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HYBRID MODEL FOR THE RELATIONSHIP BETWEEN STUDENTS' SCIENCE LITERACY LEVEL AND SOME VARIABLES[1]

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ABSTRACT

In this study, it is aimed to establish a hybrid model that reveals the relationship between the Science Literacy level of the students in the Singapore and Turkey samples in PISA 2015 and the students' test anxiety, science interest, ambitions and beliefs in the accuracy of knowledge. In this context, the research is a relational survey model. Hybrid models were established using the data of students in the Singapore and Turkey samples. With the established models, the effect levels of the variables affecting the science literacy levels of the countries were tried to be compared with the hybrid model. In the research, hybrid model and measurement models were established with 5668 student data in the Singapore sample and 5084 student data in the Turkey sample. It is seen that the multivariate normality assumption cannot be achieved in the measurement models established with the sample of Turkey and Singapore and in the hybrid model. In the study, it is seen that the measurement models of all variables and subscales of science literacy were confirmed for both samples. At the same time, it is seen that the hybrid models established with the variables related to both models are confirmed. It was concluded that the fit index values of the hybrid model established with the data of Turkey were slightly higher, and all pathways were defined. In both samples, it was concluded that the variable that most affected the students' science literacy levels was their belief in the accuracy of science, and the variable that affected the least was their ambition. In both samples, the test anxiety variable affects the science literacy levels negatively. At the same time, it was concluded that students' ambitions do not have a direct effect on their science literacy in the Singapore sample.

Keywords: Science literacy, interest, belief, ambition, test anxiety.

[1] It is an expanded and updated version of the summary statement titled "Hybrid Model for the Relationship Between Students' Science Literacy Level and Some Variables: Pısa 2015 Singapore and Turkey Sample" presented at the 26th International Congress of Educational Sciences.

INTRODUCTION

When considered in the context of the system, it can be said that education has input, process, output and monitoring elements. While countries are constructing their education systems, they want each element of the system to work and be effective with a holistic perspective. It is necessary to turn this desire into an education policy by doing long-term planning (Heyneman & Loxley, 1983; Hanushek, 1997). There are two basic questions and problems of research conducted to shed light on most educational policy debates. First of all, are there any differences between schools, which are the lowest and basic units of education systems? In other words, whether there are significant and systematic differences between schools and teachers in terms of their abilities. Secondly, are there quality differences arising from observable qualities of teachers such as teacher qualification, class size, teacher education and experience among the variables that affect student achievement as an output of education systems? If so, what are the effects? Policy discussions focus on influence and causal research on student achievement based on school and teacher characteristics (Rivkin, Hanushek & Kain, 2005). As a matter of fact, the existence of research on the subject stands out, especially those that reveal the effects of class size on achievement (Çalık, Tabak & Yavuz Tabak, 2019). Naturally, policies are focused on the characteristics of schools and teachers. Student achievement, which is the output of education systems, appears as a tool to monitor the effectiveness of the system. Therefore, in order to answer the question of how much student achievement is and to improve student achievement, it would be a better start to first search for student-related variables (Heyneman, 1976; Heyneman, Farrell & Sepulveda-Stuardo, 1981). As a matter of fact, when the research findings on the student performances of the Program for International Student Assessment (PISA) are examined, it is possible to reach a comparison of data and countries related to some of these variables. These data and comparisons consist of basic descriptive statistics. In order to make comparisons between countries based on effect and cause, it is a necessity to construct studies with predictive and comprehensive analyzes.

Student achievement and Science literacy achievement

Student achievement is seen as an output element of education systems. At the same time, one of the various variables that states use to find out the course of their education and their effectiveness in educational activities is student achievement. Although student achievement seems to be directly related to students, there are many factors that affect it (Druva & Anderson, 1983; Jaus, 1975). School and teacher, social characteristics, and family structure can be at the forefront of these factors. It is difficult to address all of these factors, which have various features, directly. For example, factors related to society and family are areas where educators cannot directly intervene and which are difficult to intervene in increasing student achievement (Fisher & Waldrip, 1997). However, it is relatively possible to investigate the characteristics of schools, teachers, and students, which are considered educational environments, and to intervene in increasing achievement in the light of empirical findings. In this direction, factors such as students' abilities, motivation, ambition, belief, interests, learning styles, and individual physical and psychological characteristics need to be

investigated, although they cannot be controlled entirely (Chidolue, 1996). Therefore, in the study, it was tried to examine the science literacy variables in PISA by considering the ones related to the students.

Table 1. General Characteristics of the PISA Science Literacy Assessment Framework

Level	Statement
Knowledge	Understanding the major facts, concepts, and explanatory theories that form the basis of scientific knowledge. Such knowledge includes knowledge of both the natural world and technological artifacts (content knowledge), knowledge of how such ideas are generated (process knowledge), and an understanding of the logic underlying these processes and the rationale for their use (epistemic knowledge).
Competencies	• Explaining facts scientifically, • Designing and evaluating the scientific inquiry method • Interpreting data and findings scientifically
Attitudes	Attitude towards science, which includes being aware of environmental problems and using scientific inquiry methods, when necessary, by showing interest in the field of science and technology.
Context	Past and present personal, local/national, and global issues that require some science and technology knowledge

(MEB., 2016, p. 9)

According to the general framework of the PISA science literacy assessment (see Table 1), it determines the science literacy of countries in (1) proficiency in science, (2) knowledge of science and (3) system subscales. In this direction, the variables of test anxiety, science interest, ambition, and belief in the accuracy of knowledge of students who took the PISA exam in Turkey and Singapore were discussed because they directly contain the characteristics of the students (OECD., 2016). To examine the variables considered in general: There may be behavioral, psychological or physiological forms of greed. The situations that are effective in the emergence of the feeling of ambition can be defined as aggression, frustration, discomfort, impulsivity and low self-esteem. It usually occurs when people show willingness and persistence in achieving a goal above the level of passion, hope, or belief (Starner & Peters, 2004). Interest is a behavior that is defined in various ways towards a person, situation, institution, or social process and is viewed as a tendency to act in a certain way towards people and situations that are believed to represent a core value or belief. In other words, it is the state of being ready to react in a certain way to a situation, person or thing. It is not a behavior itself; it is a precondition for behavior. (Küçükahmet, 1976; Ünal, 1981). Test anxiety can be defined as the combination of physiological, cognitive, and emotional responses to the stress experienced during assessment on a test or exam. It is often experienced when students take a written or oral exam. In this respect, their experience is considered important, but students do not feel well if they are still subject to evaluation. There is a negative correlation between test anxiety and students or students' performance (Abulghasemi, 2008; Spielberger, 1980).

This study aims to establish a hybrid model that reveals the relationship between the Science Literacy level of the students in the Singapore and Turkey samples in PISA 2015 and the students' test anxiety, science interest, ambitions, and beliefs in the accuracy of knowledge.

METHOD

Research Model

The correlational research model, which reveals the relationship between the variables in the context of the determined purpose, was used. The correlational research method offers the opportunity to explain the relationships between the variables and predict the results (Fraenkel, Wallen & Hyun, 2012). Hybrid models were established using the data of students from Singapore and Turkey samples.

With the established models, the effect levels of the variables affecting the science literacy levels of the countries were tried to be compared with the hybrid model. Before constructing the structural model that creates the hybrid model, the measurement models of each variable were tested. Structural equation modeling is a comprehensive statistical approach to test models in which causal and correlational relationships between observed and latent variables coexist. The measurement model specifies how the latent variables depend on the observed variables and how they are represented. The whole model that emerges with the definition of the tested structural model and measurement model, taking into account the stages of the structural equation model, is called a hybrid model.

Measurement models were tested before constructing the structural model constituting the hybrid model. The graphical representation of the measurement model is shown in Figure 1, and the graphical representation of the structural model is shown in Figure 2.

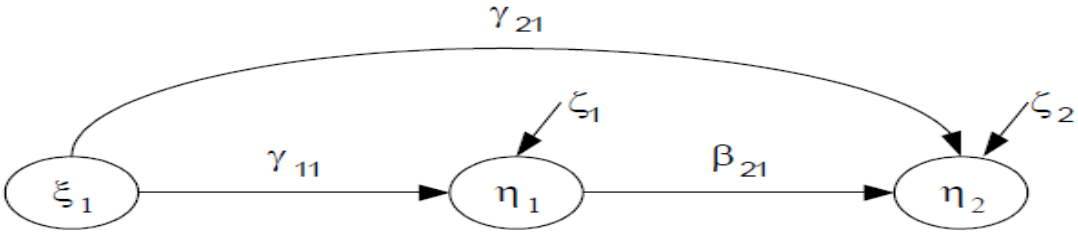

Figure 1. Graphical Representation of Structural Equation Model (Sharma, 1996: p. 420)

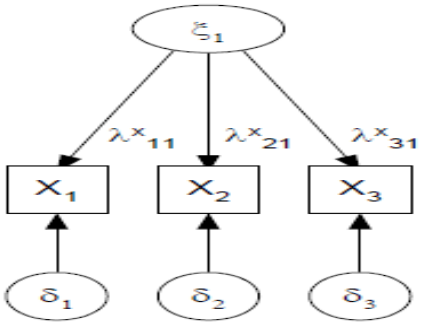

Figure 2. Measurement Model Graphic Display (Sharma, 1996: p. 145)

Before the hybrid model was established, 1st level single factor CFA analysis was performed for each scale and science literacy test. An example of the hybrid model is shown in Figure 3.

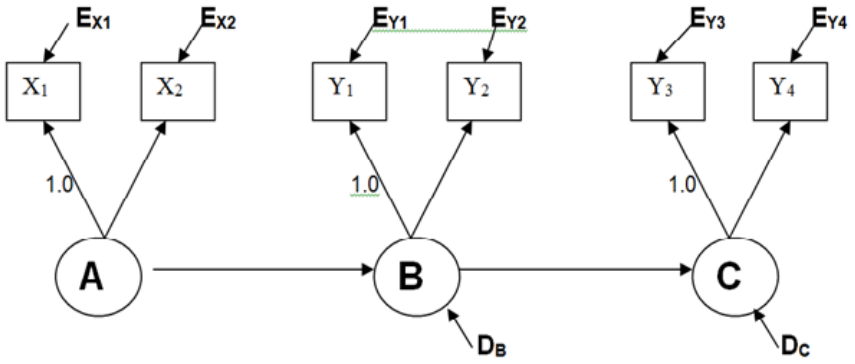

Figure 3. Hybrid Model Example

A representation of the research model is shown in Figure 4.

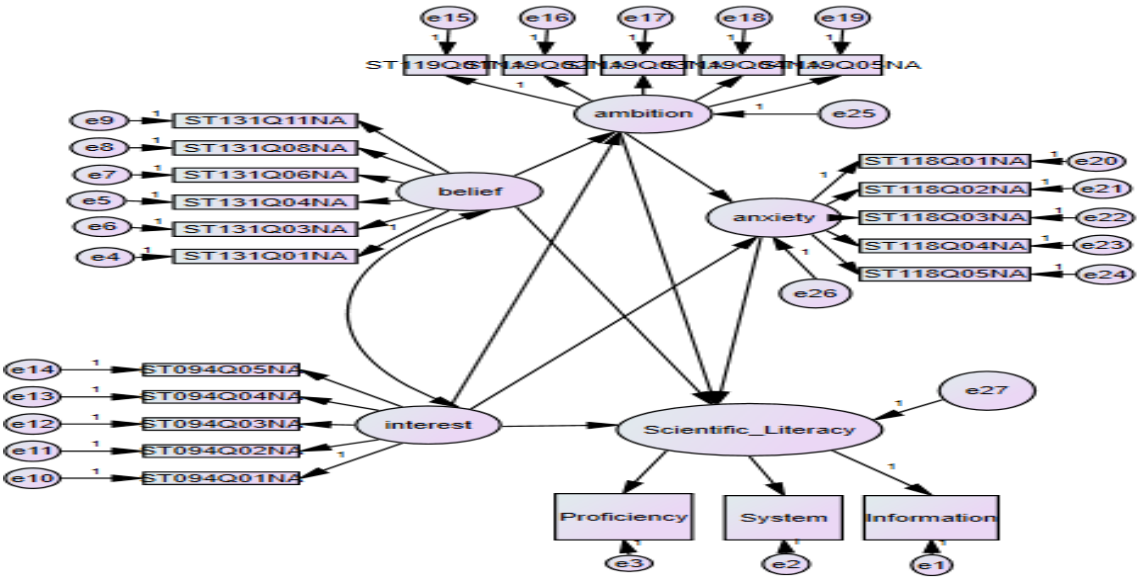

Figure 4. Hybrid Model for the Research

Study Group

When all the variables in the sample of Turkey and Singapore were examined and the data associated with the science literacy score were taken into account, the values that were not relevant were removed from the data set. In the research, hybrid model and measurement models were established with 5668 student data in the Singapore sample and 5084 student data in the Turkey sample.

Data Analysis

The data, which were processed and edited in the SPSS-25 package program of the two countries, were analyzed using the AMOS 21 package program, suitable for the purpose of the study. When multivariate normality assumptions were tested using the LISREL 8.8 package program for the data of the measurement model, the rule that the Relative Multivariate Kurtosis value was higher than the critical value of 1.00 was considered. The parameters of the first items of the variables and science literacy subscales were fixed at 1.00 and the parameters of the other items were released. When the multivariate normality assumptions regarding the data are tested in the measurement model, it is seen that the Relative Multivariate Kurtosis value is higher than the critical value of 1.00. It was concluded that the skewness and kurtosis values were significant. Since the Relative Multivariate Kurtosis value is higher than the critical value of 1.00, it was determined that the multivariate normality assumption of the variables could not be met, according to Jöreskog (2002). Since the assumption of multivariate normality could not be achieved, the Robust Maximum Likelihood (RML) estimation method was used instead of the Maximum Likelihood (ML) estimation method. For the hybrid model, analyzes were performed using the Asymptotically distribution-free parameter estimation method, where the values examined for the multivariate normality assumption were very high. The fit index values obtained for the measurement model and the structural model were used according to the criteria given in Table 2, determined by Schermelleh-Engel, Moosbrugger and Müller (2003) and Byrne (2013). Regarding the structural model, the direct, indirect, and total effects among the variables belonging to the students were examined.

Table 2. The Criteria Range for Comparing the Fit Index Values of the Measurement and Structural Model

Fit Index	Perfect Fit Criteria	Acceptable Fit Criteria
χ2/ (df)	$0 \le \chi^2 \le 3$	$3 < \chi^2 \le 5$
RMSEA	0≤RMSEA≤0.05	0.05<RMSEA≤0.08
TLI/NNFI	0.97≤TLI≤1.00	0.95≤TLI<0.97
CFI	0.97≤CFI≤1.00	0.95≤CFI<0.97
NFI	0.95≤NFI≤1.00	0.90≤NFI<0.95
AGFI	0.90≤AGFI≤1.00	0.85≤AGFI<0.90
GFI	0.95≤GFI≤1.00	0.90≤GFI<0.95

FINDINGS

The findings regarding the measurement and structural model of the hybrid model, which constitute the sub-objectives of the research, are given below:

Findings Regarding Measurement Models:

At this stage, before the hybrid model was established, the fit index values of the 1st level single-factor models were examined by looking at the CFA analysis results of the scales and science literacy subtests.

Findings of Measurement Models Related to the Turkish Sample

Table 3. Fit Index Values of Turkey Data Measurement Models

Fit Index Values	SBχ2/ (df)	RMSEA	GFI	AGFI	CFI	NNFI	Relative Multivariate Kurtosis
Belief	4.35/(3)	0.009	1.00	1.00	1.00	1.00	1.673
Interest	1.75/(2)	0.000	1.00	1.00	1.00	1.00	1.942
Ambition	4.60/(1)	0.025	1.00	0.99	1.00	1.00	1.733
Test anxiety	0.26/(2)	0.000	1.00	1.00	1.00	1.00	1.205
Bilgi (Contents)	49.72/(35)	0.008	1.00	1.00	1.00	1.00	1.036
Knowledge (Procedures and Facts)	48.14/(35)	0.008	1.00	1.00	1.00	1.00	1.036
System (Physics)	66.11/(35)	0.012	1.00	1.00	1.00	1.00	1.037
System (Life)	36.77/(27)	0.008	1.00	1.00	1.00	1.00	1.037
System (Earth and Science)	80.37/(35)	0.015	1.00	1.00	1.00	1.00	1.037
Competency (Scientific Explanation of the Phenomenon=Factor1)	65.04/(35)	0.012	1.00	1.00	1.00	1.00	1.047
Competency (Scientific Research Design and Evaluation=Factor2)	98.91/(35)	0.021	1.00	0.99	1.00	1.00	1.047
Competency (Scientific Interpretation of Data and Evidence =Factor3)	62.40/(35)	0.012	1.00	1.00	1.00	1.00	1.047

According to Table 3, when the fit index values in the variables of belief, interest, ambition and test anxiety of the measurement models established with the data of the students in the Turkish sample are examined, it is seen that the measurement models are provided when compared with the table values. It was determined that the measurement models established for the components of the knowledge, system and proficiency sub-scores that make up the science literacy scores were validated when compared with the table values, so they could be considered as sub-variables of the science literacy scores. It was concluded that the measurement models were validated before the hybrid model was established with the Turkish sample.

Findings of the Measurement Models Regarding the Singapore Sample

Table 4. Fit Index Values of Singapore Data Measurement Models

Fit Index Values	SBχ2/ (df)	RMSEA	GFI	AGFI	CFI	NNFI	Relative Multivariate Kurtosis
Belief	1.70/(2)	0.017	0.99	0.85	1.00	0.96	1.898
Interest	6.4/(3)	0.058	0.99	0.93	1.00	1.00	2.493
Ambition	0.22/(1)	0.000	1.00	1.00	1.00	1.00	1.416
Test anxiety	3.48/(2)	0.011	1.00	1.00	1.00	1.00	1.243
Bilgi (Contents)	77.63/(35)	0.014	1.00	1.00	1.00	1.00	1.030
Knowledge (Procedures and Facts)	77.53/(35)	0.012	1.00	1.00	1.00	1.00	1.030
System (Physics)	51.51/(35)	0.009	1.00	1.00	1.00	1.00	1.038
System (Life)	128.26/(44)	0.006	0.96	0.94	1.00	0.99	1.038
System (Earth and Science)	53.54/(35)	0.009	1.00	1.00	1.00	1.00	1.038
Competency (Scientific Explanation of the Phenomenon=Factor1)	32.51/(35)	0.000	1.00	1.00	1.00	1.00	1.040
Competency (Scientific Research Design and Evaluation=Factor2)	78.16/(35)	0.015	1.00	1.00	1.00	1.00	1.040
Competency (Scientific Interpretation of Data and Evidence =Factor3)	65.59/(35)	0.012	1.00	1.00	1.00	1.00	1.040

According to Table 4, when the fit index values in the variables of belief, interest, ambition and test anxiety of the measurement models established with the data of the students in the Singapore sample are examined, it is seen that the measurement models are provided when compared with the table values. It was determined that the measurement models established for the components of the knowledge, system and proficiency sub-scores that make up the science literacy scores were validated when compared with the table values, so they could be considered as sub-variables of the science literacy scores. It was concluded that the measurement models were validated before the hybrid model was established with the Singapore sample.

Findings Related to the Hybrid Model:

Findings Regarding the Hybrid Model Established for the Sample of Turkey and Singapore

Table 5. Fit Index Values of the Hybrid Model of Turkey and Singapore Data

Fit Index Values	χ2/ (df)	RMSEA	GFI	AGFI	CFI	NNFI/TLI	NFI
Turkey	1088,28/(234)=4.65	0.027	0.98	0.98	0.99	0.99	0.99
Singapore	1403,86/(234)=5.99	0.030	0.98	0.97	0.99	0.99	0.99

According to Table 5, considering X^2/df, when the fit index values of the hybrid model established with the data of 5084 students in the Turkish sample are examined, this value was calculated as 4.65, and when compared with the table values, it is seen that it has an acceptable fit index (Byrne, 2013). When RMSEA, GFI, AGFI, CFI, NNFI/TLI, and NFI values are examined, it is seen that they have excellent fit index values when compared with table values (Schermelleh-Engel, Moosbrugger & Müller, 2003). Considering X^2/df, when the fit index values of the hybrid model established with the data of 5668 students in the Singapore sample are examined, this value is calculated as 5.99, and because the number of samples is slightly larger than the sample of Turkey, this value is above the table value ranges. Although X^2/df, is popular in applied research, its use is not recommended because it is greatly affected by the sample size. In fact, in the study of Wheaton (1987), it is suggested that the X^2/df index should not be used (Brown, 2006, p. 89). The X^2 test assumes that the observed variables have a multivariate normal distribution and the sample size is sufficiently large. However, in many applications, these assumptions cannot be met (Yılmaz and Çelik, 2009, p. 38). When the RMSEA, GFI, AGFI, CFI, NNFI/TLI, NFI values of the Singapore data are examined, it is seen to have a perfect fit index value compared with the table values.

It is seen that the hybrid model established with the Turkey sample is more compatible with the X^2/df RMSEA and AGFI values compared to the hybrid model established with the Singapore sample; that is, the model is more compatible. The hybrid model of the Turkish sample is shown in figure-5.

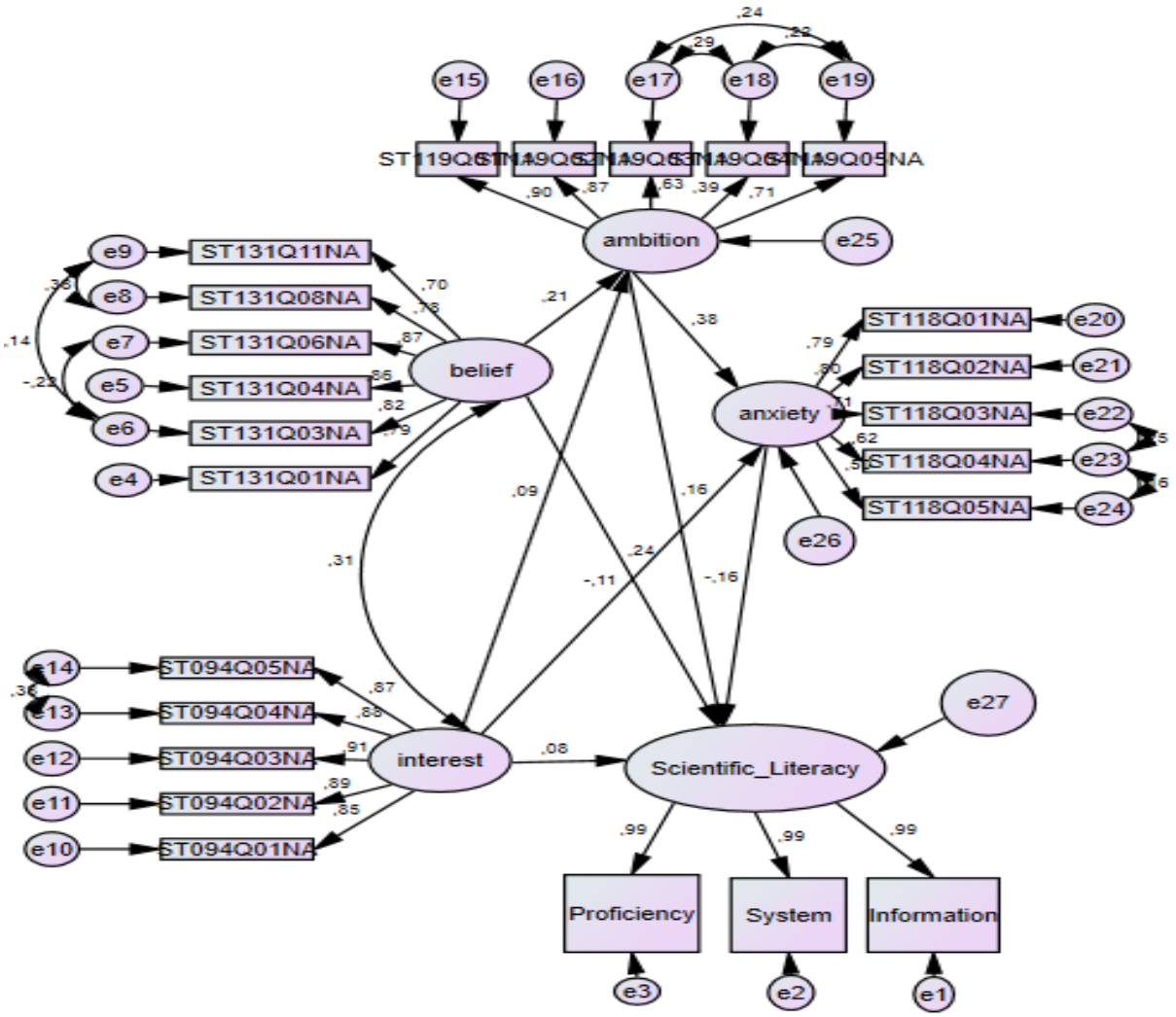

Figure 5. Hybrid Model of Turkey Sample

Table 6. Effect Levels of the Pathways Related to the Variables in the Hybrid Model of the Turkish Sample

	Science Literacy Score		
	Direct Effect	**Indirect Effect**	**Total Effect**
Interest	0,08	0,03	0,11
Belief	0,24	0,02	0,26
Ambition	0,16	-0,06	0,10
Anxiety	-0,16	0,00	-0,16

When Table 6 is examined, it is seen that students' interest scores have a direct effect of 0.08 and an indirect effect of 0.03 on science literacy scores in the Turkish sample. In total, it is seen that the total effect of students' interests on science literacy scores is 0.11. It is seen that students' belief scores have a direct effect of 0.24 and an indirect effect of 0.02 on their science literacy scores. In total, it is seen that the total effect of students' beliefs on science literacy scores is 0.26. It is seen that students' ambition scores have a direct effect of 0.16 on science literacy scores, and since anxiety is used as a variable, the indirect effect has a negative

effect of -0.06. In total, it is seen that the total effect of students' ambitions on science literacy scores is 0.10. It is seen that the anxiety scores of the students directly affect the science literacy scores and it is calculated as -0.16 in the negative direction. As the students' interest, belief and ambition scores increase, their science literacy scores also increase, but as the anxiety scores increase, their science literacy scores decrease. The hybrid model of the Singapore sample is shown in figure-6.

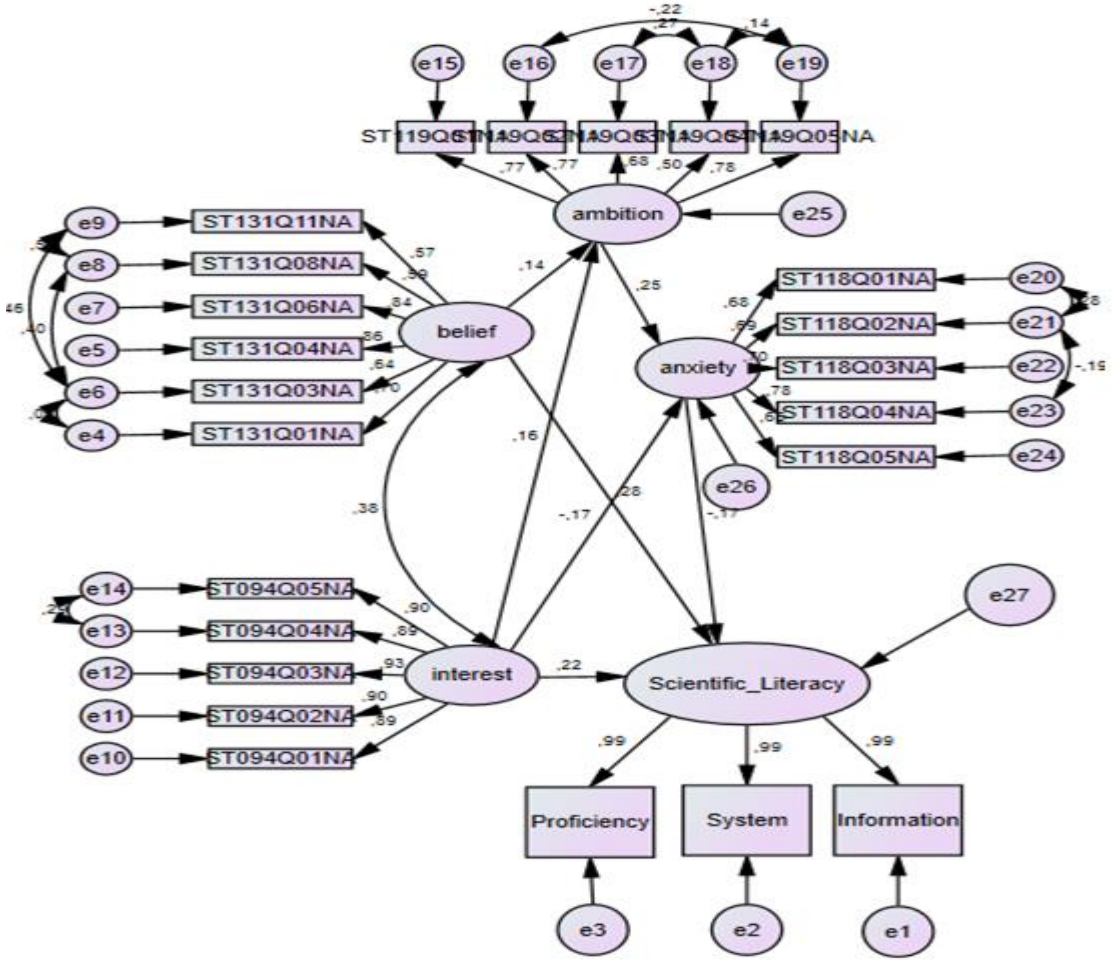

Figure 6. Hybrid Model of Singapore Sample

Table 7. Effect Levels of the Pathways Related to the Variables in the Hybrid Model of the Singapore Sample

	Science Literacy Score		
	Direct Effect	**Indirect Effect**	**Total Effect**
Interest	0.22	0.02	0.24
Belief	0.28	-0.01	0.27
Ambition	0.00	-0.04	-0.04
Anxiety	-0.17	0.00	-0.17

When Table 7 is examined, it is seen that students' interest scores have a direct effect of 0.22 and an indirect effect of 0.02 on their science literacy scores in the Singapore sample. In total, it is seen that the effect of students' interests on science literacy scores is 0.24. It is seen that students' belief scores have a direct effect of 0.28 on their science literacy scores, and since anxiety is used as a tool variable, its indirect effect has a negative effect with a score of -0,01. In total, it is seen that the effect of students' beliefs on science literacy scores is 0.27. It is seen that students' ambition scores do not have a direct effect on their science literacy scores, and since anxiety is used as a tool variable, its indirect effect has a negative effect with a score of -0.04. In total, it is seen that the effect of students' ambitions on science literacy scores is -0.04. It is seen that the anxiety scores of the students directly affect the science literacy scores and it is calculated as -0.17 in the negative direction. It is seen that as students' interest and belief scores increase, their science literacy scores also increase, but as students' ambition and anxiety scores increase, their science literacy scores decrease.

CONCLUSION and DISCUSSION

It was concluded that the model established with the data of Turkey regarding the hybrid model, which examines the effects of students' interest in science, their beliefs in the accuracy of the science, their ambitions and test anxiety on science literacy, is more confirmed than the model established with Singapore data. It was concluded that the variable that most affected the science literacy of the students in the Turkish sample was their belief in the accuracy of the science, and the variable that affected the least was their ambition. At the same time, it was determined that students' test anxiety and science literacy levels were negatively affected. It was concluded that the variable that most affected the science literacy of the students in the Singapore sample was their belief in the accuracy of the science, and the variable that affected the least was their ambition. At the same time, it was determined that students' test anxiety and science literacy levels were negatively affected.

It was concluded that the effect of science interest and test anxiety of students in Turkey on science literacy was smaller than the effect of students in Singapore. It was concluded that the effect of science interest of students in Turkey on science literacy was smaller than the effect of students in Singapore. It was concluded that the effect of students' belief in the accuracy of science on science literacy in Turkey is similar to the effect of students in Singapore. It was concluded that the effects of students' beliefs about the accuracy of science and their test anxiety on science literacy were higher than affective characteristics such as their interest and ambition toward science. It can be said that they have a remarkable effect on their affective characteristics at the stage of making comparisons about their levels in terms of science literacy between countries. It was concluded that the ambitions of the students in the Turkish sample had a direct effect on science literacy and that the ambitions of the students in the Singapore sample did not have a direct effect on science literacy. Similarly, in the study conducted by Tabak and Çalık (2020), which was conducted on international data, the relationship between student achievement and both the socio-economic status of the family and home opportunities was examined. In this study, it was concluded that science achievement affects achievement

similar to the relationship with other variables. In a different study, Atar (2014) aimed to determine the effects of multilevel effects of teacher qualifications on TIMSS 2011 science achievement on TIMSS 2011 science achievement of students in Turkey. It was found that participation in in-service training programs related to information technologies and the increase in teachers' perception of the importance that the school attaches to academic achievement has a statistically significant effect on the science achievement averages of schools. Again, Atar and Atar's (2012) studies show that while computer access affects students' science achievement positively, inquiry science teaching negatively affects students' science achievement. In addition, it was determined that students' science achievement increased in parallel with the increase in the socio-economic status of the families (SES), teacher experience, and students' self-confidence in learning science. As a result, the studies show similarities with the results of this research, the relations of the variables and the model results.

RECOMMENDATIONS

The findings obtained in the research are given below, and the recommendations for the future that may be needed:

- It is necessary to examine the changes in the performance levels that occur due to the differences arising from the affective characteristics of the students, and higher-level models can be established with more countries in future research. In this way, it is thought that the achievement sources of the countries that are successful in the international exams will be proven on the basis of variables.
- In future research, it is recommended to find the model that best explains science literacy by establishing hybrid models with more variables belonging to students, as it can contribute to the theory of different disciplines as well as reveal the evidence of statistically different models.
- Based on the assumption that there may be different reasons or sources of achievement in addition to the models that prove the sources and causes of achievement quantitatively, it is recommended to construct studies that can reach results with mixed findings, especially qualitative research constructs.
- Based on these established models, applicable policies and policy recommendations can be developed in the education system. Multiple regression analysis, bi-level or multilevel hierarchical linear models can be established by using continuous and categorical data considering school characteristics as well as student characteristics.

ETHICAL TEXT

In this article, the journal writing rules, publication principles, research and publication ethics, and journal ethical rules were followed. Responsibility for any violations that may arise regarding the article belongs to the author. “As the PISA 2015 data are open to access, no ethics committee approval is required”.

Author(s) Contribution Rate: In this study, the contribution rate of the first author is 100%.

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