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THE RELATIONSHIP BETWEEN DIFFERENT VARIABLES FOR MATH LITERACY IN PISA 2012: A HYBRID MODEL STUDY

PISA 2012'DE MATEMATİK OKURYAZARLIĞINA AİT FARKLI DEĞİŞKENLER ARASINDAKİ İLİŞKİ: BİR HİBRİD MODEL ÇALIŞMASI

Sami PEKTAŞ[1], Mustafa KILINÇ [2]

Abstract

In this study, it is aimed to determine the relationship between math self-efficacy sense, math interest, math work ethics and math achievement of students taking part in PISA 2012 Turkey sample. The data including 3211 students taking part in PISA 2012 Turkey sample have been utilized. When we look at the established hybrid model, math self-efficacy sense, math interest and math work ethics explain %64 of math achievement. Self-efficacy sense and math work ethics explain %64 of math achievement. Math self-efficacy sense and math interest explain %54 of math achievement. In general, it is seen that math self-efficacy senses of students explain math achievement in a low level. Besides, it is concluded that math achievement has been explained in a high level in this hybrid model established by taking math interest and work ethics.

Keywords: PISA 2012, Math self-efficacy sense, Math interest, Math work ethics, Math achievement, Hybrid model

Öz

Bu çalışmada, PISA 2012 Türkiye örnekleminde yer alan öğrencilerin; matematik öz-yeterlik algısı, matematik ilgisi, matematik çalışma etikleri ve matematik başarıları arasındaki ilişkiyi tespit etmek amaçlanmıştır. PISA 2012 Türkiye örnekleminde yer alan 3211 öğrencinin verisinden yararlanılmıştır. Kurulan hibrid modele bakıldığında Matematik öz-yeterlik algısı, matematik ilgisi ve matematik çalışma etiği, matematik başarısının %64'ünü açıklamaktadır. Öz-yeterlik algısı ve matematik çalışma etiği, matematik başarısının %61'ini açıklamaktadır. Matematik öz-yeterlik algısı ve matematik ilgisi, matematik başarısının %54'ünü açıklamaktadır. Genel itibari ile öğrencilerin matematik öz-yeterlik

[1] Arş. Gör., Gazi Üniversitesi Eğitim Fakültesi, Eğitim Bilimleri Bölümü, Eğitimde Ölçme ve Değerlendirme Anabilim Dalı, pektassami@gmail.com
[2] Yrd. Doç. Dr., Mehmet Akif Ersoy Üniversitesi, Eğitim Fakültesi, Eğitim Bilimleri Bölümü Eğitimde Ölçme ve Değerlendirme Anabilim Dalı, mkilinc@mehmetakif.edu.tr

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algısı, matematik başarısını düşük düzeyde açıkladığı görülmektedir. Matematik ilgisi ve çalışma etiği de ele alınarak kurulan hibrid modelde matematik başarısının daha yüksek düzeyde açıklandığı sonucuna ulaşılmıştır.

Anahtar Sözcükler: PISA 2012, Matematik öz-yeterlik algısı, Matematik ilgisi, Matematik çalışma etiği, Matematik başarısı, Hibrid model

1. INTRODUCTION

Interactions between the countries, studies of international foundations and evaluations on a shared platform make the countries compete in certain fields. This situation causes education policies developed and renewed all around the world. At the same time, these researches have the characteristics of feedback and criticism for countries.

One of the studies playing effective role on the education policies of countries; depending upon basic concepts being understood properly; measuring the ability of mission accomplishment related to the daily life and being carried out at an international level is the Program for International Student Assessment (PISA). PISA is a kind of study that is organized by the Organization for Economic Cooperation and Development (OECD) and aims to measure the ability of using knowledge and skills of 15 year-old-students under the circumstances encountered in modern-day information society. Additionally, PISA exam is the most extensive and elaborative international program that evaluates the student performance and collects data about student, family and school factors in order to explain the differences between student performances. By focusing on basic skills such as reading, math and physical sciences; PISA project evaluates in which level the students acquire these knowledge and skills in order that they join the society at the end of the compulsory education (OECD, 2006).

The weighted subject area is math in PISA 2003 when Turkey attended firstly and PISA 2012 in which Turkey attended lastly. In PISA studies done on math predominantly, problem solving abilities of students who take this exam are measured with the difference of other years. PISA math questions are mainly related to the problem solving and mathematical literacy.

34 OECD countries and 31 non-member countries attended to PISA 2012. Around the world, about 510.000 students joined this exam. The study is composed of the questions that the students make their own answers and multiple-choice questions (OECD, 2013a). Problem statuses in PISA 2012 are kinds of questions that are based on real world situations and that students can do by observing and examining in the case of lack of knowledge (Australian Council for Educational Research [ACER] et al., 2010).

While to what extent math literacy measured in PISA evaluate the subject areas properly and to what extent selected samples represent the countries are a matter of debate, that the results taken by Turkey are close and low reveal that there are some problems in education system and these problems should investigated (Altun, Aydın, Uzel and Akkaya, 2012).

In this regard, it is considered that the relationship between self-efficacy sense of students, their math interest, math work ethics and math achievement is worth to investigate.

1.1. Self-Efficacy Sense

According to Bandura (1988), self-efficacy which is one of the basic concepts of social learning theory is the belief of individuals that they can do in accordance with learning and making their behaviors reach to a required level. The self-efficacy sense that is one of the most important variables of social cognitive theory affects the choices of individuals, their efforts that they make on succeeding any job and their anxieties influentially (Aşkar and Işıksal, 2003).

There is a positive relationship between self-efficacy beliefs of individuals and their academic achievements. This perception affects the behavior about individual's task, his effort and motivation in this behavior. In other words, self-efficacy affects the performance of individual related to a certain task (Kotaman, 2008).

In the case of learning, self-efficacy is defined as judgments of students' reliance on carrying out a specific academic performance (Pajares and Grahman, 1999). Therefore, students' self-efficacies about math are their self judgments about their activities related to math and their fulfillment of duties.

Self-efficacy is a factor that affects the academic performances of individuals because they evaluate their proficiencies before they display a behavior. Self-efficacy affects the individuals' choices of activities and to what extent they make an effort in order to complete a task (Zimmerman, 2000). Researches show that the important variable affecting math achievement of students is their self-efficacy senses (Pajares and Grahman, 1999; Zimmerman, 2000). Besides, self-efficacy sense provides students manage their own learning and improve regulatory strategies (Zimmerman, 2000).

1.2. Math Interest

In general terms, interest is taken as a variable related to motivation and it is defined as the engagement of individuals with a specific activity (Franzel, Goets, Pekrun, and Watt, 2010). These behaviors which awaken positive feelings in individuals occurs as a result of interest and they are the behaviors that these individuals decide with their free will (Köller, Baumert, and Schnabel, 2001). Franzel, Goets, Pekrun, and Watt (2010) take interest as a state and a property. While they define state interest as the individuals' interests in a specific place and time, proper interest is defined as emotional tendency that individuals get into the habit with respect to a specific activity. Like emotional property, interest can vary according to different fields. Therefore, individuals' level of math interest can completely be different from their interests to another lesson.

Because interest affects the motivation of individuals in terms of working, it also affects their academic achievements implicitly. In addition to this, because it increases the intrinsic motivation, the student having more interest to a specific field indispensably has higher efficacy sense in this field. In this case, when we look at the relevant studies, it is emphasized that there is a significant relationship between academic achievement and interest (Köller, Baumert, and Schnabel, 2001).

1.3. Work Ethics

Miller, Woehr and Hudspeth (2001) define the work ethics as the value and importance that individuals give hard work. Academically, work ethics are viewpoints of students about effort and organization. In terms of academic ethics, vision holders place their working times before free times and they carry on their works in a disciplined way. Actually study ethics is not an attitude of students but a

behavior that they learn later. Work ethics helps individuals improve behaviors and attitudes that support their success, so it is an important factor affecting success positively (Rau and Durand, 2000). When we look at the results obtained from the PISA studies, the time that the students allocate for studying in and out of the school is determined as the variable predicting their success academically (Anıl, 2008; Özer and Anıl, 2011).

In the PISA 2012 student questionnaire, it has been questioned whether the students have work table, own rooms and work environment related to the opportunities at their homes; computer, internet, literature, poem, art, course and technical source books, and materials like dictionary related to the education and teaching (MEB, 2015, p. 132).

1.4. Achievement Level

The questions in PISA math test are determined as six-level. They define which mathematical processes and operations can be done by the students who reach this level of competence. Starting from this point of view, it can be possible to comment on student efficacies throughout the country (OECD, 2010).

Table 1. PISA Math Literacy Competence Level

Level	Skills
Level-6 (above 669)	- To be able to do research and modeling studies individually. - To be able to form concepts related to the complex problems and make generalization. - To be able to establish relationship between various information sources and notations. - To be able to express their own invention, comment, and points of view and defend their convenience.
Level-5 (607-669)	-To be able to develop models for complex states and determine the constraints and assumptions of these states. - To be able to determine the strategies that can be used and determine the relationship between these strategies. - To be able to explain, express and support the used strategy.
Level-4 (545-606)	- To be able to use a given strategy effectively. - To be able to realize the relationships between different notations and identify the appropriate one. - To be able to consider flexibly and convey their opinions.
Level-3 (482-544)	- To be able to execute transactions explicitly mentioned. - To be able to use simple problem solving strategies. - To be able to interpreting notations. - To be able to prepare short reports including their comments.
Level-2 (420-481)	- To be able to recognize and interpret states based on direct placement. - To be able to utilize limited notations. - To be able to use basic algorithm, formula and operations. - To be able to realize the results that can merely be seen by direct reasoning.
Level-1 (358-419)	- To be able to solve usual questions in which all the data are given for solution. - To be able to distinguish the information based on certain instructions. - To be able to do routine operations.
Below Level-1	- They can have some abilities like reading a number clearly shown in a simple notation and doing some simple operations with natural numbers.

(MEB, 2013, p.28).

According to PISA 2012, the students attending from Turkey take place in Level-2 by getting 448 points in the field of math literacy (OECD, 2013a). In PISA 2012 math literacy subject area exam, Turkey is on the 44th rank with 448 average points among 65 countries attending this exam.

Table 2. Distribution of the Students in Turkey and OECD Countries according to their Math Literacy Competence Level in PISA 2012

	Average	Below Level-1	Level-1	Level-2	Level-3	Level- 4	Level-5	Level-6
Turkey	448	15,5	26,5	25,5	16,5	10,1	4,7	1,2
OECD Average	494	8,0	15,0	22,5	23,7	18,2	9,3	3,3

(MEB, 2013, p. 12, 28).

1.5. Purpose

In this study, it is aimed to determine the relationship between math self-efficacy sense, math interest, math work ethics and math achievement of the students taking place in PISA 2012 Turkey sample.

In accordance with this purpose, determined sub-purposes are stated as follows:

- The relationship between self-efficacy sense, math interest and math achievement,
- The relationship between self-efficacy sense, math work ethics and math achievement,
- The relationship between self-efficacy sense, math interest, math work ethics and math achievement

are tried to be examined by establishing hybrid model.

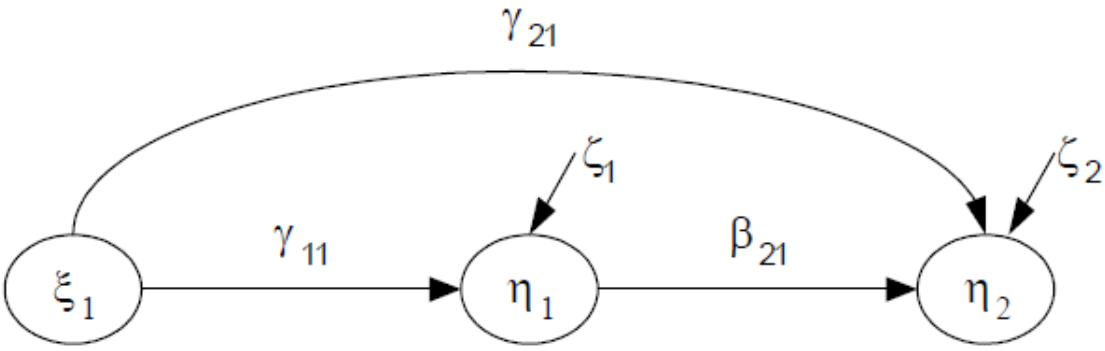
2. METHODOLOGY

2.1. Research Model

With this purpose in mind, the relational screening model that reveals the relationship between the variables has been used. The relational screening model enables explanation of the relationships between variables and prediction of the results (Tekbıyık, 2014). A hybrid model was constructed to test the relationship between the variables.

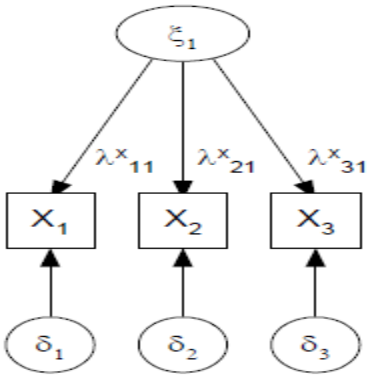
Before the structural model that is set by the hybrid model is established, measurement models have been tested. The graphic display of measurement model is seen in Figure-1 and the graphic display of structural model is seen in Figure-2.

Figure 1. Graphic Display of Structural Equation Modeling



(Sharma, 1996: p.420)

Figure 2. Graphic Display of Measurement Model



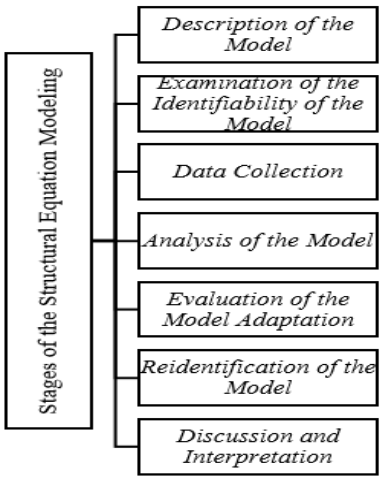
(Sharma, 1996: p.145)

The Structural Equation Modeling is a statistical approach that is used in order to test the models in which the causal (shown with one-way arrow) and correlated (shown with two-way arrow) relations between clear (observed, measured) and hidden (unobservable, imponderable) variables occur together (Hoyle, 1995: p.158-177).

The measurement model indicates how the implicit variables or theoretical structures depend on the observed variables and how they are demonstrated (Dursun and Kocagöz, 2010).

According to Kline (2010), the stages followed while establishing a traditional structural equation model is seen in Figure-3.

Figure 3. Stages of the Structural Equation Modeling



(Kline, 2010)

That the structural model and measurement model which are tested by considering the stages of the structural equation modeling are defined means that the entire model is supposed as defined. The entire model that is defined is called as hybrid model.

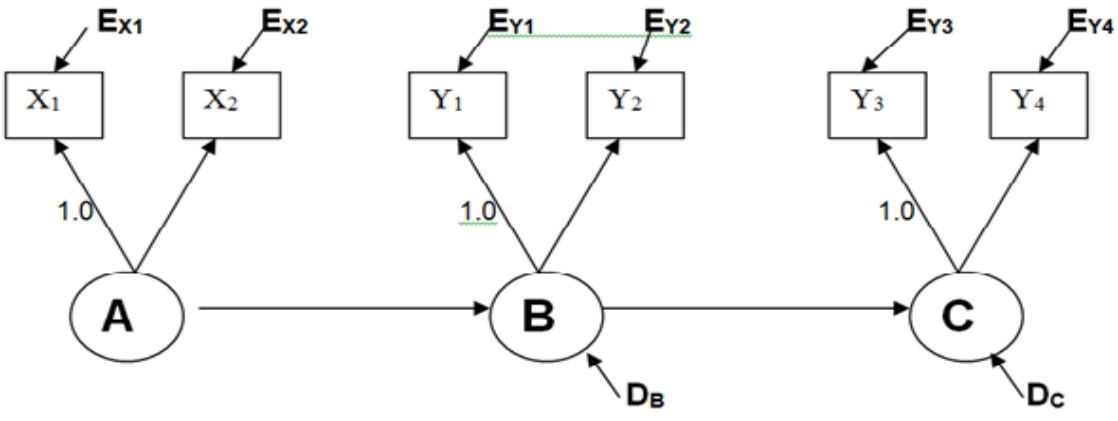
Hybrid Model is considered as a synthesis of structural model and measurement models. Bollen (1989) suggests two-step rule related to the identification of the Hybrid Model:

(1) Hybrid Model should be re-determined as a CFA (Measurement) Model including the relationships that are not identified in all possible parts between factors. It also requires to evaluate whether this model provides the necessary conditions for this definition.

(2) After that, only the structural part of the Hybrid Model should be taken and examined. If this model is alternate, the model is accepted as defined. If it is not an alternate model, the structural model should be evaluated whether it provides the necessary conditions for description.

Hybrid Model sample is seen in Figure-4:

Figure 4. Hybrid Model Sample



2.2. Study Group

There are 4848 students who take place in PISA 2012 Turkey sample. Among them, 1637 students who are coded as missing data common in all scales have been removed before the model is set. The hybrid model has been set with the rest of these 3211 students.

2.3. Data Analysis

Before the hybrid model is established, Level-1 single factorial CFA analysis has been done for each scale and achievement test. When the multivariate normality hypotheses related to the data in respect of the measurement model and the structural model are tested, it is seen that the Relative Multivariate Kurtosis value is higher than the critical value 1.00. It is also concluded that the value of skewness and kurtosis is significant. Because the Relative Multivariate Kurtosis value is higher than the critical value 1.00, according to Jöreskog (2002) it is stated that is does not provide the multivariate normality hypothesis.

As the multivariate normality hypothesis has not been provided, Robust Maximum Likelihood (RML) estimation method has been used instead of Maximum Likelihood (ML). First items belonging to the scales and achievement points have been fixed on 1.00 and the other items have been estimated freely.

3. FINDINGS

The findings related to the measurement model and the structural model belonging to the hybrid model which constitutes the sub-purposes of the research:

Findings related to the Measurement Models:

In this stage, conformity index values of Level-1 single factorial models have been examined by looking at the CFA analysis results related to the scales and achievement tests before the hybrid model has been established.

3.1. Math Self-Efficacy

Because of the Relative Multivariate Kurtosis = 3.890>1.00, it is seen that it does not provide the multivariate normality hypothesis. The conformity index values related to the math self-efficacy sense are stated in Table-3:

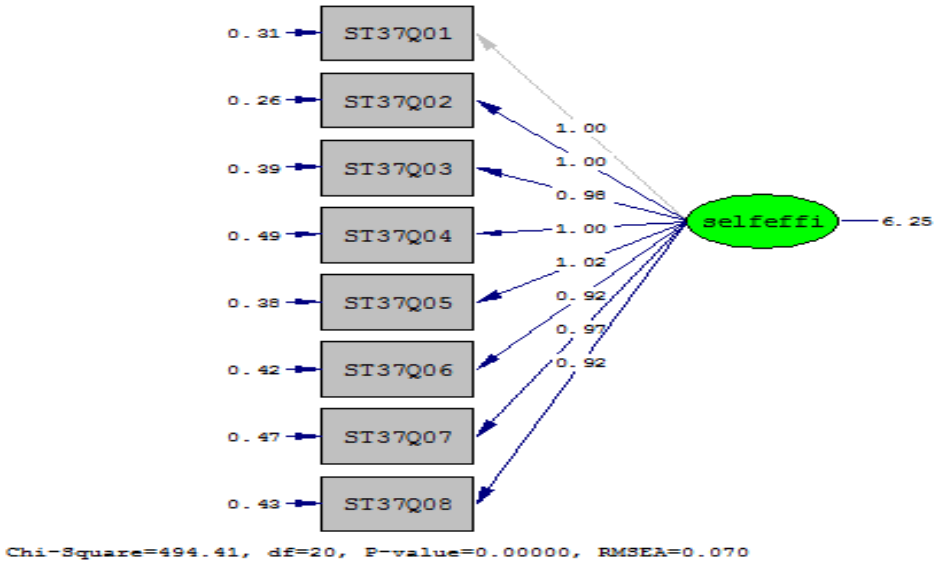
Table 3. The Conformity Values related to the Measurement Model for Self-Efficacy Sense

Conformity Index	χ^2/(df)	RMSEA	GFI	AGFI	CFI	NNFI
	494.41/(20)	0.070	0.92	0.86	1.00	0.99

In Table-3, the conformity index values related to the measurement model for math self-efficacy sense are examined. χ^2/(df) comes out higher because it is affected by the sample size; therefore, it is not taken into consideration in great samples (Yılmaz and Çelik, 2009, p. 39). When we look at the RMSEA value, it has admissible conformity index because it is smaller than 0.08 critical value (Kline, 2010, p. 206). It is seen that GFI and AGFI values have admissible conformity index and CFI and NNFI values have perfect conformity index (Schermelleh-Engel, Moosbrugger and Müller, 2003). When the conformity index values are examined, it is seen that the measurement model established for math self-

efficacy sense is confirmed. The measurement model related to the math self-efficacy sense is stated in Figure-5.

Figure 5. The Measurement Model for Math Self-Efficacy Sense



3.2. Math Interest

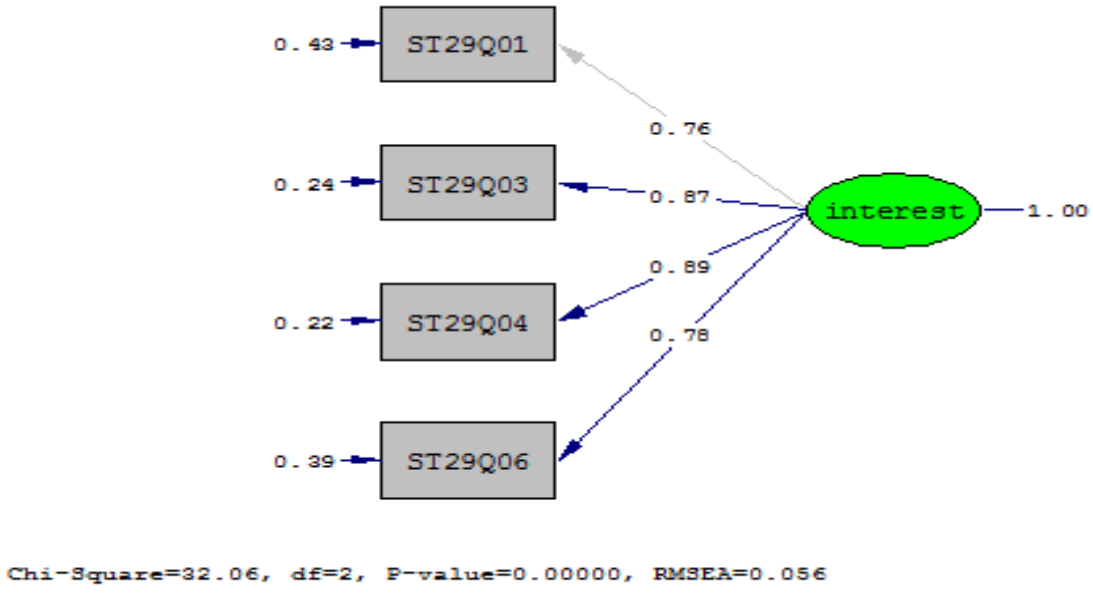
Because of the Relative Multivariate Kurtosis = 1.306>1.00, it is seen that it does not provide multivariate normality hypothesis. The conformity index values related to the math interest is seen in Table-4.

Table 4. The Conformity Index Values belonging to the Measurement Model for Math Interest

Conformity Index	χ^2/(df)	RMSEA	GFI	AGFI	CFI	NNFI
	32.06/(2)	0.056	1.00	0.98	1.00	0.99

In Table-4, the conformity index values related to the measurement model established for math interest of students are examined. χ^2/(df) is not taken into consideration in great samples (Yılmaz, and Çelik, 2009, p. 39). When we look at the RMSEA value, it is seen that it has the admissible conformity index because it is smaller than the critical value 0.80 (Kline, 2010, p. 206). When we look at the GFI, AGFI, CFI and NNFI values, it is seen that they have perfect conformity (Schermelleh-Engel, Moosbrugger, and Müller, 2003). When the conformity index values are examined, it is seen that the measurement model established for math interest of students is confirmed. The measurement model related to the math interest is stated in Figure-6.

Figure 6. The Measurement Model for Math Interest



3.3. Math Work Ethics

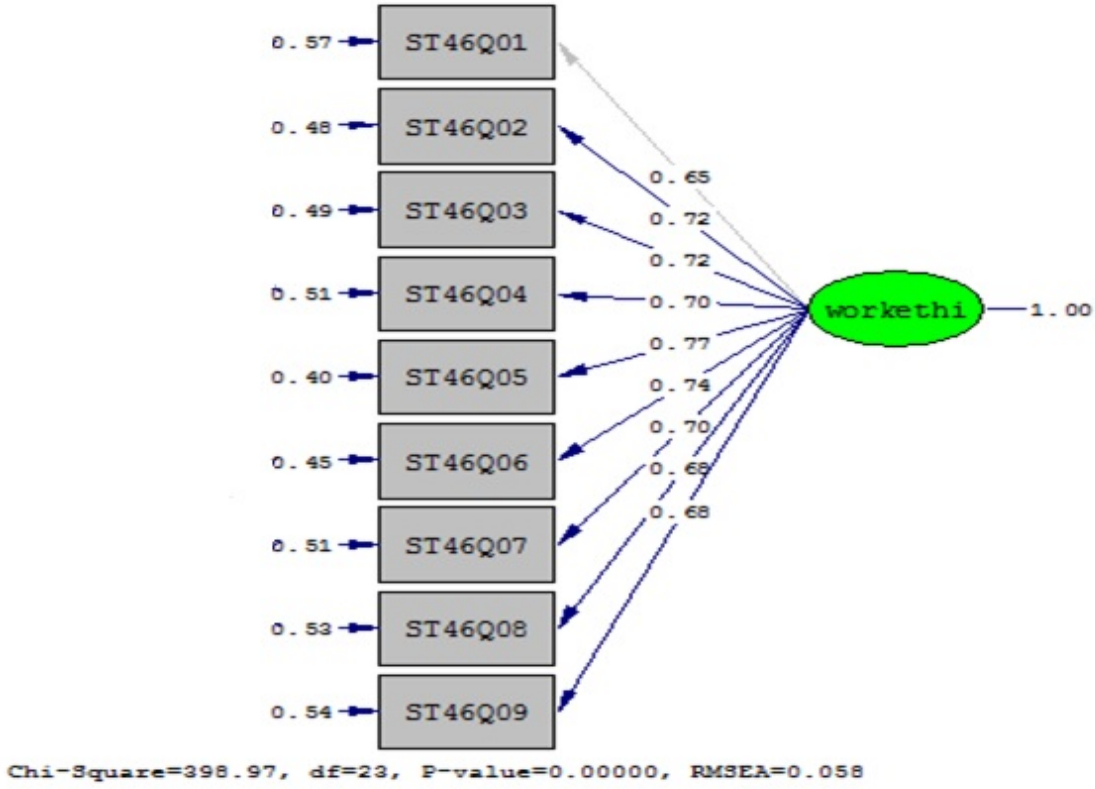
Because the Relative Multivariate Kurtosis = 1.331>1.00, it is seen that it does not provide the multivariate normality hypothesis. The conformity index values related to the math work ethics are stated in Table-5.

Table 5. The Conformity Index Values belonging to the Measurement Model for Math Work Ethics

Conformity Index	χ^2/(df)	RMSEA	GFI	AGFI	CFI	NNFI
	398.97/(23)	0.058	0.97	0.95	0.99	0.99

The conformity index values related to the measurement model established for math work ethics of students are examined in Table-5. χ^2/(df) is not taken into consideration in great samples (Yılmaz, and Çelik, 2009, p. 39). When we look at the RMSEA value, it is seen that it has an admissible conformity index as it is smaller than the critical value 0.080 (Kline, 2010, p. 206). When GFI, AGFI, CFI and NNFI values are taken, it is seen that they have the perfect conformity (Schermelleh-Engel, Moosbrugger, and Müller, 2003). Besides, it is stated that the measurement model established for the math work ethics of students is confirmed when the conformity index values are examined. The measurement model related to the math work ethics is seen in Figure-7.

Figure 7. The Measurement Model for Math Work Ethics



3.4. Math Achievement

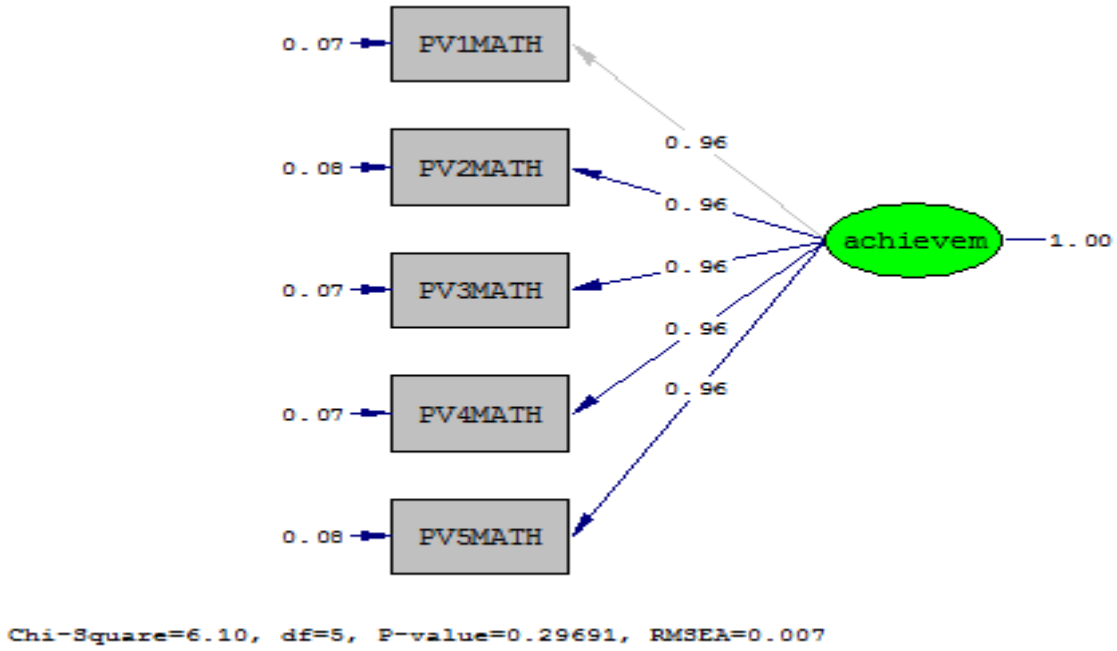
Because of the Relative Multivariate Kurtosis = 1.016>1.00, it is seen that it does not provide multivariate normality hypothesis. The conformity index values related to the math achievement is stated in Table-6:

Table 6. The Conformity Index Values belonging to the Measurement Model for Math Achievement

Conformity Index	χ^2/ (df)	RMSEA	GFI	AGFI	CFI	NNFI
	6.10/(5)	0.007	1.00	1.00	1.00	1.00

The conformity index values related to the measurement model established for math achievements of students are examined in Table-6. When we look at the χ^2/(df) value, it seen that it has the perfect conformity. When we look at the RMSEA value, it is seen that it has an admissible conformity index as it is smaller than the critical value 0.080 (Kline, 2010, p. 206). When GFI, AGFI, CFI and NNFI values are taken, it is seen that they have the perfect conformity (Schermelleh-Engel, Moosbrugger, and Müller, 2003). Additionally, it is stated that the measurement model established for the math achievements of students is confirmed when the conformity index values are examined. The measurement model related to the math achievements is seen in Figure-8.

Figure 8. The Measurement Model for Math Achievement



3.5. Findings Related To The Structural Model

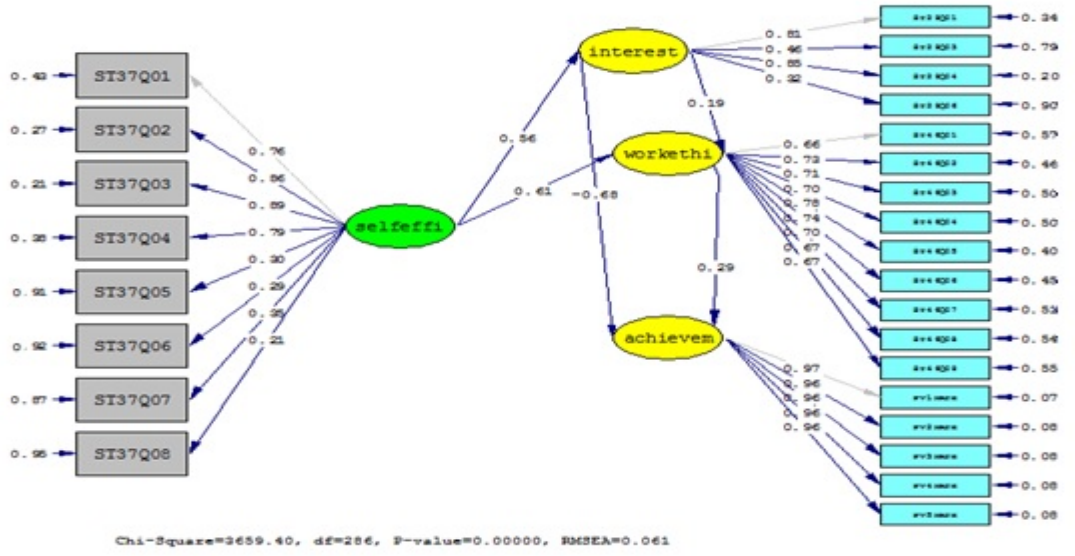
Because of the Relative Multivariate Kurtosis = 1.161>1.00, it is seen that it does not provide the multivariate normality hypothesis. The conformity index values related to the structural model are stated in Table-7.

Table 7. The Conformity Index Values related to the Structural Model

Conformity Index	χ^2/ (df)	RMSEA	GFI	AGFI	CFI	NNFI
	3659.40/(286)	0.061	0.91	0.89	0.98	0.97

The conformity index values related to the structural model are examined in Table-7. χ^2/(df) comes out higher because it is affected by the sample size and it is not taken into consideration in great samples (Yılmaz, and Çelik, 2009, p. 39). When we look at the RMSEA value, it is seen that it has an admissible conformity index as it is smaller than the critical value 0.080 (Kline, 2010, p. 206). It is also seen that GFI and AGFI have an admissible conformity index and CFI and NNFI have the perfect conformity (Schermelleh-Engel, Moosbrugger, and Müller, 2003). Besides, it is stated that the structural model is confirmed when the conformity index values are examined. The hybrid model belonging to the identified structural and measurement model is seen in Figure-9.

Figure 9. Hybrid Model for Math Self-Efficacy, Math Interest, Math Work Ethics and Math Achievement



R^2 values related to the ways defined in the hybrid model are given in Table-8.

Table 8. R^2 Values related to Hybrid Model

The way of Relation	R^2
Math Self-Efficacy → Math Interest→Math Work Ethics→Math Achievement	0.64
Math Self-Efficacy→ Math Work Ethics → Math Achievement	0.61
Math Self-Efficacy → Math Interest → Math Achievement	0.54
Math Self-Efficacy → Math Interest → Math Work Ethics	0.54
Math Self-Efficacy → Math Work Ethics	0.51
Math Self-Efficacy → Math Interest	0.31
Math Self-Efficacy → Math Achievement	0.03
Math Interest → Math Work Ethics → Math Achievement	0.33
Math Interest → Math Work Ethics	0.23
Math Work Ethics → Math Achievement	0.10

When the relationships between the variables belonging to the hybrid model are examined, it is seen that the effect of math self-efficacy, math interest and math work ethics on math achievement is R^2=0.64. The effect of math self-efficacy and math work ethics on math achievement is calculated as R^2=0.61. The effect of math self-efficacy and math interest on math achievement is R^2=0.54.

It is seen that the effect of math self-efficacy and math interest of students on math work ethics is R^2=0.54. The effect of math self-efficacy on math work ethics is calculated as R^2=0.51. The effect of math self-efficacy on math interest is R^2=0.31, and the effect of math self-efficacy on math achievement is R^2=0.03. It is seen that the effect of math interest and work ethics on math achievement is R^2=0.33. The effect of math interest on work ethics is calculated as R^2=0.23. The effect of math work ethics on math achievement is R^2=0.10.

4. CONCLUSION AND DISCUSSION

It is concluded that CFI and NNFI values have the perfect conformity when the conformity index values belonging to the single factorial CFA models (measurement models) established before hybrid model are examined. When we look at the GFI and AGFI, they have the admissible conformity. In the research, χ^2/ (df) value comes out high because of the large number of the sample.

When RMSEA values are examined, it is concluded that they have the admissible conformity level. CFI and GFI values can be said that they provide the multivariate normality because there are not too many differences between them. In general, it is concluded that there is an admissible conformity between factors and items in the measurement models established for the scales and achievement points.
When it is looked at the established hybrid model, math self-efficacy sense, math interest and math work ethics explain %64 of the math achievement. Math self-efficacy and math work ethics explain %61 of the math achievement. Math self-efficacy and math interest explain %54 of the math achievement.

As a result of the hybrid model, when the formulas are examined, math self-efficacy sense and math interest explain %54 of the math work ethics. It is concluded that math self-efficacy sense explain %51 of the math work ethics. Math self-efficacy sense explain %31 of math interest. Math self-efficacy sense of the students explain %3 of the math achievements. Math interest of the students and work ethics explain %33 of the math achievement. Math interest of the students explain %23 of the work ethics. Math work ethics of the students explain %10 of the math achievement.

In accordance with these results, math self-efficacy sense of the students explains the math achievement at a little rate. Increase of the math interest and work ethics affects the math achievement at a positive level. When the concepts of self-efficacy, interest and work ethics are taken into consideration, it is concluded that the most effective concept impressing math achievement is math interest.
In general, it is seen that math self-efficacy sense of the students explain the math achievement at a low level. In the hybrid model established by taking math interest and work ethics into consideration, math achievement is explained at a high level. In the study of Kotaman (2008), it is stated that self-efficacy sense affects the motivation and thus the achievement of the student in any math subject or solving any problem. Multon, Brown and Lent (1991) have done 39 meta-analyses of the study. According to the results obtained from the analysis of the studies including various student samples and research designs, self-efficacy explains %14 of the student achievement variance (Kotaman, 2008). In the study of Yıldırım (2011), the relationships have been defined in a way that self-efficacy has an indirect effect on PISA math achievement in terms of both direct and also intrinsic motivation and anxiety in theoretical model suggested in the research. As a result of the study, Ayotola and Adedeji (2009) state that there is a strong relationship between math self-efficacy and math achievement positively. For this reason, they assert that teachers should find the ways of improving math self-efficacy of the students. The findings of these studies done on math achievement support the results of the relationships between variables in hybrid model established within the scope of this research.

5. SUGGESTIONS

The math self-efficacies of the students attending PISA 2012 and taking part in Turkey sample do not have low-level effect on math achievement directly. In this case, it is considered that increasing the math interest and the methods used in math work ethics affects the student success higher-up.

Points to take into account like giving more places to the activities that increase the students' level of interest toward math and providing self sacrificing teacher guidance on the basis of determining the right work ethics toward math in social life and school environment of the students are asserted in PISA applications. It is considered that creating environments associated with the math subjects except social life and family life environments can be useful in order to increase the math self-efficacies.

Additionally, in-service training seminars can be organized within the scope of MEB on the basis of providing the test contents applied at the international level like PISA and TIMSS and the transmission of the evaluation results of these tests to teachers.

The effect of the various models including factors like anxiety, sense of self, attitude, intent, behavior, out-of-school learning, experiences, and preparedness on math achievement of the students can be tested.

Similar models can be tested on the reading skill and physic literacy measured in PISA.

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