descriptive evaluation	2981	1	10	2.96	1.200
Use of EBS textbooks and materials	2981	0	8	1.55	2.595

[Table 3] Descriptive statistics of the 3rd grade in high school (2015) data

Student Variable	N	Minimum	Maximum	Mean	Standard Deviation
Student's attitude in mathematics lessons	2378	1	5	3.278	1.039
Student's satisfaction in teacher class activity	2378	1	5	3.878	0.718
Student's perception on mathematics classroom atmosphere	2378	1	5	3.461	0.779
Student's mathematics course satisfaction	2378	1	5	2.864	0.918
Mathematics achievement score	2378	452	712	556.26	34.029
Teacher Variable	N	Minimum	Maximum	Mean	Standard Deviation
Teacher's participation in class improvement activity	2378	1	5.33	2.096	0.614
Teacher's participation time in professional development program (curriculum related)	2378	0.99	4.33	1.512	0.522
Teacher's participation time in professional development program (extra-curriculum related)	2378	1	3.5	1.532	0.441
Teacher's teaching method -instructional organization	2378	1.5	5	3.938	0.641
Teacher's teaching method -instructional activities	2378	2.57	5	3.947	0.488
Teacher's teaching method -encouragement activities	2378	1.5	5	3.584	0.654
Teacher's instruction for creativity	2378	2	5	3.794	0.526
Use of online instructional materials	2378	3	29	10.73	3.267
Use of descriptive evaluation	2378	0	10	2.71	1.348
Use of EBS textbooks and materials	2378	0	8	4.26	2.396

2. Mixture modeling analysis

1) 3rd grade in middle school

As a result from the analysis investigating how teachers' efforts for teaching-learning methods influence students' academic achievement and course satisfaction, students were assigned into three classes that represented varied descriptive statistics and

relationships among student and teacher variables. The group of 3rd grade students in middle schools was divided into three classes: class 1, class 2, and class 3. Classes 1, 2, and 3 included 8.61%, 85.02%, 6.37% of the total number of students, respectively. According to the intercept of students' vertical scaling scores in mathematics, students in class 1 showed the highest mean of mathematics score (613.185) followed by class 2 and class 3 in order.

Students' attitudes in mathematics lessons commonly influenced their mathematics scores for all three classes. In addition, for class 1, students' perception on mathematics classroom atmosphere and teachers' participation time in professional development program (curriculum related) had statistically significant relationship with students' vertical scaling scores of mathematics. For class 2, the use of descriptive evaluation in midterm/final exams had significant effects on students' vertical scaling scores of mathematics. For class 3, teachers' teaching methods that encourage students had significant effects on students' vertical scale of mathematics. One thing to note for class 3, teachers' use of EBS textbooks and class materials showed negative effect on students' vertical scaling scores in mathematics.

Students' satisfaction in teachers' activity also was affected significantly by their attitude toward in all three classes. Also, students' perception on mathematics classroom atmosphere affected their satisfaction in teacher class activity for all three classes. Other ten factors showed statistically significant relationship with satisfaction of teacher-student interactions in different classes. Students' satisfaction in mathematics lessons also had similar trends with satisfaction in teachers' activity. In other words, students' attitude toward mathematics lessons and classroom atmosphere had statistically significant effects on students' satisfaction in mathematics lessons for all three classes. Other variables did not have statistically significant effects. But for class 2, teachers' participation in professional development activity had significant effect on students' satisfaction in mathematics lessons.

2) 1st grade in high school

Conducting mixture modeling analysis, 1st grade high school students was also divided into three classes. There were interclass differences on the path representing teachers' characteristics, students' satisfaction, and students' achievement. The percentages of students in three classes were 11.23% (class 1), 17.44% (class 2), and 71.32% (class 3). According to the interception of students' vertical scaling scores in mathematics, students in class 3 had highest score (556.46), followed by class 2 (551.35) and class 1 (545.08).

Among the factors that affect mathematics score directly, there was no variables that was statistically significant. In the case of class 1, teachers' teaching method to organize the instruction showed statistically significant effect on vertical scale of mathematics. For class 2, class atmosphere variable, and for class 3, teaching method regarding instructional activities and the use of descriptive evaluation were analyzed to have effects on students' vertical scaling scores in mathematics.

Same as the 3rd grade in middle school, it was shown that students' satisfaction in teachers' class activity was significantly affected by attitude toward mathematics lessons and class atmosphere for all three classes. In the case of class 3, which was the majority of the sample for 1st grade high school students, unlike students in class 1 and class 2, teachers' teaching methods (instructional organization and encouragement activities), instruction for creativity, lesson improving activity, and participation time in professional development program (extra-curriculum related) were analyzed to affect

students' satisfaction in teachers' class activity. Students' mathematics course satisfaction was also significantly affected by their attitude toward mathematics lessons and classroom atmosphere. Exceptionally, teachers' teaching method (instructional organization) and participation time in professional development program were analyzed to be significant factors only for students in class 2.

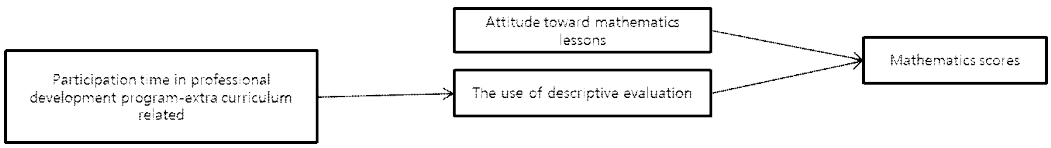
3) 3rd grade in high school

In mixture modeling analysis for 3rd grade students in high school, sample was not divided into classes; therefore, the following analyses were implemented as one class. For vertical scaling scores in mathematics, teachers' use of EBS textbooks and materials was the only factor that had significant effect. Among mediation variables, students' attitudes toward mathematics lessons, class atmosphere, teaching method (instructional organization) and instruction for creativity statistically influenced students' satisfaction in teacher class activity. For students' vertical scale of mathematics, it was shown that students' attitudes toward mathematics lessons and class atmosphere had significant effects. Among the relationship between exogenous variables and mediator variables, all other than relationship between teachers' participation time in professional development program (extra-curriculum related) and the use of EBS textbooks and materials, and between participation time in professional development program (extra-curriculum related) and the use of descriptive evaluation, had significant relation.

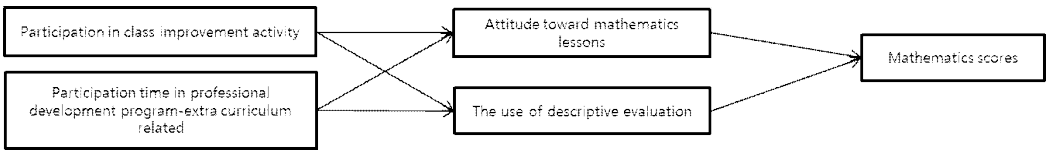
4) Comparison across the three grade levels

The statistically significant paths were varied across three grade levels. When comparing the relationships among student and teacher variables across grade levels, the classes that made up the majority were used for 3rd middle school and 1st high school grade levels.

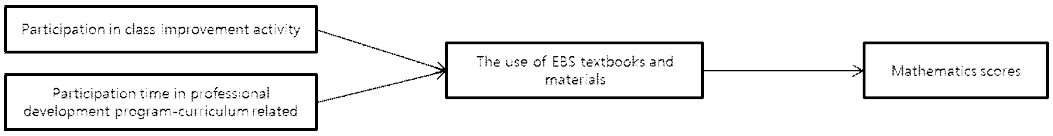
When the students were 3rd grade level in middle schools, attitudes toward mathematics lessons and the use of descriptive evaluation were the factors that have the greatest effects on students' mathematics score, however, as the students grown up to 1st grade level in high schools, teachers' teaching method (instructional activities) and the use of descriptive evaluation were the greatest effects. When they were 3rd grade level in high schools, teachers' use of EBS textbooks and materials was the only factor that affected student's mathematics scores (see Figure 2).



3rd grade in middle school



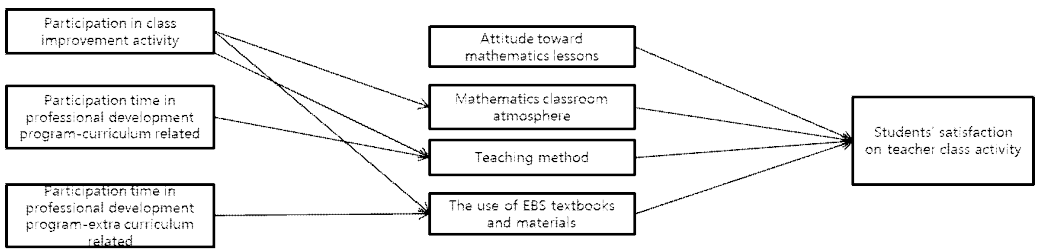
1st grade in high school



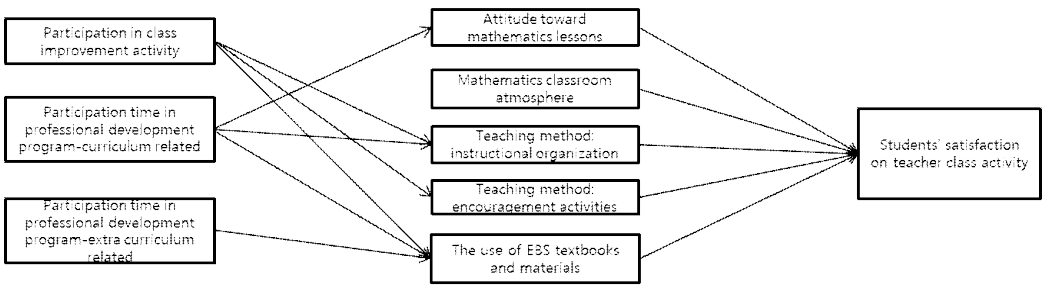
3rd grade in high school

[Figure 2] Effects on students' mathematics score

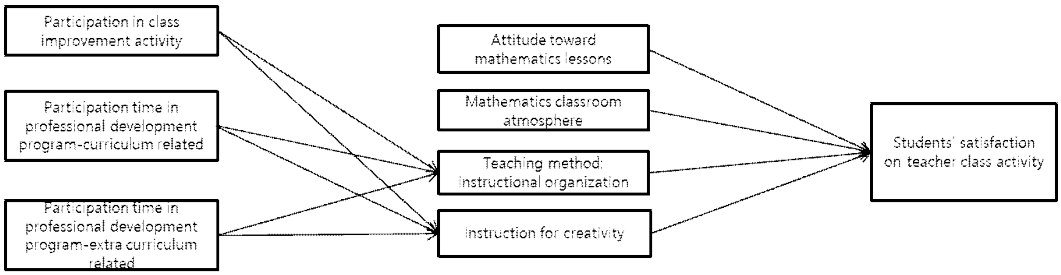
For the factors affecting students' satisfaction in teachers' class activity, attitude toward mathematics lessons, classroom atmosphere, and teaching method (instructional organization) were statistically significant. Although there were some differences over the years, students' attitude toward mathematics lessons and classroom atmosphere mostly were not affected by teachers' class improving activities and participation time in professional development programs (curriculum-related and extra-curriculum related) (see Figure 3). On the other hand, teaching method (instructional organization) was affected by teachers' class improvement activity and participation time in professional development (curriculum and extra-curriculum related). In case of 1st and 3rd grade high school students, teachers' participation in class improvement activity and professional development program (curriculum and extra-curriculum related) had impacts on their instruction for creativity, which in turn influenced students' satisfaction in teachers' class activity. In case of 3rd grade middle school students, the use of EBS textbooks and materials affected students' satisfaction in teachers' class activity, which was influenced by teachers' participation in class improvement activities and professional development (extra-curriculum related).



3rd grade in middle school



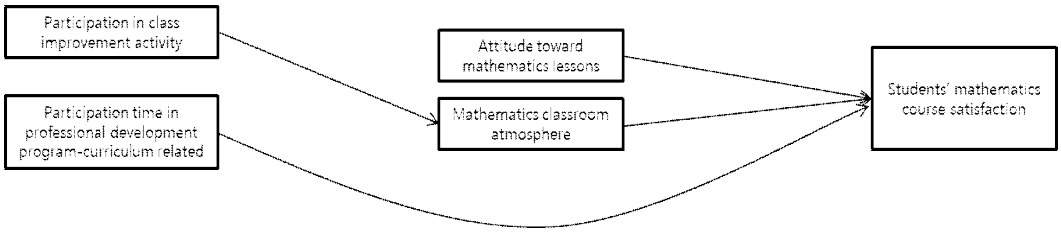
1st grade in high school



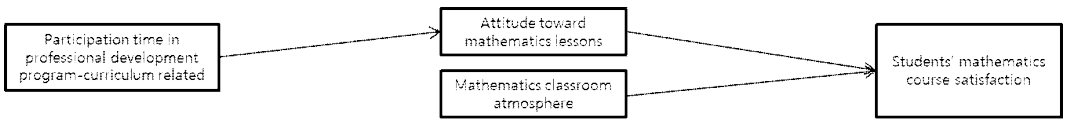
3rd grade in high school

[Figure 3] Effects on students' satisfaction in teacher class activity

Students' satisfaction in mathematics lessons was turned out to affect their attitude toward mathematics classrooms and class atmosphere for all three years consistently. However, for the factors that affect students' attitudes toward mathematics lessons and class atmosphere, teachers' class improvement activity and professional development program (curriculum and extra-curriculum related) were not shown to be affected consistently (see Figure 4).



1st grade in middle school



3rd grade in high school

3rd grade in high school

[Figure 4] Effects on students' mathematics course satisfaction

V. Conclusion

1. Discussion

This study is meaningful in that it examined the effects teachers' various efforts to improve teacher professionalism have on their teaching methods and instructional activities, and ultimately the effects it has on students' academic achievement and class satisfaction. The result of the longitudinal study was analyzed by dividing samples of 3rd grade in middle school and 1st grade in high school into three classes using latent class analysis, and the sample of 3rd grade high school students was analyzed by single class. Therefore, to synthetically interpret the result of this study, we underwent comparison analysis for result of three classes and results of three years.

1) The effect of teachers' effort on improving teaching professionalism

Teachers' effort to improve teaching professionalism (instruction enhancement activity, teacher development) was appeared to have an effect via various path on students' mathematics scores and their satisfaction in teachers' activity. However, it had no dramatic effects on satisfaction in mathematics class. The survey items related to satisfaction of teachers' activity were 'teacher works for lessons diligently', 'teacher has lots of knowledge on the subject he teaches', and 'teacher teaches the contents well making us easy to understand'. The survey items related to the satisfaction of mathematics class were 'students are noisy and disordered in class', 'students concentrate in class', and 'I like the class and I am waiting to go to the class', which asked about the classroom and the class rather than the teachers. In other words, teachers' effort on improving instruction professionalism, has changed teachers' view and attitude on their own classes, and that in turn increased students' satisfaction in teacher. However, it could not change the class itself, and students' satisfaction in the class itself might not increase.

2) The effect of teachers' effort to participate in professional development programs

The effects of teachers' participation in professional development program on students' achievement and satisfaction in teachers' activity were positive and statistically significant. Both Jacob and Lefgren(2004) and Lee and Chung(2011) showed that professional development program had no noticable positive effect on students' achievement, while Siegle and McCoach(2007) asserted that there is a positive effect. According to the result from 3rd grade middle school students, it was shown that teachers' participation in professional development program brings change to their class method, and this ultimately improves students' mathematics score. As consistent with results from Harris and Sass(2008), teachers' participation in professional development programs showed indirect effects on students, and teachers' instructional methods played a role mediating two factors. In addition, in the result from 1st grade high school students, teachers' participation in development of subject program and instruction enhancement activity had an effect on the use of EBS textbooks and class materials, which increased students' mathematics score. This shows that professional development programs positively impact students' achievement and teachers' use of extra learning materials mediated the effects from teachers to students, which was consistent with Lee and Chung(2011). Therefore, this study does not only supports the findings from Siegle and McCoach(2007), but also shows through which path the findings were resulted.

3) The effect of teachers' time spent on extra-curriculum related programs

The findings from the current study illuminate that teachers' participation time in extra-curriculum related professional development programs positively influences the use of descriptive evaluation, EBS textbooks and materials, and refining instructional organization. According to the previous studies (Harris, & Sass, 2008; Jacob, & Lefgren, 2004; Kim, & Cha, 2003), it was expected that only curriculum related professional development programs impact teachers' development of professionalism. It was unexpected to find that extra-curriculum related programs influence teachers' teaching method and instructional activities as well. This finding might be possible because extra-curriculum related programs change teachers' beliefs in teaching methods (Timperley, & Phillips, 2003) and efficacy (Lee & Chung, 2011), which are, in turn, reflected into their actual lesson activities. Therefore, it would be necessary to prepare varied professional development programs for teachers' improvement in professionalism.

4) Overall discussion

This study has provided more details about the factors that affect students' mathematics score and satisfaction than the existing studies. Kang and Park(2010) said that teachers' efforts on designing lessons for creativity, and activities done in lessons to help students increase students' satisfaction. In this context, according to this study, not only teachers' instruction for creativity, but also the organized teaching method and student encouragement increases students' satisfaction.

These results of the study are meaningful in that they supplement the existing studies on the relationships between teachers' education, students' achievement and satisfaction. It can also provide a meaning to policy of teacher education, and support of students' education.

2. Policy implications

The results of this study shed light on policy development for teacher education. First, the result of this study provided basis for government-wise effort on professional development program and improvement of instruction professionalism. The findings of the study indicate the process *how* teachers participation in professional development program influences students' academic achievement and satisfaction. Teachers participation in professional development program had both direct and indirect effects on students' academic achievement and satisfaction. Educators in teacher education field need to keep in mind that teachers' participation in professional development program might not directly affect students' academic achievement and satisfaction. However, despite of this case, teachers' efforts to change students' attitudes toward mathematics lessons and the atmosphere of the classroom might ultimately influence student achievement and satisfaction. That is, educators providing professional development programs need to be aware that the program affects learners through various paths, and it will need to be explained to teachers who participate in the program.

Secondly, the effects that other school policies for class improvement (ability grouping, use of EBS, etc.) have on students' achievement and understanding was longitudinally verified. By applying the same models to all three grades at the same time, it could be noticed that the paths from teachers' participation in professional development program to students' academic achievement and satisfaction might vary according to grade. For example, ability grouping and use of EBS were some of the policies that were used

in school field constantly and were expected to be effective. A number of research verified the effectiveness of these policies in a single year, but only limited amount of research conducted with a longitudinal approach. In addition, the model of this research is designed to control all other various school variables and student variables, and so it provided information to accurately diagnose the effect of ability grouping and use of EBS materials. In other words, by analyzing the factors that affect students' academic achievement, and satisfaction when they are 3rd grade in middle school, and 1st and 3rd grade in high school, they can prepare policies that suit each grade. That is, educators who provide professional development programs for teachers will need to revise the focus of the programs depending on the grade that teachers are charge of. It will also help to modify and improve the policies with direct impact on classroom practice, such as ability grouping and the use of EBS textbooks and materials.

Lastly, the model of this research shows that students' class satisfaction is the factor that ultimately increase students' academic achievement and lesson comprehension. In addition, it assumes that various school variables and teacher variables are the variables that decide students' class satisfaction. According to the findings, the factors that affect students' class satisfaction were teachers' teaching method, use of EBS, and instruction for creativity. Therefore, we expect that this study will provide important information by extracting the factors that affect students' class satisfaction, and making educational policy that can be realized in every classroom.

3. Limitations

In this research, teachers' time spent in professional development programs was considered as a variable, but the content and characteristics of each programs was not included. In the survey, professional development program is consisted with 8 categories (curriculum related, improving instruction professionalism, improving evaluation, creative activity, student guidance related, use of ICT and information, job and upper level school - admission officer system, professional development, liberal arts - advanced foreign language, sports dance etc.). For this study we grouped these 8 categories into two, namely curriculum related and extra-curriculum related. Numerous researchers (Capraro et al., 2016; Duff, Brown & van Scoy, 1995; Garet et al., 2001; Guskey, 2003; Han, 2013) pointed out that the characteristic of development program affect the effectiveness of the program. Therefore, the fact that we simplified the development programs into two categories is the limitation of this study.

In addition, the SELS data used in this research is a data that used students as panels, where correspondence of teacher and students was possible for 2012, 2013, and 2015 data, but impossible in 2014 data. Therefore, the data from 2014 was excluded from this study.

References

Antoniou, P., & Kyriakides, L. (2013). A Dynamic Integrated Approach to teacher professional development: Impact and sustainability of the effects on improving teacher behaviour and student outcomes. *Teaching and Teacher Education, 29*, 1-12.

Arah, O. A. (2008). The role of causal reasoning in understanding Simpson's paradox, Lord's paradox, and the suppression effect: Covariate selection in the analysis of observational studies. *Emerging Themes in Epidemiology, 5*(1), 5.

Atweh, B., & Ochoa, M. D. A. (2001). Teachers and school change: Lessons from Mexico. In B. Atweh,

H. Forgasz, & B. Nebres (Eds.), *Sociocultural research on mathematics education: An international perspective* (pp. 167-184). New Jersey: Lawrence Erlbaum.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In G. Sykes (Ed.), *Teaching as the learning profession* (pp. 3-32). CA: Jossey-Bass.

Barbosa, J. C., & de Oliveira, A. (2014). Supporting mathematics teachers' learning with educative curricular materials. *Journal of Mathematics Education, 7*(2), 161-169.

Bausmith, J. M., & Barry, C. (2011). Revisiting professional learning communities to increase college readiness: The importance of pedagogical content knowledge. *Educational Researcher, 40*, 175-178.

Begghetto, R. A. (2010). Creativity in classroom. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge handbook of creativity* (pp. 447-466). Cambridge: Cambridge University Press.

Camburn, E. M., & Han, S. W. (2015). Infrastructure for teacher reflection and instructional change: An exploratory study. *Journal of Educational Change, 16*(4), 511-533.

Capraro, R. M., Capraro, M. M., Scheurich, J. J., Jones, M., Morgan, J., Huggins, K., S., Corlu, S., Younes, R., & Han. S. Y. (2016). Impact of sustained professional development in STEM PBL on outcome measures in a diverse urban district. *Journal of Educational Research, 109*(2),181-196.

Cochran-Smith, M., & Zeichner, M. K. (2005). Studying teacher education: The report of the AERA Panel on Research and Teacher Education. Mahwah, NJ: Erlbaum.

Corlu, M. S. (2012). *A pathway to STEM education: Investigating pre-service mathematics and science teachers at Turkish universities in terms of their understanding of mathematics used in science* (Unpublished doctoral dissertation). Texas A&M University, College Station, TX.

Crespo, S. (2006). Elementary teacher talk in mathematics study groups, *Educational Studies in Mathematics, 63*(1), 29-56.

Dede, C., Ketelhut, D., Whitehouse, P., Breit, L., & McCloskey, E. M. (2008). A research agenda for online teacher professional development. *Journal of Teacher Education, 60*(1), 8-19.

Denton, J. J., Davis, T. J., Smith, B. L., Beason, L., & Strader, R. A. (2005, February). *The development and implementation of an online professional development model for pre-service teachers education.* Paper presented at the annual meeting of the Southwest Educational Research Association, New Orleans, LA.

Dudley, P. (2013). Teacher learning in Lesson Study: What interaction-level discourse analysis revealed about how teachers utilised imagination, tacit knowledge of teaching and fresh evidence of pupils learning, to develop practice knowledge and so enhance their pupils' learning. *Teaching and Teacher Education, 34*, 107-121.

Duff, R. E., Brown, M. H., & van Scoy, I. J. (1995). Reflection and self-evaluation: Keys to professional development. *Young Children, 50*(4), 81-88.

Fishman, B., Konstantopoulos, S., Kubitskey, B. W., Vath, R., Park, G., Johnson, H., & Edelson, D. C. (2013). Comparing the Impact of Online and Face-to-Face Professional Development in the Context of Curriculum Implementation. Journal of Teacher Education, 64(5), 426-438.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.

Guskey, T. R. (2003). Analyzing lists of the

characteristics of effective professional development to promote visionary leadership. *NASSP Bulletin, 87*(637), 4-20.

Han, S. Y. (2013). *The Impact of STEM PBL Teacher Professional Development on Student Mathematics Achievement in High Schools* (Doctoral dissertation). Retrieved from OAKTrust.

Harris, D. N., & Sass, T. R. (2007). Teacher training, teacher quality and student achievement. *Journal of public economics, 95*(7-8), 798-812.

Hur, J. W., & Brush, T. A. (2009). Teacher Participation in Online Communities. *Journal of Research on Technology in Education, 41*(3), 279-303.

Jacob, B. A., & Lefgren, L. (2004). The impact of teacher training on student achievement: Quasi-experimental evidence from school reform efforts in Chicago, *The Journal of Human Resources, 29*(1), 50-79.

Kang, N.-H. & Park, Y. (2010). Identification of instructional components to increase students' interest and creativity in American science classrooms. *Journal of Science Education, 34*(2), 421-431.

Kang, J. W. (2001). The relation structure between principals' instruction leadership and student achievement. *Journal of Yeolin Education, 9*(2), 255-279.

Kim, A. Y. & Cha, J. E. (2003). Multi-level analysis of the effects of teacher-efficacy and students' academic self-efficacy on academic achievement. *Korean Journal of Educational Psychology, 17*(2), 25-43.

Lee, H.-S. & Chung, J.-Y. (2011). An analysis of the influence of teachers' traits on student achievement: Focusing on teachers' efforts to enhance professionality in TIMSS 2007. *Journal of Korean Teacher Education, 28*(1), 243-366.

Lewis, C., & Perry, R. (2006). How should research contribute to instructional improvement? The case of lesson study, *Educational Researcher, 35*(3), 3-14.

Males, L. M., Otten, S., & Herbel-Eisenmann, B. A. (2010). Challenges of critical colleagueship: Examining and reflecting on mathematics teacher study group interactions. *Journal of Mathematics Teacher Education, 13*(6), 459-471.

Meiers, M., & Ingvarson, L. (2005). Investigating the links between teacher professional development and student learning outcomes, Vol. 1. Australia: Australian Council for Educational Research, Department of Education, Australian Government.

Muthen, L. K., & Muthen, B. (2015). Mplus. *The comprehensive modelling program for applied researchers: user's guide, 5.*

Nam, H. W., & Lee, K. T. (2002). The effect of in-class differentiated collaborative learning on students' academic achievement and attitude. Soonchunhyang *Journal Institute of Humanities, 10,* 47-68.

Pearl, J. (2009). Causal inference in statistics: An overview. *Statistics Surveys, 3,* 96-146.

Siegle, D., & McCoach, D. B. (2007). Increasing student mathematics self-efficacy through teacher training. *Journal of Advance Academics, 18*(2), 278-312.

Pyo, J. H., Lee, K. M., & Jeong, S. H. (2010). The effect of intrinsic motivation of physical subject and teaching behavior of physical education teacher on class satisfaction in physical education of middle school students. *Korean Society for the Study of Physical Education, 15*(2), 311-324.

Reason, P., & Bradbury, H. (Eds.). (2001). *Handbook of action research: Participative inquiry and practice.* London: Sage Publications.

Sedova, K., Sedlacek, M., & Svaricek, R. (2016). Teacher professional development as a means of transforming student classroom talk. *Teaching and Teacher Education, 57,* 14-25.

Siegle, D. & McCoach, D. B. (2007). Increasing student mathematics self-efficacy through teacher training. *Journal of Advanced Academics, 18*(2), 278-312.

So, Y.-H. (2012). The effects of perceived teachers' creative instructional leadership on creativity in elementary school students: A mediation effect of course satisfaction. *Journal of Child Education, 21*(3), 67-81.

Sung, E., Leem, J., & Kim, S. (2010). Affects of visualization tendency of attitude on subject, learning flow, and learning satisfaction through the IPTV based instruction in elementary school. *Journal of Elementary Education, 23*(3), 293-320.

Timperley, H. S., & Phillips, G. (2003). Changing and sustaining teachers' expectations through professional development in literacy. *Teaching and Teacher Education, 19*(6), 627-641.

Villalta-Cerdas, A., McKeny, P., Gatlin, T., & Sandi-Urena, S. (2015). Evaluation of instruction: students' patterns of use and contribution to RateMyProfessors.com. *Assessment & Evaluation in Higher Education, 40*(2), 181-198.

Vogt, F., & Rogalla, M. (2009). Developing adaptive teaching competency through coaching. *Teaching and Teacher Education, 25*(8), 1051-1060.

Wiliam, D. (2010). Teacher quality: How to get more of it. In *Spectator 'Schools Revolution' conference* (March 2010). Retrieved from: http://www.dylanwiliam.org/Dylan_Wiliams_website/Papers_files/Spectator%20talk.doc.

Yackel, E. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27*(4), 458-477.

The impacts of teacher education on students' academic achievement and satisfaction in mathematics lessons

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Teacher quality is a key factor that determines quality of education. Being aware of this, the Korean government and teachers have been striving to improve teachers' professionalism. Research about the impacts of efforts to enhance teacher professionalism on students' academic achievement and course satisfaction, however, is extremely limited. This study sought to advance our understanding of the relationship between these factors by analyzing what teacher characteristics impact students' achievement and satisfaction. To this end, the study drew on the middle and high school data from 3rd to 6th year survey of the Seoul Educational Longitudinal Study. Structural equational modeling were used as the main approach. Latent profile analysis, a kind of mixture modeling analysis, were used as needed. This study found that teachers' participation in instruction enhancement activity and professional development impact students' attitude toward mathematics lessons and their perception on class atmosphere, and ultimately impact their academic achievement as well as their overall satisfaction in the course. In addition, teachers' use of EBS textbooks and videos impact 3rd grade high schoolers' academic achievement. These findings suggest that effort to improve teacher professionalism positively impact students' academic achievement and course satisfaction, although there is a difference according to the year grade. This study provides implications for education policy makers and teacher educators.

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* ZDM Classification : C70
* 2000 Mathematics Subject Classification : 97C70
* Key words : teacher education, mixture modeling analysis, academic achievement, course satisfaction
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