Education and Science

Vol 46 (2021) No 206 1-26

Original Article

Modeling the Effects of Instructional Quality on Mathematical Literacy Performance from the Students' Perspective: PISA 2012 Turkey Sample

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Abstract

The purpose of this study was to determine the effect of students' perceptions of instructional quality in mathematics lessons on the PISA 2012 mathematical literacy performance as well as the mediating role of self-concept and interest in mathematics in this effect by using the PISA 2012 data for Turkey. The sample of this research in the descriptive-relational survey model included all of the students in Turkey sample of 4848 students. Structural Equation Modeling (SEM) was used to analyze the data. Based on the theoretical framework of the triarchic model conceptualizing the instructional quality, the independent variables discussed in the research were defined as cognitive activation, classroom management, student orientation, and teacher support, while non-cognitive variables such as mathematics self-concept and mathematics interest were defined as mediating independent variables. Mathematical literacy performance obtained from PISA 2012 mathematics test was used as the dependent variable of this study. The findings of the study revealed that while student orientation was the variable that best explained mathematical literacy performance in terms of a net total effect (albeit negative), the variable that positively explained it the most was cognitive activation. It was also found that classroom management and teacher support were not significant explanatory variables for mathematical literacy performance in the model. On the other hand, similar to the direct effect of the perceptions of cognitive activation and classroom management on the mathematics self-concept, it was determined that the perceptions of teacher support had also a low direct effect on the perception of interest in mathematics. In terms of indirect effects on mathematical literacy performance, the study showed that the perceptions of cognitive activation and classroom management had a significant positive low effect. The results and limitations of the research were discussed and some suggestions were made for further research.

Keywords

Instructional quality
Mathematical literacy
PISA 2012
Turkey sample
Structural equation modeling

Article Info

Received: 09.13.2019
Accepted: 11.30.2020
Online Published: 12.30.2020

DOI: 10.15390/EB.2020.9013

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Introduction

Most of the students' learning experiences are achieved by acquiring knowledge and skills in interaction with the teacher and their peers. Since the quality of instruction is accepted as one of the most important factors related to the learning experiences of the students (Creemers & Kyriakides, 2008; Hattie, 2009; Seidel & Shavelson, 2007), studies on the effects of teachers' behaviors and practices in the classroom on learning have received great attention from the researchers (Klieme, 2013; Organisation for Economic Co-operation and Development [OECD], 2013a). Many of the researchers interested in this topic have focused on determining and making sense of teachers' behaviors in mathematics classes in order to identify the qualities that define the characteristics of effective instruction (Baumert et al., 2010; Brown, Roediger, & McDaniel, 2014; Seidel & Shavelson, 2007). In this context, a theoretical model based on the classical process-product model and constructivist perspective, involving dimensions such as cognitive activation that requires high-level thinking, a supportive and student-oriented classroom climate, and well-structured classroom management, has been proposed (Creemers & Kyriakides, 2008; Klieme, 2013). Klieme, Pauli, and Reusser (2009) suggest that these three dimensions affect learning in the classroom setting. Brophy (2000) mentioned the importance of effective teachers planning activities that stimulate students' cognitive curiosity and the use of problems to allow students to think deeply about the content being taught. On the other hand, it has also been mentioned that engaging students in activities with high difficulty levels may not be enough to encourage them to participate in effective learning processes (Stefanou, Perencevich, DiCintio, & Turner, 2004; Turner et al., 1998). In other words, cognitive activation strategies can positively affect learning by improving the quality of instruction when taken together with healthy and supportive teacher-student relations, positive and constructive feedback on errors and misconceptions, and individual student support that creates optimal conditions for success (Brophy, 2000; Klieme et al., 2009). Besides, good and effective classroom management has been seen as very important to facilitate the course flow and to ensure order, control, and ultimately sufficient learning time in the classroom (Baumert et al., 2010).

In addition to the above studies that conceptualize the basic dimensions of instructional quality, other studies have also been conducted to investigate the relationships between one or more dimensions of instructional quality and student performance. For example, Baumert et al. (2010) found that the cognitive levels of mathematical activities given to students and the quality of classroom management were important determinants of the mathematics performance of 10th-grade students. Wang, Haertel, and Walberg (1993) stated that various factors such as teaching and classroom management techniques and social and academic interactions between students and teachers significantly affect learning. Besides, the PISA 2012 report discussed that the relationships between the learning environment and some affective variables such as students' interest and motivation towards mathematics were not fully addressed in studies on PISA 2003 (OECD, 2013b). Although fewer studies focus on affective outcomes than those related to cognitive outcomes, recent meta-analysis results by Seidel and Shavelson (2007) show that instructional quality may be more closely related to affective outcomes than cognitive outcomes.

In this sense, this study aims to examine the instructional quality of mathematics teachers closely according to PISA 2012 math results and to investigate the relationships between instructional quality and affective and cognitive outcomes of students. In this study, questionnaire data for the assessment of PISA 2012 mathematics literacy, which is an international survey including student responses for a large number of cognitive and non-cognitive variables, was used. This questionnaire provides secondary data on teachers' behaviors perceived by students in mathematics lessons as well as on students' affective characteristics related to mathematics. In this context, based on the theoretical framework of the triarchic model defining the effects of instructional quality on learning (Klieme et al., 2009), the model reflecting the relationships between the basic dimensions of instructional quality and mathematical literacy performance of students was analyzed. Students' mathematical literacy performance in PISA 2012 was used as the final outcome criterion and non-cognitive variables such as mathematics self-concept and mathematics interest were identified as mediators. To this end, answers to the following research questions were sought:

1. Do the students' perceptions of the instructional quality significantly predict their mathematical literacy performance in PISA 2012?
2. Do the students' perceptions of the instructional quality significantly predict their mathematics self-concept and mathematics interest in PISA 2012?
3. What is the mediating role of the students' mathematics self-concept and mathematics interest on the relationship between students' perceptions of the instructional quality and the mathematical literacy performance in PISA 2012?

Related Literature and Theoretical Framework

Given the importance of the teacher's role in student success, it is constantly tried to be determined by policymakers and researchers which components contribute significantly to instructional quality in order to take the necessary steps to ensure that education policies, teacher education and professional development programs are more qualified and efficient (OECD, 2016). In this regard, Klieme et al. (2009) proposed a triarchic theory of instructional quality emphasizing three basic dimensions such as cognitive activation (including the use of deep content, higher-level thinking tasks, and other challenging activities), supportive and student-oriented classroom climate (including a positive environment and individualized guidance), and effective classroom management (including main components for direct instruction) to guide teachers to perform more efficient teaching in their classrooms.

Instructional Quality

In Figure 1, it is stated that the three components under the 'Instructional Quality' heading form a triarchic model of instructional quality that affects the learning experiences and outcomes of the students.

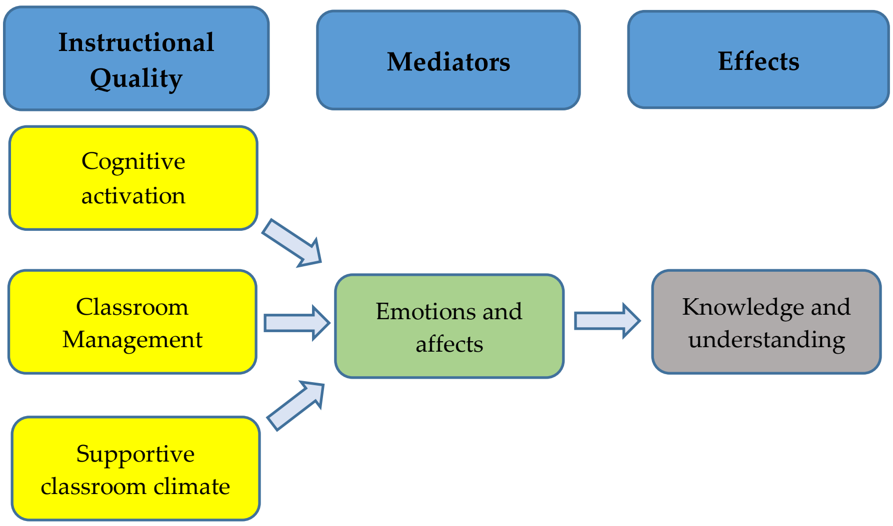

Figure 1. Theoretical Model for the Effects of Instructional Quality Dimensions on Learning (Reproduced from Klieme et al., 2009)

The triarchic model of instructional quality was used for the first time in the Teaching and Learning International Survey (TALIS) study to examine teachers' classroom practices, and then adapted to measure student perceptions of teaching behaviors of mathematics teachers, including cognitive activation, student- or teacher-centered instruction, use of feedback in the classroom, and teacher support in the International Student Assessment Program (PISA) survey (OECD, 2013b). The

TALIS survey results showed that the majority of teachers held views consistent with active teaching practices that targeted higher-level thinking skills and pedagogy with a student-centered approach, but did not give much room for practices reflecting these views within the classroom (Burns & Darling-Hammond, 2014).

Cognitive activation, which is one of the three main components constituting the quality of instruction based on the constructivist paradigm, includes the teaching activities in which students have to evaluate, integrate and implement knowledge in the context of problem-solving (Lipowsky et al., 2009). Cognitive activation is important and recommended to encourage students to participate in constructive and reflective high-level thinking and thus to build up a broad knowledge in the relevant field (Klieme et al., 2009). Teaching mathematics that promotes conceptual understanding is clearly related to concepts and transitions between mathematical facts, processes, thoughts and representations, and requires a high level of cognitive function (Hiebert & Grouws, 2007). This teaching process should also be maintained by a supportive and well-structured classroom climate that includes student-oriented instruction, constructive feedback and care for individual learners (Brophy, 2000; Stefanou et al., 2004; Turner et al., 1998). Teacher support, which is another component of the instructional quality model and is thought to be one of the factors enabling this supportive and positive classroom climate, should include behaviors such as providing extra help when necessary, listening to and respecting students' ideas and questions, caring and encouraging students (Klusmann, Kunter, Trautwein, Lüdtke, & Baumert, 2008). In addition to these two components, an effective classroom management component with clear and well-defined rules to facilitate the understanding and use of knowledge is seen as a prerequisite for students' participation in the given activities and tasks (Baumert et al., 2010; Klieme et al., 2009). Classroom management includes disciplinary elements dealing with disturbing student behaviors and effective time management in classroom activities. In other words, it can be described as actions taken by teachers to ensure a positive classroom climate and efficient use of time in lessons (Klusmann et al., 2008; Van Tartwijk & Hammerness, 2011).

Relationships between Instructional Quality and Achievement

Studies examining the relationships between instructional quality and learning provide evidence that instructional quality, in general, is related to student achievement. For example, Wang et al. (1993) showed that effective classroom management enables teachers to focus more on teaching and positively affects student achievement. In addition, academic and social interactions between teachers and students not only allow teachers to adapt teaching methods to the needs of students, but also help students to acquire instruction that builds upon and connects prior knowledge, responds to misunderstandings, and enables them to organize knowledge in a meaningful way. A success-oriented and disciplined classroom environment with supportive student-teacher and student-student relationships has been put forward as a vital factor in creating effective learning (OECD, 2013b). However, it has also been shown that the effects of each component of instructional quality on student performance are not always significant. For example, it was found that cognitive activation and classroom management were positively related to student achievement, but supportive classroom climate had no direct effect on student achievement in terms of positive teacher-student relationships and constructive teacher feedback (Lipowsky et al., 2009; Baumert et al., 2010).

Relationships between Instructional Quality and Affective Qualities

The dimensions of instructional quality are also assumed to be related to affective variables underlining the multidimensional effects of instructional quality on mathematical literacy performance. Ryan and Deci (2000, 2002) developed a theory of self-determination as an instrument which takes into account intrinsic and extrinsic motivation, and stresses the importance of three psychological needs: perceived competence, perceived autonomy, and perceived social relatedness for intrinsic motivation. Self-determination theory stipulates that students naturally show effort, agency, and commitment in their school lives. This natural tendency is also called "inherent growth tendency". These natural tendencies are fostered when teachers are caring and fulfill their students' relatedness needs. It also refers to the theory of self-determination while talking about key components of the positive classroom atmosphere and motivation that provide an effective learning environment. Since intrinsic motivation cannot always be realized, it is the responsibility of the teacher to support students based on the various types of extrinsic motivation (Deci & Ryan, 2002; Klieme et al., 2009). On the other hand, social comparison theory suggesting people have a natural drive to compare their own performance or attributes with the performance or attributes of others posits that comparing one's abilities or efforts against like others might increase intrinsic motivation by introducing competition (Festinger, 1954). Social comparisons to the self, especially comparison with higher-performing others, motivates people to improve their performance. Research on academic self-concept also often refers to social comparison theory (Marsh, 1987; Marsh et al., 2014; Möller, Pohlmann, Köller, & Marsh, 2009).

In this sense, some researchers have focused on studies trying to explain the relationships between the dimensions of instructional quality and the affective characteristics of students. Yair (2000) observed that realistic learning experiences and willingness to participate in class discussions are important determinants of intrinsic motivation and sense of achievement, but teaching processes that stimulate cognitive development have no significant effect on intrinsic motivation and even have a negative effect on the sense of achievement. In another study, it was emphasized that the provision of a supportive classroom climate with a more cognitively active teaching process increases the motivation of the students and eventually has the potential to turn into high mathematics achievement (Klieme et al., 2009; Seidel, Rimmele, & Prenzel, 2005). Vieluf, Lee, and Kyllonen (2009) also showed that teacher support positively correlates with students' interest in mathematics. Although fewer studies are focusing on affective, or emotional, outcomes than studies focusing on cognitive outcomes to determine the quality of instruction, some of these studies may produce results contrary to general expectations. Indeed, it has also been stated that instructional quality may be more closely related to affective qualities than cognitive outcomes (Seidel & Shavelson, 2007).

It is emphasized that attitudes and affective variables such as mathematics self-concept and mathematics interest are important for mathematics achievement (Singh, Granville, & Dika, 2002). It has been shown that there is a positive relationship between mathematics achievement and mathematics self-concept that is defined as an individual's awareness of his/her mathematical skills, knowledge, experiences, and interest in mathematics (Marsh & Shavelson, 1985; Marsh & Scalas, 2011; Nagy, Trautwein, Baumert, Köller, & Garrett, 2006). In another study, it was revealed that students' perceptions of instructional quality are related to mathematics self-concept and attitudes towards mathematics (Lazarides & Ittel, 2012a).

Another important factor for teaching mathematics is the interest in mathematics, which is associated with achievement goals in mathematics courses and career choices related to mathematics (OECD, 2006; Schiefele, Krapp, & Winteler, 1992). It was stated that students who are interested in mathematics enjoy dealing with mathematics, are constantly engaged in mathematics, and consider mathematics very important for their personal development (Renninger & Hidi, 2011). Both self-concept and interest in mathematics can be influenced by educational environments and teaching methods. Research in this context shows that the determinants of instructional quality in mathematics classes such as classroom management, classroom climate, and cognitive activation are related to students' attitudes and emotions towards mathematics (Chen, Thompson, Kromrey, & Chang, 2011; Frenzel, Goetz, Pekrun, & Watt, 2010).

Relationships between Classroom Management and Self-Concept as well as Interest in Mathematics

The classroom management dimension of instructional quality refers to preventing or minimizing unwanted disturbing student behaviors through effective classroom and time management in general (Baumert et al., 2010; Wang et al., 1993). Studies have revealed that well-planned and organized instruction is an important component of effective classroom management (Gruehn, 2000).

Trends in international mathematics and science education studies have also shown that a safe and teaching-focused learning environment positively affects student achievement in many countries (Martin, Foy, Mullis, & O'Dwyer, 2013). It was stated that effective classroom management shaped by instruction that focused on learning and teaching is a significant indicator of students' interest in mathematics lessons (Daniels, 2008). Research based on self-determination theory has shown that effective classroom management increases students' internal satisfaction needs and thereby increases students' interest in the subject (Deci & Ryan, 2002; Kunter, Baumert, & Köller, 2007; Ntoumanis, 2001).

Relationship Between Classroom Climate and Self-Concept as well as Interest in Mathematics

The classroom climate dimension, another component of instructional quality, includes teacher-student interactions such as supportive teacher-student relationships, caring and interested teacher behavior, or constructive feedback (Brophy, 2000). It was emphasized that a supportive classroom climate is the most powerful determinant of students' affective development (Klieme et al., 2009). Some studies showed that supportive teacher behaviors are highly correlated with students' level of interest (Den Brok, Levy, Brekelmans, & Wubbels, 2006; Wentzel, 1998; Wentzel, Battle, Russell, & Looney, 2010). On the other hand, studies based on social comparison theory showed that students' perceptions of self-concept are affected by the social environment they are in and the social comparisons provided by this environment (Festinger, 1954; Wood, 1989). It was noted that the perception of social support leads to a more accurate perception of peer relations (Langford, Bowsher, Maloney, & Lillis, 1997). It was also said that the perception of social support can help students build positive relationships with others and their environment by increasing their intrinsic motivation (Reinboth, Duda, & Ntoumanis, 2004). On the other hand, according to Deci and Ryan (1985), the two emotions thought to characterize intrinsic motivation are interest and satisfaction. Research also showed that the level of students' perceptions of teacher support in the classroom can play a critical role in developing students' perceptions of self-concepts and increasing interest in mathematics (Demaray, Malecki, Rueger, Brown, & Summers, 2009; Wentzel et al., 2010).

Relationship Between Cognitive Activation and Self-Concept as well as Interest in Mathematics

The cognitive activation dimension of instructional quality consists of teaching methods that support students' conceptual understanding with challenging activities, different solution strategies, and non-routine problems (Lipowsky et al., 2009). In addition, the discursive activities, which are seen as an opportunity for students to build knowledge through participating in discussions in mathematics class, are also expressed as another mechanism that activates the cognitive process (Brophy, 2000; Walshaw & Anthony, 2008). It was also emphasized that participation in classroom discourse that requires cognitively higher-order thinking is related to students' mathematics self-concept and interest in mathematics lessons and contributes to their affective development (Lazarides & Ittel, 2012b; Pauli & Lipowsky, 2007). A similar result was also reported by showing that teacher support and cognitive activation are significantly related to the increase in students' interest in the subject, and it was suggested that classroom management can also be directly related to student achievement (Fauth, Decristan, Rieser, Klieme, & Büttner, 2014).

Although many studies take into account the characteristics of instructional quality and their effects on learning (Daniels, 2008; Demaray et al., 2009; Wentzel et al., 2010), fewer studies have been conducted to investigate the differences in students' perceptions of instructional quality in mathematics lessons (Yi & Lee, 2017). However, it is also important to address individual differences as the realization of effective learning depends on the level of adaptation of teaching environments to students' individual needs (Brophy, 2000; Lipowsky et al., 2009). In this context, this study aimed to reveal the effect of students' perceptions of instructional quality in mathematics lessons on the PISA 2012 mathematical literacy performance as well as the mediating role of self-concept and interest towards mathematics in this effect.

Method

Research Design

This study is descriptive-relational research designed to investigate the effect of students' perceptions of the instructional quality on mathematical literacy performance in the PISA 2012 survey and explore if any mediating role of self-concept and interest in mathematics in this effect.

Population and Sample

Since students participating in PISA are randomly chosen from among all the 15-year-olds, the population of this study consists of 1,266,638 students in the 15-year-old group studying in Turkey. A total of 4848 students from 170 schools participated in the PISA 2012 Turkey survey. According to school types in 57 provinces representing 12 regions, a two-stage stratified sampling technique was used to select a representative school sample from each region and school type, and then students were randomly selected from the students of this representative school sample (OECD, 2014). All of the students in the Turkey sample (4848 students) were included in this study. The distribution of these students by school types and genders is given in Table 1.

Table 1. Distribution of Students by School Types and Genders in PISA 2012 Turkey Sample

School Type	Girls		Boys		Total	
	n	%	n	%	n	%
Anatolian High School	593	12,23	457	9,43	1050	21,66
Anatolian Vocational High School	175	3,61	104	2,15	279	5,75
Anatolian Teacher High School	117	2,41	90	1,86	207	4,27
Anatolian Technical High School	21	0,43	102	2,10	123	2,54
Multi-Program High School	81	1,67	97	2,00	178	3,67
Science High School	22	0,45	13	0,27	35	0,72
General High School	712	14,69	750	15,47	1462	30,16
Primary School	56	1,16	64	1,32	120	2,48
Vocational High School	564	11,63	652	13,45	1216	25,08
Police College	0	0,00	68	1,40	68	1,40
Social Sciences High School	20	0,41	15	0,31	35	0,72
Technical High School	9	0,19	66	1,36	75	1,55
Total	**2370**	**48,89**	**2478**	**51,11**	**4848**	**100,00**

As seen in Table 1, of the total number of students (4848) participating in PISA 2012 in Turkey, approximately 49% are female students and 51% are male students. The Turkey sample consisted of students from 12 different school types including Primary School, General High School, Anatolian High School, Science High School, Social Sciences High School, Anatolian Teacher-High School, Vocational High School, Anatolian Vocational High School, Technical High School, Anatolian Technical High School, Multi-Program High School, and Polis College. The numbers of schools representing the 12 regions in Turkey were included in the sample in proportion to the numbers of schools in each region (Ministry of National Education [MoNE], 2015).

Data Collection Instrument

The data used in this study were from the student questionnaire and mathematics test derived from the PISA 2012 database. The student questionnaire consists of three different forms and each form has a common part answered by all students and a rotated part administered to only one-third of the students involving questions about non-cognitive constructs. In this study, some of the teaching practices and the quality of teaching dimensions mentioned in the PISA 2012 technical report were considered as independent variables (OECD, 2014). 'Teacher Behavior: Student Orientation' scale was taken into consideration in the process of teaching practices, while 'Cognitive Activation', 'Teacher Support' and 'Classroom Management' scales were taken into consideration in the process of teaching quality. In addition to these scales, the 'Mathematics Self-Concept' and 'Mathematics Interest' scales, which were included in the PISA 2012 technical report among the attitudes towards mathematics indices, were also considered as mediating independent variables of this study. 'Mathematical Literacy Performance' obtained from the mathematics scale was used as a dependent variable in this study. In the PISA test, each student's mathematical literacy performance is measured along with his/her skills in formulating situations mathematically, employing mathematical procedures, and interpreting mathematical outcomes in various situations such as quantities, space and shape, change and relationships, and uncertainty. A total of 110 mathematics questions are included in the PISA 2012 survey. However, since PISA uses the rotated booklet design where students are assigned to a set of different clusters, they do not answer all the questions. Unobserved responses are estimated from the observed responses of the students. Hence, for mathematics scores in the PISA test, a set of five plausible values are provided by using Markov Chain Monte Carlo (MCMC) multiple imputation techniques. In PISA 2012 Assessment and Analytical Framework, the four areas that form the content domain of mathematical literacy are change and relationship, quantity, space and shape, and uncertainty and data. These four areas of the mathematical content domain, one of the important domains constituting the framework for assessing and evaluating PISA mathematical literacy, were used as subscales of mathematical literacy performance, and the five plausible values obtained were given as PV1MACC - PV5MACC, PV1MACQ - PV5MACQ, PV1MACS - PV5MACS, PV1MACU - PV5MACU, respectively (OECD, 2013b). For further details on the multiple imputation procedures for plausible values used in PISA 2012, please refer to the PISA 2012 Technical Report (OECD, 2014).

Data Analysis

In this study, first of all, an analysis of the missing data was performed, and the missing values belonging to independent and mediation variables were estimated by using a multiple imputation approach (Rutkowski, Gonzalez, Joncas, & von Davier, 2010). Kaplan and Su (2016) state that three different techniques (predictive mean matching, Bayesian linear regression, and proportional odds logistic regression) can be used for missing data imputation. Among the three techniques, they emphasized that the predictive mean matching technique generates the plausible values yielding a very close approximation to the distribution of the original data. Therefore, in order to handle missing data for this study, the predictive mean matching technique was used and five plausible values were produced via 100 iterations. Accordingly, the imputed data sets consisting of five plausible values were analyzed separately with each plausible value representing the four mathematics content subscales of mathematical literacy, change and relationships, quantity, space and shape, uncertainty and data (PV1MACC - PV5MACC, PV1MACQ - PV5MACQ, PV1MACS - PV5MACS, and PV1MACU - PV5MACU), and the estimates from the statistical analysis were pooled to produce the final parameter and sampling error estimates. For pooling the standardized coefficients in regression, an ad hoc method was used by averaging the values across multiply imputed data sets (van Ginkel, Linting, Rippe, & van der Voort, 2020). Besides, the PISA 2012 data file provides the weight variable that is referred to as the final student weight (W_FSTUWT). All inferential analyses of the study were carried out by weighing the data using the variable W_FSTUWT to avoid biased parameter estimates due to differential probabilities of sampling and non-response (OECD, 2009, 2014).

Structural Equation Modeling (SEM) was used to explain the relationships between the variables used in the study, taking into account the errors that occurred during the measurement. Firstly, Confirmatory Factor Analysis (CFA) was applied to the one-dimensional structures used in SEM and their compatibility with the data set was examined. Secondly, in order to examine the effect of students' perceptions of the instructional quality on mathematics achievement in the PISA test, and to determine the mediating role of their mathematics self-concept and interest in this effect, SEM in Figure 2 was used. Besides, multi-group models were designed to determine whether the final model to be differentiated according to the types of the school attended. In the PISA 2012 data set, school types are divided into four main groups. The groups were designated as follows: the first group (Group 1) as 'Primary' (*n*=120), the second group (Group 2) as 'General Secondary' (*n*=2789), the third group as (Group 3) 'Vocational and Technical Secondary' (*n*=1871) and the fourth group (Group 4) as 'Police Education' (*n*=68). Regression weights and fit index values of the models between four groups were examined and it was determined whether they were compatible with the values related to the final model.

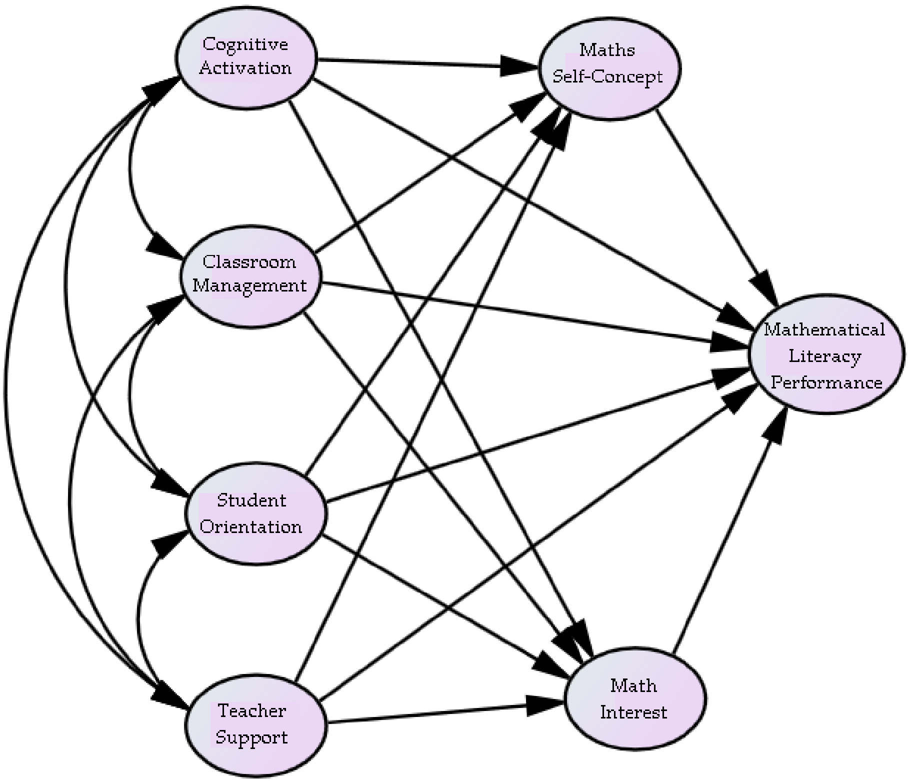

Figure 2. Theoretical Hypothesis Model

The hypothesis model in the figure was analyzed using AMOS 21.0 statistical package program. The full model overview with observed indicators for each latent variable and error term was also given in Appendix 1. The maximum likelihood method was used to estimate the regression coefficients between the parameters defined in SEM. Based on a probability level of .05, then, the test statistic that is the critical ratio (C.R.) representing the parameter estimate divided by its standard error needs to be greater than 1.96 or less than -1.96 to be considered statistically significant (Byrne, 2010). The most important feature of this method is that the observed variables must be in accordance with the normal distribution. Bentler (2005) suggested that Mardia's coefficients greater than 5.00 indicate that data are not normally distributed. The z value of Mardia obtained from the observed variables in this study was 57,178. In such cases, Byrne (2010) recommended examining chi-square distributions of newly derived data sets using bootstrap (n = 500) based on data replication. The chi-square distributions obtained from the samples derived from the model analyzed by the Bootstrap method are shown in Figure 3.

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                                |--------------------
                    1943,161    |*
                    1950,218    |*
                    1957,274    |****
                    1964,331    |********
                    1971,388    |****************
                    1978,445    |*************
                    1985,501    |*****************
N = 500             1992,558    |****************
Mean = 1986,695     1999,615    |*************
S. e. = ,734        2006,671    |********
                    2013,728    |****
                    2020,785    |***
                    2027,842    |*
                    2034,898    |*
                    2041,955    |*
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Not: ML discrepancy (implied vs population)

Figure 3. Chi-square Distributions of Samples Derived by Bootstrap Method (n=500)

The mean of chi-square distributions (Chi-square $_{mean}$ = 1986,695) for the random samples (n= 500) generated by the Bootstrap method gives results that are close to the chi-square value (Chi-square= 1871,103) of the data collected for the original sample. The estimated number of parameters before making modifications to the model was 87 (41 regression weights, 6 covariances, and 40 variances). Byrne (2010) proposed that the sample size used in the analysis with SEM should be more than 10 times the estimated number of parameters. The sample size (n = 1459) of this study was determined to be more than 10 times the estimated number of parameters (estimated number of parameters * 10 = 870), which was eighty-seven. In addition, correlation levels between latent variables for the instructional quality were interpreted according to Cohen's (1988) classification of 0 to 0.29 (low), 0.30 to 0.49 (medium) and above 0.50 (high).

Variables Defined in Theoretical Model

CFA was applied to the dependent and independent variables used in SEM analysis with 4848 students estimated by a multiple imputation method. The purpose of this analysis is to determine whether each of the latent variables that determine the instructional quality has one-dimensional structures. Abbreviations used to display the latent variables in the model are shown in Table 2 through the index names specified by PISA. Accordingly, Cognitive Activation, Classroom Management, Teacher Behavior: Student Orientation, Teacher Support, Mathematics Self-Concept, Interest in Mathematics, and Mathematical Literacy Performance are shortened as COGACT, CLSMAN, TCHBEHSO, MTSUP, SCMAT, INTMAT, and MATHPERF, respectively. In addition, Quantity, Uncertainty, Change and Relationship, and Space and Shape, which constitute four sub-categories of Mathematical Literacy Performance, are shown as PV1MACQ-PV5MACQ, PV1MACS-PV5MACS, PV1MACU-PV5MACU, and PV1MACC-PV5MACC over five plausible values, respectively. Along with the items describing the implicit variables in the theoretical model, the reliability coefficients for these items are also calculated over five plausible values and given in Table 2.

Table 2. List of Indicators That Make Up the Latent Variables in The Model

Latent Variables	PISA Index	Number of Items	List of Observed Variables (Items)	Reliability
Instructional Quality	COGACT	9	ST80Q01; ST80Q04; ST80Q05; ST80Q06; ST80Q07; ST80Q08; ST80Q09; ST80Q10; ST80Q11	,86
	ST80Q01: The teacher asks questions that make us reflect on the problem. *ST80Q04: The teacher gives problems that require us to think for an extended time. ST80Q05: The teacher asks us to decide on our own procedures for solving complex problems.* *ST80Q06: The teacher presents problems for which there is no immediately obvious method of solution.* *ST80Q07: The teacher presents problems in different contexts so that students know whether they have understood the concepts.* *ST80Q08: The teacher helps us to learn from mistakes we have made.* *ST80Q09: The teacher asks us to explain how we have solved a problem.* *ST80Q10: The teacher presents problems that require students to apply what they have learned to new contexts.* *ST80Q11: The teacher gives problems that can be solved in several different ways.*			
	CLSMAN	4	ST85Q01; ST85Q02; ST85Q03; ST85Q04	,60
	ST85Q01: My teacher gets students to listen to him or her. *ST85Q02: My teacher keeps the class orderly.* *ST85Q03: My teacher starts lessons on time.* *ST85Q04: The teacher has to wait a long time for students to <quiet down>.*			
	TCHBEHSO	4	ST79Q03; ST79Q04; ST79Q07; ST79Q10	,78
	ST79Q03: The teacher gives different work to classmates who have difficulties learning and/or to those who can advance faster. *ST79Q04: The teacher assigns projects that require at least one week to complete. ST79Q07: The teacher has us work in small groups to come up with joint solutions to a problem or task.* *ST79Q10: The teacher gives me feedback on my strengths and weaknesses in mathematics.*			
	MTSUP	4	ST83Q01; ST83Q02; ST83Q03; ST83Q04	,78
	ST83Q01: My teacher lets us know we need to work hard. *ST83Q02: My teacher provides extra help when needed.* *ST83Q03: My teacher helps students with their learning.* *ST83Q04: My teacher gives students the opportunity to express opinions.*			
Mathematics Self-Concept	SCMAT	5	ST42Q02; ST42Q04; ST42Q06; ST42Q07; ST42Q09	,85
	ST42Q02: I am just not good at mathematics. *ST42Q04: I get good <grades> in mathematics.* *ST42Q06: I learn mathematics quickly.* *ST42Q07: I have always believed that mathematics is one of my best subjects.* *ST42Q09: In my mathematics class, I understand even the most difficult work.*			
Mathematics Interest	INTMAT	4	ST29Q1; ST29Q03; ST29Q04; ST29Q06	,89
	ST29Q01: I enjoy reading about mathematics. *ST29Q03: I look forward to my mathematics lessons.* *ST29Q04: I do mathematics because I enjoy it.* *ST29Q06: I am interested in the things I learn in mathematics.*			
Mathematical Literacy Performance	PV1MACQ (Quantity) PV2MACU (Uncertainty) PV3MACC (Change and Relationships) PV4MACS (Space and Shape)			,97

The results of the analysis of the one-dimensional CFA of the items that make up the latent variables in the model are given in Table 3. The factor loadings of the items forming one-dimensional structures were significant at p<,001. The factor loadings for cognitive activation, classroom management, student orientation, teacher support, mathematics self-concept, interest in mathematics, and mathematical literacy performance range from 0.45 to 0.71, 0.61 to 0.88, 0.57 to 0.80, 0.50 to 0.82, 0.61 to 0.81, 0.75 to 0.90, and 0.92 to 0.97, respectively.

Analysis of Model Fit for One-Dimensional Structures

The model fit index values for one-dimensional CFA models that constitute instructional quality, mathematics self-concept, interest in mathematics, and mathematical literacy performance are given in Table 3.

Table 3. Model Fit Index Values of One-Dimensional PISA Indices

Models	Chi-square	df	SRMR	CFI	GFI	AGFI	NFI	TLI	RMSEA	90% CI
COGACT	5117,38	105	,06	,95	,96	,90	,95	,91	,04	,04-,05
CLSMAN	40,97	10	,01	,99	,99	,99	,99	,99	,01	,00-,01
TCHBEHSO	24,37	10	,00	,99	,99	,99	,99	,99	,01	,00-,01
MTSUP	103,99	10	,01	,99	,99	,99	,99	,99	,02	,02-,02
SCMAT	654,00	25	,02	,99	,99	,97	,99	,97	,03	,03-,03
INTMAT	338,77	10	,01	,99	,99	,97	,99	,98	,04	,03-,04
MATHPERF	40,41-71,55	10	,00	1,00	,99	,99	1,00	,99	,01	,01-,02

In the model fit statistics, CFI (Comparative Fit Index), GFI (Goodness of Fit Index), AGFI (Adjusted Goodness of Fit Index), NFI (Normed Fit Index) values of CFA models tested for one-dimensional structures were found to be above 0.90, which is the desired critical value (Byrne, 2010). In one-dimensional CFA models of Cognitive Activation, Classroom Management, Teacher Behavior: Student Orientation, Teacher Support, Mathematics Self-Concept, Interest in Mathematics and Mathematical Literacy Performance, SRMR (Standardized Root Mean Square Residual) and RMSEA (Root Mean Square Error of Approximation) values were found to below the level of 0.08 indicating a good fit (Browne & Cudeck, 1993; Hooper, Couglan, & Mullen, 2008).

Results

Figure 4 displays the final version of the model designed to determine the effect of the students' perceptions of the instructional quality on the mathematical literacy performance in PISA 2012 and the mediating role of the perceptions of mathematics self-concept and mathematics interest on this effect after the modifications have been made in order to reduce the chi-square value of the model.

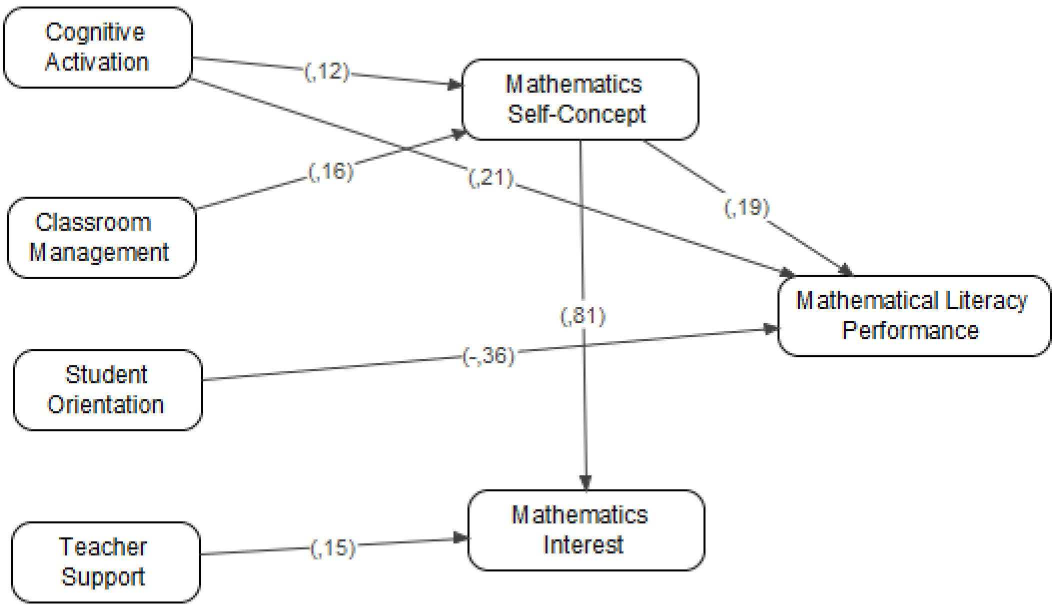

Figure 4. Structural Equation Model on the Relations Between Instructional Quality, Self-Concept and Interest in Mathematics (Pooled Regression Values)

The model fit index values of the structural equation model obtained as a result of the analysis are given in Table 4. In the model fit statistics, it is seen that the final model meets the desired critical values (CFI, NFI, and TLI > 0,90; RMSEA < 0,05). Although GFI and AGFI values appear below 0.90 and SRMR value above 0.05, it is stated that these values can be strongly influenced by the sample size (Marsh, Balla, & McDonald, 1988), and the most important fit index value to be considered for the model fit is the RMSEA value (MacCallum & Austin, 2000). The obtained model fit values signify that there is a good fit between the hypothesis model and the data set.

Table 4. Model Fit Index Values for the Final Model

	Chi-square	df	SRMR	CFI	GFI	AGFI	NFI	TLI	RMSEA	90% CI
Final Model	41088,72	2410	0,06	,92	0,87	0,85	0,91	0,92	0,03	0,03 – 0,03

In order to determine whether the final model differs according to the type of school, the regression weights and fit indices of the models between groups were also examined, and the values obtained for Group 1 (*n*=120) and Group 4 (*n*=68) were found to be non-significant. It can be indicative of a sample size that is too small. On the other hand, all parameters obtained for Group 2 (*n*=2789) and Group 3 (*n*=1871) were found to be significant. The fit index values for the groups were found as follows: Chi-square = 10329,50; df = 1928; GFI = ,86; CFI = ,91; NFI = ,89; IFI = ,91; TLI = ,90; SRMR = ,09; RMSEA = ,03. Accordingly, it was determined that the final model obtained was compatible with the 'General Secondary' and 'Vocational and Technical Secondary' groups. Considering the differences in the chi-square change (Δ(Chi-square) = -30759,22; Δ(df) = -482), it was seen that the differences in the fit index values were quite small (Δ(GFI) = ,01; Δ(CFI) = ,01; Δ(NFI) = ,02; Δ(TLI) = ,02; Δ(SRMR) = ,03; Δ(RMSEA) = ,0). According to this finding, there was a maximum 3% change in all fit index values except the chi-squared and df values. Besides, giving that Group 2 and Group 3 constitute 96% of the entire sample, it can be said that the regression weights and fit indices of the between-group models are compatible with the values for the final model.

Analysis of Direct and Indirect Effects

Table 5 presents the standardized and non-standardized regression values for the direct and indirect effects of latent variables in the model.

Table 5. Standardized and Non-Standardized Regression Values for Direct and Indirect Effects

		SCMAT		INTMAT		MATHPERF	
	Model	**B (SE)**	**β**	**B (SE)**	**β**	**B (SE)**	**β**
Direct effects							
Instructional Quality	COGACT	,17 (,03)	,12	-		42,30 (5,22)	,21
	CLSMAN	,17 (,02)	,16	-		-	
	MTSUP	-		,20 (,02)	,15	-	
	TCHBEHSO	-		-	-	-51,10 (4,39)	-,36
	SCMAT	1		,95 (,03)	,81	27,67 (2,63)	,19
	INTMAT	-		1		-	
Indirect effects (the mediating role of self-concept and interest)							
	COGACT => SCMAT => MATHPERF					4,76	,02
	CLSMAN => SCMAT => MATHPERF					4,62	,03
Correlations (level)							
						B (SE)	β
	COGACT <=> TCHBEHSO (high)					,17 (,01)	,64
	COGACT <=> MTSUP (medium)					,11 (,01)	,46
	TCHBEHSO <=> MTSUP (medium)					,11 (,01)	,33

Table 5. Continued

	SCMAT		INTMAT		MATHPERF	
Model	**B (SE)**	**β**	**B (SE)**	**β**	**B (SE)**	**β**
Correlations (level)						
					B (SE)	β
CLSMAN <=> TCHBEHSO (low)					,07 (,01)	,20
CLSMAN <=> MTSUP (high)					,19 (,01)	,60
CLSMAN <=> COGACT (medium)					,09 (,01)	,35

B: Non-standardized; β: Standardized; COGACT (Cognitive Activation); CLSMAN (Classroom Management); TCHBEHSO (Teacher Behavior: Student Orientation); MTSUP (Teacher Support); SCMAT (Mathematics Self-Concept); INTMAT (Interest in Mathematics); MATHPERF (Mathematical Literacy Performance)

In response to the first research question, the analysis of the direct effects of students' perceptions of the instructional quality on mathematical literacy performance indicates that the perception of cognitive activation has a positive low effect (r = ,21; R^2 = ,04), and the perception of student orientation has a negative moderate effect (r = -,36; R^2 = ,13). While the students' perception of cognitive activation accounts for 4% of mathematical literacy performance, this rate is 13% in the perception of student orientation (See Appendix 2 for more detail). Furthermore, the negligible non-significant effects of students' perceptions of classroom management and teacher support on mathematical literacy performance were also observed.

In response to the second research question, the analysis of the direct effects of students' perceptions of the instructional quality on mathematics self-concept and interests shows that the perceptions of cognitive activation (r = ,12; R^2 = ,01) and classroom management (r = ,16; R^2 = ,03) have a low effect on the mathematics self-concept. Similarly, it was determined that the perception of teacher support (r = ,15; R^2 = ,02) has a low effect on the perception of interest in mathematics. Students' perceptions of cognitive activation and classroom management account for 1% and 3% of their perceptions of mathematics self-concept respectively, and similarly their perceptions of teacher support account for about 2% of the perceptions of their interest in mathematics (See Appendix 2 for more detail).

In response to the third research question, the indirect and total effects of perceptions of the instructional quality on mathematical literacy performance are given in Table 6. The combination of the direct and indirect effects makes up the total effect of each of the explanatory variables (cognitive activation, classroom management, student orientation, teacher support) of this study on the dependent variable (mathematical literacy performance) (Raykov & Marcoulides, 2006).

Table 6. Regression Values of Direct, Indirect and Total Effects on Mathematical Literacy Performance

	Mathematical Literacy Performance		
Variables	r_1	r_2	r_3
COGACT (Bilişsel Aktivasyon)	,21	,02	,23
CLSMAN (Sınıf Yönetimi)	-	,03	,03
TCHBEHSO (Öğrenci Oryantasyonu)	-,36	-	-,36
SCMAT (Matematiğe Yönelik Öz-benlik)	,19	-	,19
MTSUP (Öğretmen Desteği)	-	-	-
INTMAT (Matematiğe Yönelik İlgi)	-	-	-

r_1: Direct effect; r_2: Indirect effect; r_3: Total effect

In terms of indirect effects on mathematical literacy performance, Table 6 demonstrates that the perceptions of cognitive activation (r_2 = ,02; p<,01) and classroom management (r_2 = ,03; p<,01) have a significant positive low effect. The other indirect effects in the model also show that students' perceptions of cognitive activation (r_2 = ,10 ; p<,01) and classroom management (r_2 = ,13; p<,01) have a low effect on the perception of interest in mathematics through the perception of mathematics self-concept (See Appendix 3 for more detail).

Discussion, Conclusion and Suggestions

In this study, the relationships between instructional quality and mathematical literacy performance based on PISA 2012 Turkey sample survey data from a student point of view were examined with SEM analysis using self-concept and interest in mathematics as mediator variables. In the generated model, it was found that while student orientation was the variable that best explains mathematical literacy performance in terms of a net total effect (albeit negative), the variable that positively explains it the most was cognitive activation. It was also found that classroom management and teacher support were not significant explanatory variables for mathematical literacy performance in the model.

At first, based on the analysis of the generated structural equation model, it was determined that the most important variable explaining mathematical literacy performance in terms of the total effect is student orientation. Student orientation refers to differentiation in teaching or the extent to which teachers offer students different tasks based on their skills as well as the use of small-group instruction and project work by teachers in order to tailor classroom learning to optimize student involvement. This study showed that greater reported use of student orientation in mathematics lessons was linked to lower achievement in mathematical literacy. What is expected to happen in theory is that student-oriented approaches increase the effectiveness of teaching (Cornelius-White, 2007). However, the relationship between specific student orientation practices and mathematical literacy achievement should not be generalized and interpreted as causal. In other words, higher use of student orientation does not necessarily result in lower achievement. Rather, this result may be reflecting the effectiveness of the student orientation practices with particular groups of students in this study. Besides, student groups sharing the same mathematics instructor may also vary in their understanding of the use of these student-oriented activities. Nevertheless, it is also possible to come across studies that are in line with the results of this research. These studies have linked the negative impact of student orientation on students' mathematical literacy performance to the use of excessive constructivist practices by teachers and different effects of student orientation on low and high achieving students (Caro, Lenkeit, & Kyriakide, 2015; Karaman & Yılmaz-Koğar, 2017). In the study by Yi and Lee (2017) comparing South Korea and Singapore samples, it was stated that the student orientation had a negative effect on mathematical literacy performance for both countries and that the student-oriented approach was much preferred for students with lower mathematical literacy level. Hence, as shown in this study, the negative effect of perceptions of student orientation on mathematical literacy performance can be interpreted as the tendency of mathematics teachers to use the student-orientated approach more often for students with poor mathematical literacy performance. The same researchers also pointed out that student-oriented instruction may not be effective if it fails to engage students in cognitively challenging tasks but only makes them work on activities in a superficial way (Yi & Lee, 2017).

Moreover, based on the results of this study, it was noticed that teachers' use of cognitive activation strategies positively affected students' mathematical literacy performance. It is also possible to find similar PISA research results in the literature (Davis-Langston, 2012; Dibek & Demirtaşlı, 2017; Hendricks, 2013). This effect is attributed by Dibek and Demirtaşlı (2017) to the positive impact of teachers' pedagogical content knowledge on students' cognitive activation in mathematics classes. The more a teacher knows about how the content she teaches can be accessible for all students, the more the content will be ready for cognitive activation, and as students become cognitively active, their mathematical literacy performance will also be positively affected (Baumert et al., 2010). Teachers' use of cognitive activation strategies also helps students become more active in their learning environments and develop their critical thinking skills (Hendricks, 2013). These skills can also contribute positively to mathematical literacy as they help students develop high-level problem-solving skills that enable them to analyze a situation, make decisions, and manage multiple situations simultaneously (Türnüklü & Yeşildere, 2005).

In another respect, the positive effect of cognitive activation on mathematical literacy performance can also be interpreted that teachers prefer cognitive activation strategies mostly for students with high mathematical literacy achievement. Indeed, it is also known that teachers use cognitive activation strategies more frequently for students with higher PISA proficiency levels than students with lower proficiency levels (Burge, Lenkeit, & Sizmur, 2015). However, it is also difficult to say whether the use of these strategies will result in high mathematical literacy performance for all students, or whether high mathematical literacy performance is actually the result of only those students who are able to use these strategies in their courses.

Moreover, for students with low mathematical literacy, the preference for more student orientation and the use of fewer cognitive activation strategies also support the idea that student orientation approach cannot be effective alone without cognitive processes that encourage higher-order thinking (Klieme et al., 2009; Turner et al., 1998). Thus, the positive effect of the cognitive activation variable on mathematical literacy performance and the negative effect of student-orientation on this performance provides evidence for the idea that teachers' behaviors that encourage cognitive activation should not be confused with student-oriented behaviors of teachers. This has also shown that student orientation may not be effective enough when mathematics-related activities are studied superficially by not engaging students fully in their learning. In other words, as long as in-depth learning does not emerge as a form of strategies to activate students' cognitive process, student orientation may not contribute to effective learning (Klieme et al., 2009; Stefanou et al., 2004). Thus, teachers need to put more effort into helping students with low mathematical literacy engage in a cognitively more active teaching process (Yair, 2000). In that way, students' mathematical literacy performance can be improved by introducing challenging, new, and original activities stimulating their cognitive structures as well as student orientation.

In addition to the positive effect of cognitive activation on mathematical literacy performance, it has also been shown to have a positive effect on mathematics self-concept which is one of the mediator variables used to measure its indirect effect on that performance. Similarly, Lazarides and Ittel (2012b) stressed that cognitively higher-order thinking activities are associated with students' mathematics self-concept. An indirect effect of students' perceptions of cognitive activation similar to the direct positive effect of cognitive activation on mathematical literacy performance has also been observed on mathematical literacy performance. On the other hand, as found in this study, it should be noted that students' mathematics self-concept is not indirectly very effective on mathematical literacy performance as long as activities promoting cognitive activation take place in the classroom (see Table 4).

It was also found that classroom management, another component of instructional quality, had no significant and direct effect on mathematical literacy performance. This result is consistent with the findings of Yi and Lee (2017)'s study with the PISA 2012 South Korea sample. However, findings from international studies show that well-structured classroom management positively affects student achievement (Fauth et al., 2014; Martin et al., 2013; Wang et al., 1993). In this study, although classroom management does not have a direct effect on mathematical literacy performance, it has an indirect effect through mathematics self-concept.

This study also showed that although students' perceptions of cognitive activation and classroom management had no direct effect on interest in mathematics, they did have an indirect effect on it. This shows that planning activities for cognitive development in the classroom and effective classroom management can positively affect students' interest in mathematics via mathematics self-concept. There are also studies indicating that teaching with an emphasis on cognitive development and effective classroom management directly contribute to students' interest in mathematics courses (Daniels, 2008; Lazarides & Ittel, 2012b; Pauli & Lipowsky, 2007). This suggests that instructional quality may also be closely related to affective and motivational outcomes (Seidel & Shavelson, 2007).

On the other hand, it was found that students' perception of teacher support had a direct positive effect on mathematics interest and no effect on mathematical literacy performance. Moreover, it can be said that the students' interest in mathematics is not both directly and indirectly effective on mathematical literacy performance even if the teacher support is provided in the classroom. This is consistent with the findings of some studies showing that a supportive learning environment does not play an important role in predicting mathematical literacy performance (Baumert et al., 2010; Lipowsky et al., 2009). However, it should be recognized that there are also studies claiming that teachers who create a supportive learning environment in which all students can feel successful and have a sense of development can help create the essential elements for effective learning (Anderman et al., 2001; Yi & Lee, 2017).

As a result, cognitive activation appears to be the most important factor that is positively associated with mathematical literacy achievement. This naturally indicates that teaching methods that challenge students to think about and reflect on mathematical ideas and provide them with the opportunity to choose their own methods when presented with problems that are not clearly solved can enable students to think critically about mathematics and to increase their achievements. However, it is also possible to say the opposite. In order to provide students with opportunities that contribute to cognitive activation, teachers need to present mathematical problems that can be resolved in various ways and can necessitate various solutions in diverse contexts. Such a teaching process also requires a classroom environment in which students are encouraged to discuss alternative mathematical ideas and asked to explain and justify their strategies, and helps students to learn from their mistakes.

There are also some limitations to this study. First of all, PISA data has a hierarchical structure consisting of clustered samples presumably having some degree of dependence within themselves. This means that the application of a single-level analysis for calculating the model parameter estimates may be reasonably accurate, but it tends to underestimate the sampling variance for dependent scores. However, it is also argued that in such cases, if multilevel analyzes are not used, the results obtained with single-level analyzes should not necessarily be considered as completely biased or inaccurate (Bickel, 2007; Hox, Moerbeek, & Van de Schoot, 2018; Kline, 2011). Nonetheless, it may be possible to better represent or predict the results of this study in a multilevel mediation structural equation modeling (MLM-SEM) compared with either a structural equation modeling (SEM) or multilevel modeling (MLM) alone. However, specialized software for SEM, including AMOS and many others, does not incorporate a multilevel mediation structural equation modeling analysis. Besides, many of the SEM's special strengths correspond to MLM constraints. For instance, the latent variables measured with multiple indicators can be interpreted either as predictors or as outcome variables in SEM. As a result of this specification, the error of measurement in the analysis can be kept under control. In addition, the estimation of direct or indirect effects in SEM is fairly straightforward and computationally quite suitable even for large scale datasets. On the other hand, the convergence of MLM and SEM in the form of a multilevel mediation structural equation modeling offers many potential benefits for researchers to test a wider range of hypotheses (Kline, 2011, 2016). Thus, with the help of newer versions of specific computer programs, a multilevel mediation structural equation modeling can be applied for further study to account for a nested data structure of PISA by simultaneously considering school and student-level variables and the interactions between them. In this way, the results obtained from the single-level and multilevel mediation analyses can also be compared with each other to appropriately test direct and indirect effects in hierarchical/clustered data and the differences can be revealed (Krull & MacKinnon, 2001). Moreover, since there is no teacher questionnaire in the PISA 2012 survey, teacher characteristics perceived by the students are used to demonstrate the instructional quality of the teachers in this study. Contrary to teachers' own assessments, it is believed that teachers' behaviors in the classroom can be evaluated more accurately and reliably by their students. However, when the analysis unit is a student, making inferences based on students' perceptions of their teachers' behaviors rather than teachers' views about their own behaviors may also cause some limitations. Thus, limitations resulting from the use of secondary data such as the PISA database and student-perceived teacher behaviors can be overcome by future studies that explore the relationship between instructional quality and students' cognitive and non-cognitive outcomes based on first-hand data collected directly from teachers. Furthermore, in order to determine the effect of the triarchic model of the instructional quality on the mathematical literacy performance, the mediator variables in the generated model within the scope of this research are limited to two non-cognitive variables including mathematics self-concept and mathematics interest. Therefore, for future research, it is recommended to develop alternative models that show the mediating role of other non-cognitive variables in the student questionnaire of PISA 2012, such as mathematics self-efficacy and mathematics anxiety, which may perhaps further explain mathematical literacy performance in depth.

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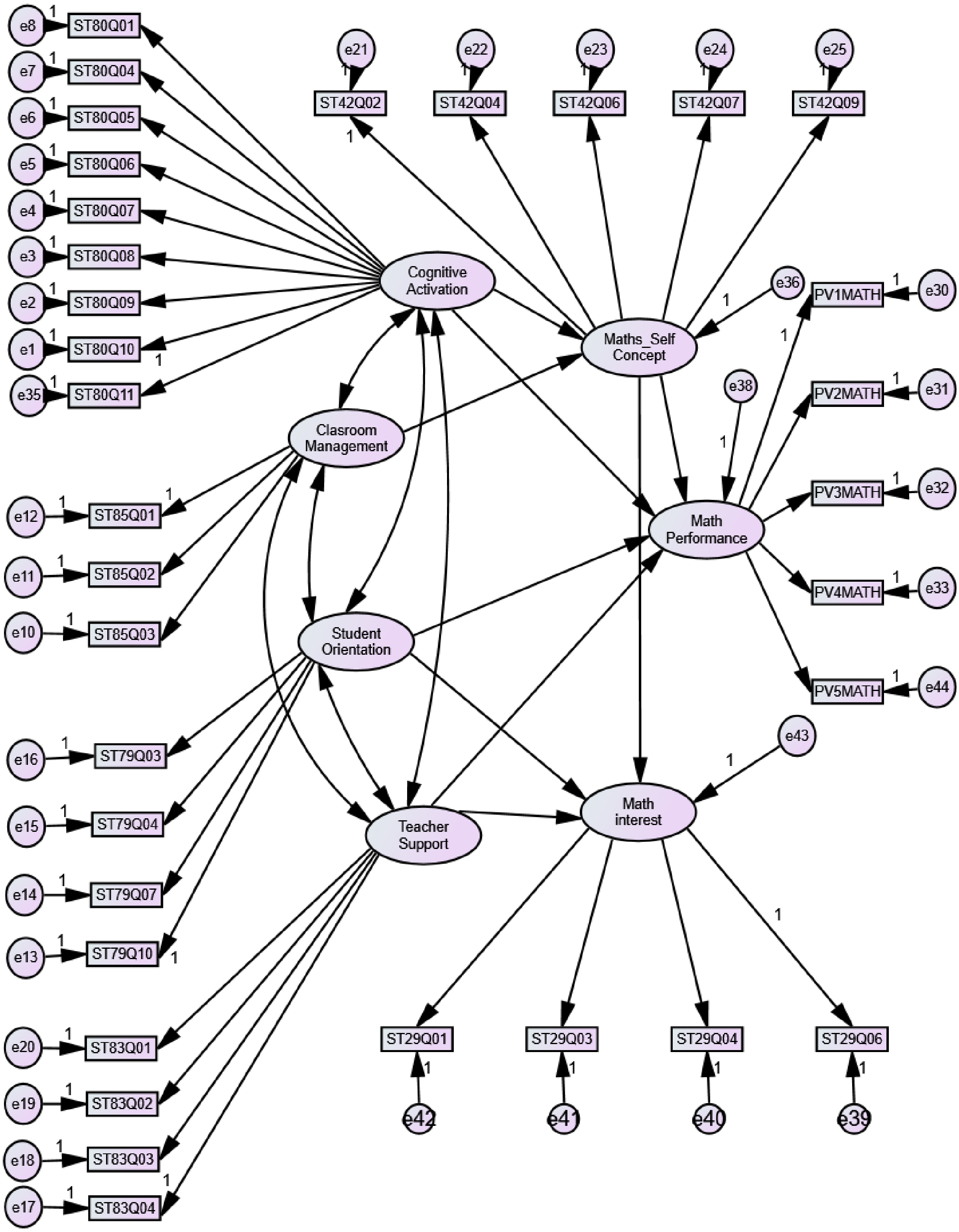
Appendix 1. An Example of a Full SEM Model with Observed Indicators for Each Latent Variable and Error Term



Appendix 2. Regression Values of Twenty-Five SEM Models for Direct Effects

Variables			**Regresyon Değerleri**																									
			PV1 (MACC-MACQ-MACS-MACU)					**PV2 (MACC-MACQ-MACS-MACU)**					**PV3 (MACC-MACQ-MACS-MACU)**					**PV4 (MACC-MACQ-MACS-MACU)**					**PV5 (MACC-MACQ-MACS-MACU)**					**Pooled Regression**
			P1	**P2**	**P3**	**P4**	**P5**	**P1**	**P2**	**P3**	**P4**	**P5**	**P1**	**P2**	**P3**	**P4**	**P5**	**P1**	**P2**	**P3**	**P4**	**P5**	**P1**	**P2**	**P3**	**P4**	**P5**	
Cognitive Activation	=>	Math Self Concept	0,14	0,10	0,12	0,12	0,14	0,14	0,10	0,12	0,12	0,14	0,14	0,10	0,12	0,12	0,14	0,14	0,10	0,12	0,12	0,14	0,14	0,10	0,12	0,12	0,14	0,12
Math Self Concept	=>	Math Performance	0,19	0,18	0,18	0,18	0,18	0,2	0,19	0,19	0,19	0,19	0,20	0,19	0,18	0,19	0,19	0,20	0,19	0,19	0,20	0,20	0,19	0,19	0,19	0,19	0,19	0,19
Cognitive Activation	=>	Math Performance	0,20	0,22	0,21	0,19	0,21	0,20	0,22	0,22	0,19	0,21	0,21	0,23	0,22	0,20	0,22	0,20	0,22	0,22	0,19	0,21	0,21	0,23	0,22	0,19	0,22	0,21
Classroom Management	=>	Math Self Concept	0,16	0,18	0,17	0,15	0,15	0,16	0,18	0,17	0,15	0,15	0,16	0,18	0,17	0,15	0,15	0,16	0,18	0,17	0,15	0,15	0,16	0,18	0,17	0,15	0,15	0,16
Student Orientation	=>	Math Performance	-0,34	-0,37	-0,36	-0,34	-0,36	-0,34	-0,37	-0,37	-0,34	-0,37	-0,34	-0,37	-0,37	-0,34	-0,36	-0,35	-0,36	-0,36	-0,33	-0,36	-0,35	-0,37	-0,37	-0,33	-0,36	-0,36
Teacher Support	=>	Math Interest	0,15	0,16	0,14	0,16	0,15	0,15	0,16	0,14	0,16	0,15	0,15	0,16	0,14	0,16	0,15	0,15	0,16	0,14	0,16	0,15	0,15	0,16	0,14	0,16	0,15	0,15
Math Self Concept	=>	Math Interest	0,81	0,81	0,82	0,80	0,83	0,81	0,81	0,82	0,80	0,83	0,81	0,81	0,82	0,80	0,83	0,81	0,81	0,82	0,80	0,83	0,81	0,81	0,82	0,80	0,83	0,81

Appendix 3. Regression Values of Twenty-Five SEM Models for Indirect Effects

Variables	Regression Coefficients																									
	PV1 (MACC-MACQ-MACS-MACU)					PV2 (MACC-MACQ-MACS-MACU)					PV3 (MACC-MACQ-MACS-MACU)					PV4 (MACC-MACQ-MACS-MACU)					PV5 (MACC-MACQ-MACS-MACU)					Pooled Regression
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	
F1 => F5 => F7	0,03	0,02	0,02	0,02	0,03	0,03	0,02	0,02	0,02	0,03	0,03	0,02	0,02	0,02	0,03	0,03	0,02	0,02	0,03	0,03	0,03	0,02	0,02	0,02	0,03	0,02
F2 => F5 => F7	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
F1 => F5 => F8	0,13	0,10	0,10	0,10	0,11	0,11	0,10	0,10	0,10	0,10	0,11	0,10	0,10	0,10	0,10	0,13	0,10	0,10	0,10	0,11	0,11	0,10	0,10	0,10	0,11	0,10
F2 => F5 => F8	0,11	0,14	0,14	0,12	0,12	0,13	0,14	0,14	0,12	0,12	0,13	0,14	0,14	0,12	0,12	0,12	0,14	0,14	0,12	0,12	0,12	0,14	0,14	0,12	0,12	0,13

Cognitive Activation (F1); Classroom Management (F2); Math Self-Concept (F5); Math Literacy Performance (F7); Math Interest (F8)