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A Comparative Analysis of the Effect of Students' Affective Characteristics on Their Science Performance between Countries Based on PISA 2015 Data

PISA 2015 Sonuçlarına Göre Duyuşsal Özelliklerin Öğrencilerin Fen Performansları Üzerine Etkisinin Ülkeler Arası Karşılaştırılması

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ABSTRACT: Based on the results of the Programme for International Student Assessment (PISA) 2015, this study aimed to determine the extent to which affective characteristics such as epistemic beliefs, motivation and self-efficacy predicted students' performance in science and whether this differed between countries that exhibited different levels of achievement. In accordance with the purpose of the study, two countries were randomly selected from each of the three achievement levels defined by PISA (above average, average, and below average) and all the students that took the test from the selected countries were included in the analysis. A simple linear regression analysis was performed using the IDB Analyzer program, which facilitated the analysis of the layered data collected in this study. According to the results, it was determined that the students' affective characteristics predicted their science performance by 30% regardless of the achievement level.
Keywords: PISA, science performance, affective characteristics

ÖZ: Bu araştırma kapsamında PISA 2015 sonuçlarına göre, epistemelojik inanç, motivasyon ve öz yeterlik gibi duyuşsal özelliklerin, öğrencilerin fen performanslarını ne derece açıkladığı ve bu açıklama düzeyinin farklı başarı performansı sergileyen ülkeler arasında farklılık gösterip göstermediğinin belirlenmesi amaçlanmıştır. Araştırmanın amacına uygun olarak, PISA tarafından tanımlanmış üç başarı düzeyinin (ortalama üstü, ortalama düzey, ortalama altı) her birinden seçkisiz yolla ikişer ülke seçilmiş ve seçilen ülkelerdeki sınava giren öğrencilerin tamamı analize dâhil edilmiştir. Verilerin analizi için, PISA verilerinin katmanlı yapısı sebebiyle IDB Analyzer programı kullanılmış ve değişkenlerin öğrencilerin fen performanslarını yordama düzeylerinin tespiti için doğrusal regresyon analizi yapılmıştır. Elde edilen sonuçlara göre hangi başarı diliminde olursa olsun, öğrencilerin duyuşsal özelliklerinin fen performanslarını %30 oranında yordadığı tespit edilmiştir.
Anahtar Kelimeler: PISA, fen performansı, duyuşsal özellikler

1. INTRODUCTION

The Program for International Student Assessment (PISA) is an international comparative student surveillance and assessment process conducted every three years by the Organization for Economic Co-operation and Development (OECD) to determine the achievement levels of 15-

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year-old students from the participant countries in science, mathematics, and literacy. In addition to the achievement levels, this assessment also allows for cross-country comparisons to be undertaken in terms of the students' skills regarding science, mathematics and literacy. Furthermore, PISA collects other data related to different variables that are considered to affect the quality of education, such as family, school, and socioeconomic status. In every three-year cycle of this implementation, the focus is on one of the domains including reading skills, mathematical literacy and science literacy. Science literacy, as one of the focal subjects of PISA, is defined as "the ability to engage with science-related issues" (OECD, 2016); thus, through this item, PISA aims to measure scientific competencies, understanding, and attitudes toward science (Bybee, McCrae, and Laurie, 2009). The definition of PISA science literacy is based on the assumption that a student's specific science-related response not only requires skills and knowledge but also depends on their willingness to engage in the topic (OECD, 2016).

A review of the related literature shows that socio-economic level is the most important factor that determines the scientific and literacy levels of students (Perry, 2010). According to Perry (2010), the socio-economic level of not only students' family but also their school directly affects their science achievement. Stacey (2010) showed that in addition to students from low socio-economic status having lower academic achievement in science, they also have lower levels of interest in science-related issues compared to those students with higher socio-economic status. The author reported that this result was more prominently observed in Switzerland, Belgium, Ireland, and France. Sun, Bradley and Akers (2012) stated that another factor affecting students' positive attitude towards science is how much their parents place value on and are interested in this area. It may not be possible to explain this effect directly using the socio-economic level. However, the findings of the research conducted by Lin, Hong and Huang (2012) offer an insight into this issue by demonstrating that affective factors, such as interest and enjoyment significantly influence students' level of scientific literacy. Undoubtedly, students acquire the positive emotions of their main careers and develop a positive attitude towards science.

PISA states that students' thoughts about themselves and their attitudes towards science-related activities effect their current and future engagement with science. The attitudes and beliefs of students play an important role in their responses to items that measure their science performance. In PISA 2015, the attitudes, beliefs and values of students were examined by their performance in the test items, rather than their responses to items presented in the form of written questions (OECD, 2016). In addition to external factors such as teacher experience, teaching environment, and teaching strategies and techniques that are used, many internal dynamics; i.e., affective characteristics, such as motivation, self-efficacy, readiness, self-control, and epistemic beliefs play a significant role in the determination of student achievement. Although the academic achievement of students is expressed in numerical results, it is known that such affective characteristics directly influence student achievement (Cano, 2005; Linnenbrink and Pintrich, 2003; Schunk, 1990). Thus, international assessment programs, such as PISA and the Trends in International Mathematics and Science Study (TIMMS) use tools developed in the light of current literature specifically to examine affective characteristics considered to influence students' science achievement (Marsh and Hau, 2004; Zhang and Liu, 2016).

Beliefs, in the general sense, are convictions regarding issues, events and cognitive schemes (Krows, 1999). One of the most important dynamics that affect the learning process of students is their belief that they will learn. A person's belief that they will be able to perform a task is referred to as self-efficacy (Bandura, 1982). The relationship between an individual's self-efficacy levels and achievements has been noted in the literature. Palmer (2006) suggested that individuals with higher self-efficacy perform tasks actively and willingly, which leads to success, whereas those with lower self-efficacy have lower levels of willingness and enthusiasm to perform tasks and consequently, their achievement is usually below the target level. Pajares (1996) considered that the higher success of students with high self-efficacy compared to those having lower self-efficacy but with similar skills is due to the greater effort and persistence of the former to achieve. The findings of several studies have revealed the significant relationship between academic achievement and self-efficacy (Britni and Pajares, 2006; Anderman and Young, 1994; Lau and Roeser, 2002). In addition, Bandura and Locke (2003) suggested that none of the tools that are available in educational research have the same capacity as self-efficacy in predicting student achievement.

Another affective characteristic of individuals is their beliefs about knowledge and learning, which was referred to as ‘epistemic beliefs’ by Schommer (1990). The term epistemology can be defined as the source, nature, limitations, system, and accuracy of human knowledge (Hofer, 2002). Epistemic beliefs, in the general sense, are the subjective beliefs of individuals concerning what knowledge is and how knowing and learning take place (Deryakulu, 2004). Perry (1981) considers epistemic beliefs as an individual’s views concerning what knowledge is, how it can be obtained, and its level of certainty, boundaries and criteria. From this, it can be assumed that epistemic beliefs play an undeniable role in structuring knowledge, producing new knowledge, and achieving academic success.

Learning motivation is one of the important determinants of student achievement. Yılmaz, Huyugüzel and Çavaş (2007) defined motivation as an affective factor that drives the human organism, determines their persistence and energy, and directs and maintains their behavior. According to Watters and Ginns (2000), motivation is a complex psychological structure that attempts to explain the behavior and effort exhibited in different activities. The relationship between achievement and this complex psychological structure; i.e., motivation is explained by Wolters and Rosenthal (2000) as that highly motivated students tend to devote more effort and show more determination when performing classroom activities and tasks than those with a lower level of motivation.

1.1. Objective and Significance of the Study

A review of the national and international literature shows that many demographic variables such as teacher attitudes, the budget allocated to education, educational level of parents, and physical conditions of schools, and more importantly the gross national products of countries, significantly predict the academic achievement of students. The affective characteristics of students can be considered as important variables that predict student achievement (Dursun-Sürmeli and Ünver, 2017). Previous studies have demonstrated the relationship between self-efficacy beliefs and student achievement (Ader, 2004; Pajares and Graham, 1999; Schunk, 1990; Zimmerman, Bandura, and Martinez-Pons, 1992), the effect of motivation and affective characteristics on academic achievement (Mcleod, 1992; Richardson and Suinn, 1972), and the ability of Bloom’s affective entry characteristics (interest, attitude, and academic self-concept) to explain 25% of variability in achievement (Senemoğlu, 2010). In this context, it is clear that affective characteristics are strongly related to and have a predictive power over student achievement.

Despite the wide availability of studies emphasizing the importance of affective characteristics for student achievement, no study has been undertaken to measure the variations in the predictive capacity of these characteristics between different countries. Based solely on the reports of PISA and TIMMS, it is not easy to establish the presence of a relationship between motivation and achievement in a way that could cover all the countries. For example, according to results of PISA 2015 (OECD, 2016), in South Korea, while the vast majority of students report that they do not like science, this country has a high level of science achievement. In contrast, the attitude of students in Turkey is very positive but their science achievement is very low. There is no agreed explanation in the literature for the different forms of relationships between student attitude and achievement. Therefore, this study attempts to approach the relationship between science achievement and affective characteristics from a different perspective by comparing the predictive ability of affective characteristics for student achievement between the participant countries of PISA 2015.

The aim of this research is to determine the extent to which students' affective characteristics; i.e., beliefs, motivation, and self-efficacy explain their science achievements and whether this predictive power differs between countries that have different student performance. It is considered that an examination of the countries in which students have different achievement levels will shed light on the determination of policies that will improve student achievement. In line with the objectives, the following research questions were formulated:

- To what extent do affective characteristics of students predict their achievement?
- Does this predictive ability differ between countries with different achievement levels?

2. METHODOLOGY

2.1. Source of Data

In PISA studies, the preferred sample design is two-step stratified sampling. The first step involves the sampling of individual schools in which 15-year-old students are registered. In the second step, students are selected from the schools identified in the first step (OECD, 2016). In this study, two countries were randomly selected from each of the three achievement levels (above average, average, and below average) defined by PISA for the areas relevant to the study and all the students from the selected countries were included in the analysis. Only Turkey was intentionally chosen for the group with below-average achievement. Table 1 presents a list of all the countries included in the research together with the number of students from each country.

Table 1: Countries included in the study and number of students

Achievement Level	Country	Number of Students
Level 1: Above average	Korea	5581
	Japan	6647
Level 2: Average	Spain	6736
	Sweden	5458
Level 3: Below average	Turkey	5895
	Hungary	5658

The distribution of the students of the countries included in the study according to their science performance levels is given in the Table 2.

Table 2: Distribution of the students into the PISA science performance levels

	Level 1 and Below	Level 2	Level 3	Level 4	Level 5	Level 6
	%	%	%	%	%	%
Japan	9,6	18,1	28,2	28,8	12,9	2,4
Korea	14,4	21,7	29,2	24,0	9,2	1,4
Spain	18,3	26,5	31,3	18,9	4,7	0,3
Sweden	21,6	24,0	26,8	19,0	7,2	1,3
Hungary	26	25,5	27,3	16,6	4,3	0,3
Turkey	54,4	31,3	19,1	4,8	0,3	0,0

When Table 2 is examined it can be seem that, the majority Turkish students' science performance stayed at level 1 and under. Korea and Japan have the highest student percentage in level 5 and 6.

2.2. Variables

Within the context of this study, the affective characteristics that were expected to predict students' science achievement were identified as epistemic beliefs, current and future engagement with science, science learning motivation, sense of belonging at school, and educational motivation. PISA produces index scores for these variables and analyzes them. More detailed information on the variables examined in the study is given below.

Students' Epistemic Beliefs about Science (EPIST)

Scientific literacy defined in PISA includes not only the knowledge of the natural world and technological artifacts (content knowledge), but also how scientists produce these ideas, and the purpose and nature of scientific research (epistemic knowledge) (OECD, 2016b). Rather than epistemic beliefs in general, PISA focuses on measuring students' "epistemic beliefs about science", which include their convictions concerning the validity and limitations of scientific experiments and the temporary and evolving nature of scientific knowledge. In PISA 2015, to produce an index score on epistemic beliefs about science, the students were given the following statements and asked to respond on a four-point Likert scale as strongly agree, agree, disagree, and strongly disagree (OECD, 2016b):

"a good way to know if something is true is to do an experiment"
"ideas in science sometimes change"
"good answers are based on evidence from many different experiments"
"it is good to try experiments more than once to make sure of [your] findings"
"sometimes scientists change their minds about what is true in science"
"the ideas in science books sometimes change"

Current and Future Engagement with Science

BSMJ: In PISA, to predict the extent to which students will engage with science in the future, the participants are asked about the occupational status they hope to have when they are 30 years old. In response to this item, the students write down an occupation and its definition. The responses to this question are classified according to the 2008 version of the International Classification of Occupational Standards (ISCO-08). The responses obtained are used as a measure of science-related career expectation of students and an index score is generated.

SCIEACT: In different implementation years, to analyze the variations in responses by year, PISA repeats some of the questions. These are called 'trend questions'. The scientific activities (SCIEACT) index is also based on a trend question from PISA 2006 (ST146) (ID 2006: ST19). During the process of producing this index, the students were asked to choose the frequency of performing the following activities using the response categories of "very often", "regularly", "sometimes", and "never or hardly ever" (OECD, 2016b);

"Watch TV programmes about <broad science>"
"Borrow or buy books on <broad science> topics"
"Visit web sites about <broad science> topics"
"Read <broad science> magazines or science articles in newspapers"
"Attend a <science club>"
"Simulate natural phenomena in computer programs/virtual labs"
"Simulate technical processes in computer programs/virtual labs"
"Visit web sites of ecology organisations"
"Follow news of science, environmental, or ecology organizations via blogs and microblogging"

Motivation for Learning Science

JOYSCIE: PISA approaches the determination of student motivation from two different perspectives; intrinsic and instrumental. Intrinsic motivation refers only to the power of performing an activity for the enjoyment it will provide. Intrinsic motivation for science means that a student enjoys science and science-related subjects and finds pleasure in science learning activities (Ryan and Deci, 2009). This type of motivation influences the willingness of students to spend time and effort in science-related activities and their choices of elective courses and future career (Nugent et al., 2015). Enjoyment of science (JOYSCIE) is based on another trend question set that was first used in PISA 2006. This set involves the following statements, to which students are asked to respond according to one of the four points of Likert type; “strongly agree”, “agree”, “disagree”, and “strongly disagree” (OECD, 2016b);

“I generally have fun when I am learning <broad science> topics”
“I like reading about <broad science>”
“I am happy working on <broad science> topics”
“I enjoy acquiring new knowledge in <broad science>”
“I am interested in learning about <broad science>”

Broad interest in science topics

INTBRSCIE: Interest is one of the components of intrinsic motivation and also one of the reasons why students enjoy learning. What distinguishes interest from other enjoyment sources is that it is always oriented towards an object, activity, knowledge area or target since being interested in something means being engaged in it (Krapp and Prenzel, 2011). PISA created the INTBRSCIE index to measure students’ interest in science. For this purpose, students are given statements about biosphere, motion and forces, energy and transformation, universe and history, and asked to define their level of interest in these topics using a five-point Likert scale “not interested”, “hardly interested”, “interested”, “highly interested”, and “I don’t know what this is” (OECD, 2016b).

Instrumental Motivation to Learn Science

INSTSCIE: Besides intrinsic motivation, another concept used in PISA to measure students’ motivation for science is “instrumental motivation”, which refers to students’ willingness to learn science for themselves and their future careers (Wigfield and Eccles, 2000). For intrinsically motivated students, the science knowledge they acquire at school is useful because it will help them find a job and make it easier for them to perform occupational tasks in the future. INSTSCIE is another index used first in PISA 2006 to determine trends. In this context, the students were asked to respond to the following statements on a four-point Likert-type scale of “strongly agree”, “agree”, “disagree”, and “strongly disagree” (OECD, 2016b);

“Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on”
“What I learn in my <school science> subject(s) is important for me because I need this for what I want to do later on”
“Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects”
“Many things I learn in my <school science> subject(s) will help me to get a job”

Science Self-Efficacy

SCIEEFF: This refers to competence in situations that require scientific skills, such as scientific explanation of phenomena, evaluation and design of scientific research, or scientific interpretation of data and evidence (Mason et al., 2012). SCIEEFF concerns not only the performance of students but also their career orientations and choice of courses (Nugent et al., 2015). In order to generate the science self-efficacy (SCIEEFF) index, PISA uses the following statements, to which students respond using a four-point Likert-type scale; “I could do this easily", "I could do this with a bit of effort", “I would struggle to do this on my own”, and "I couldn’t do this" (OECD, 2016b);

“Recognise the science question that underlies a newspaper report on a health issue”
“Explain why earthquakes occur more frequently in some areas than in others”
“Describe the role of antibiotics in the treatment of disease”
“Identify the science question associated with the disposal of garbage”
“Predict how changes to an environment will affect the survival of certain species; interpret the scientific information provided on the labelling of food items”
“Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars”
“Identify the better of two explanations for the formation of acid rain”

As a trend index, SCIEEFF facilitates the monitoring of student improvement from 2006 to 2015.

BELONG: This index contains items that measure students’ sense of belonging at school. A four-point Likert-type scale is used, in which students choose among “strongly agree”, “agree”, “disagree”, and “strongly disagree” for the following statements (OECD, 2016b):

“I feel like an outsider (or left out of things) at school”
“I make friends easily at school”
“I feel like I belong at school”
“I feel awkward and out of place in my school”
“Other students seem to like me”
“I feel lonely at school”

Three of these statements are reverse-coded; thus, high scores in the index would convey a greater sense of belonging.

MOTIVAT: Achievement motivation (MOTIVAT) is a new index developed for PISA 2015 and comprises the following items based on a four-point Likert-type scale; “strongly disagree”, “disagree” “agree", and “strongly agree” (OECD, 2016b):

“I want top grades in most or all of my courses”
“I want to be able to select from among the best opportunities available when I graduate”
“I want to be the best, whatever I do”
“I see myself as an ambitious person”
“I want to be one of the best students in my class”

Environment and sustainable development

ENVAWARE: PISA developed this index to measure students’ awareness concerning environmental issues such as the increased greenhouse gases in the atmosphere, use of genetically modified organisms (<GMO>), nuclear waste, clearing forests for other land use, air pollution, extinction of plants and animals, and water shortages. Students are given a four-point Likert-type scale with which to rate their knowledge concerning these issues with the possible responses being; “I have never heard of this”, “I have heard about this but I would not be able to explain what it is really about”, “I know something about this and could explain the general issue”, and “I am familiar with this and I would be able to explain this well” (OECD, 2016b).

ENVOPT: This index measures the students’ level of optimism regarding the future state of the environmental problems listed above. A three-point Likert-type scale is used and the students are asked to consider each statement and give one of the following responses; “improve”, “stay about the same”, and “get worse” (OECD, 2016b).

2.3. Analytical Models and Data Analysis

Since PISA data is collected at both student and school levels, the dataset has a layered structure. Eliminating this nested structure by using ordinary least squares regression for the analysis of data would result in loss of characteristic dependencies. As a result, the application of an ordinary least squares regression analysis to a nested structure may fail and the rate of Type I error may increase (Raudenbush and Bryk, 2002). Therefore, a simple linear regression analysis was performed using the IDB Analyzer program to facilitate the analysis of the layered data in this study. The regression equation can be expressed as:

Pvscie1-10 = belong + bsmj + envaware + envopt + epist + instscie +iıntbrsci + joyscie + motivat + scieact + scieeff + ε

$$Y=\beta_0+ \beta_1X_1\ (Belong)+ \beta_2X_2\ (bsmj)+ \beta_3X_3\ (envaware)+ \beta_4X_4\ (envopt)+ \beta_5X_5\ (epist)+ \beta_6X_6\ (instscie) +\beta_7X_7\ (intbrsci)+ \beta_8X_8\ (joyscie)+ \beta_9X_9\ (Motivat)+ \beta_{10}X_{10}\ (scieact)+ \beta_{11}X_{11}\ (scieeff) +\varepsilon$$

The descriptive analyses of the data covered in the research demonstrated that for each variable, there was approximately 2% of data loss. The expectation maximization (EM) method was used to generate estimates for the incomplete data (Cheema, 2014).

3. RESULTS

Table 3 presents the descriptive statistical values for the results of linear regression analysis performed to determine the extent to which the variables given in the model predict students’ science performance in the six selected countries.

Table 3: Descriptive statistics

	Hungary		Japan		Korea		Spain		Sweden		Turkey	
	Mean	**STD**	**Mean**	**STD**	**Mean**	**STD**	**Mean**	**STD**	**Mean**	**STD**	**Mean**	**STD**
BELONG	0.06	1.00	-0.03	0.90	0.16	0.88	0.46	1.15	0.04	1.20	-0.43	1.11
BSMJ	53.95	16.07	52.10	14.10	56.08	14.37	59.79	15.83	57.39	15.94	63.31	15.89
ENVAWARE	0.00	1.05	-0.48	0.91	0.06	1.15	0.08	1.11	0.12	1.26	0.56	1.45
ENVOPT	0.09	1.18	0.31	1.04	0.06	1.32	0.05	1.14	0.04	1.10	-0.53	1.43
EPIST	-0.34	0.80	-0.07	1.02	0.02	0.96	0.09	0.98	0.10	0.99	-0.17	1.16
INSTSCIE	-0.03	0.87	-0.03	1.02	0.03	1.00	0.25	1.08	0.24	0.91	0.37	0.91
INTBRSCI	-0.21	0.91	-0.11	0.91	-0.07	0.97	0.09	0.89	-0.02	1.03	-0.03	0.99
JOYSCIE	-0.22	1.02	-0.33	1.14	-0.14	1.16	0.02	1.11	0.06	1.20	0.14	1.15
MOTIVAT	-0.29	0.86	-0.51	1.02	0.34	0.98	-0.16	0.91	0.14	1.03	0.61	1.03
PV_SCIE*	476.75	96.34	538.39	93.47	515.81	95.18	492.79	88.01	493.42	102.48	425.49	79.26
SCIEACT	0.21	1.10	-0.56	1.00	-0.28	1.17	-0.19	1.11	-0.22	1.10	0.66	1.14
SCIEEFF	-0.07	1.16	-0.46	1.21	-0.02	1.22	-0.15	1.26	0.04	1.22	0.34	1.29

* (PV_SCIE: science achievement)

As shown in Table 3, the index scores of the selected countries were similar in general; however, there were significant differences concerning certain variables. For example, INTBRSCI had a positive value in one country, Spain, but had negative values in the remaining five countries. This should be interpreted as students in the sample of Spain being more engaged with broad science topic than those in other countries. Another noteworthy point is that the ENVOPT index had a negative value only in the Turkish sample. The plausible values (PV_SCIE) of science performance index in Table 3 shows the average science performance of the selected countries. The highest science performance was found to be 538.39, which was observed in Japan and the lowest was 425.49 obtained from Turkey. This result is directly associated with distribution of the students into the PISA science performance levels shown in Table 2. In this study, regression analysis was carried out to determine how the affective characteristics of students, such as beliefs, motivations and self-efficacy, affected their science achievement and to clarify whether this prediction power differs between countries with different student performance. Table 4 presents the results of the regression analysis on the predictive power of the PISA 2015 student questionnaire index scores in students' science performance.

Table 4: Results of regression analysis on students' index scores in affective characteristics in PISA 2015

		Japan	Korea	Spain	Sweden	Hungary	Turkey
Belonging at school	B(SE)	1.54(1.38)	-5.92(1.41)	-1.90(0.99)	3.37(1.09)	3.83(1.53)	1.18(0.99)
	β	0.01	-0.06	-0.02	0.04	0.04	0.02
	t	1,11	-4.20**	-1.92	3.08**	2.50*	1.20
Students' expected occupational status	B (SE)	1.10(0.10)	1.14(0.10)	1.24(0.08)	0.96(0.10)	2.05(0.10)	1.09(0.11)
	β	0.17	0.17	0.22	0.15	0.34	0.22
	t	10.67**	11.17**	16.38**	9.88**	19.59**	9.84**
Awareness concerning environmental issues	B (SE)	14.12(1.89)	12.85(1.40)	6.86(1.08)	8.62(1.37)	9.45(1.46)	8.41(0.92)
	β	0.14	0.15	0.09	0.11	0.10	0.15
	t	7.45**	9.18**	6.34**	6.30**	6.47**	9.13**
Level of optimism regarding the future state of environmental problems	B (SE)	-6.48(1.07)	-6.74(0.93)	-7.51(1.05)	-4.77(1.32)	-7.47(1.26)	-13.69(0.95)
	β	-0.07	-0.09	-0.10	-0.05	-0.09	-0.25
	t	-6.08**	-7.29**	-7.15**	-3.62**	-5.92**	-14.34**
Epistemological beliefs	B (SE)	20.39(1.32)	20.41(1.64)	16.51(1.22)	24.10(1.87)	14.45(1.69)	8.63(1.16)
	β	0.22	0.21	0.18	0.23	0.12	0.13
	t	15.41**	12.44**	13.53**	12.92**	8.57**	7.43**
Instrumental motivation	B (SE)	-3.03(1.22)	-3.91(1.65)	-3.35(1.24)	-0.71(1.87)	-9.42(1.95)	0.59(1.20)
	β	-0.03	-0.04	-0.04	-0.01	-0.09	0.01
	t	-2.48*	-2.36*	-2.69**	-0.38	-4.82**	0.49
Interest in science	B (SE)	7.75(1.54)	-5.80(2.06)	4.40(1.38)	6.35(1.98)	4.56(1.87)	-1.37(0.98)
	β	0.08	-0.06	0.04	0.06	0.04	-0.02
	t	5.02**	-2.81**	3.19**	3.21**	2.43*	-1.39
Enjoyment of science	B (SE)	9.85(1.86)	20.31(1.64)	13.78(1.41)	9.18(1.61)	8.82(1.81)	3.25(1.12)
	β	0.12	0.25	0.17	0.11	0.09	0.05
	t	5.29**	12.38**	9.77**	5.69**	4.88**	2.89**
Achieving motivation	B (SE)	2.28(1.49)	7.97(1.43)	6.66(1.34)	0.92(1.44)	0.35(2.20)	-0.31(1.10)
	β	0.02	0.08	0.07	0.01	0.00	0.00
	t	1.53	5.59**	4.98**	0.64	0.16	-0.28
Science activities	B (SE)	-5.08(1.65)	-2.10(1.62)	-6.78(1.29)	-10.14(1.75)	-10.44(1.34)	-6.16(1.09)
	β	-0.05	-0.03	-0.09	-0.11	-0.12	-0.09
	t	-3.08**	-1.30	-5.27**	-5.81**	-7.79**	-5.66
Science self-efficacy	B (SE)	2.30(1.26)	3.18(1.09)	7.81(1.07)	7.96(1.31)	2.12(1.56)	5.60(1.00)
	β	0.03	0.04	0.11	0.09	0.03	0.09
	t	1.84	2.91**	7.30**	6.06**	1.36	5.61**

(B: unstandardized beta, SE: the standard error for the unstandardized beta, ***β:*** the standardized beta)
(* p < 0,05, ** p < 0,01)

Table 4 shows that, effects of the variables investigated in this study are statistically significant. But it shouldn't been overlooked that some variables such as belonging at school, are not significant in some countries. According to Table 4 students' epistemological beliefs are one of the most powerful predictor ($p < 0,01$) in six countries, additionally, it can be seen that, β weight of the epistemological beliefs decreases parallel with countries average science performance scores. Another conspicuous finding of this analyze is that, students' daily life science activities (SCIEACT) negatively effect their science performances in most of the countries. Considering that, while enjoyment of science index effects students' science performances positively, the negative effect of participating in daily life science activities suggests that these two features are not directly related to each other. The other remarkable finding is that, although the level of optimism regarding the future state of environmental problems index (ENVOPT) and awareness concerning environmental issues index (ENVAWARE) are originated from the same topic, "*Environment and sustainable development*", their effect to students' science performances are considerably different. While ENVAWARE has a positive impact on students' performances, ENVOPT has negative impact ($p<0,01$). Table 5 shows the R^2 values calculated for each country, which indicates the extent to which the regression model explained the variations in the students' science performance.

Table 5: R^2 values

	R^2	Adjusted R^2	R^2 se	a. R^2 se
Hungary	0.28	0.28	0.02	0.02
Japan	0.24	0.24	0.01	0.01
Korea	0.29	0.29	0.01	0.01
Spain	0.29	0.29	0.01	0.01
Sweden	0.25	0.25	0.02	0.02
Turkey	0.27	0.27	0.02	0.02
Table Average	0.27	0.27	0.01	0.01

According to the findings, the model generated similar results for countries with different achievement levels. More specifically, students' affective characteristics were able to explain 27% of their science performance and this percentage was similar in countries with different achievement levels.

4. DISCUSSION AND CONCLUSION

This study used the PISA 2015 data to determine the predictive ability of students' affective characteristics such as interest, attitude, and motivation in their science performance and whether this ability varies between countries with different achievement levels. An interesting finding of this research was that all the variables examined regarding the affective characteristics of the students explained student achievement at a similar level in all the selected countries despite the great differences in student achievement between these countries. This implies that the differences in student achievement between countries may be related to variables other than students' affective characteristics.

Previous research has found that student attitudes are not directly positively related to their science performance (OECD, 2016; Özel, Çağlak, and Erdoğan, 2013). Although some studies have shown that students' attitudes towards science may be negative in countries where science performance is high, other studies have reported that student traits such as self-efficacy (SCIEEFF) and enjoyment of science (JOYSCIE) showed a positive correlation with science performance (Fonseca, Valente, and Conboy 2011). PISA calculates students' engagement with science using different index scores based on the source of motivation and an intrinsic type of motivation is interest (INTBRSCI). In the current study, the results of analyses showed that the students from countries with different levels of achievement generally had a low level of interest; i.e., intrinsic motivation for science (Table 2). Similarly, in the literature, it has been reported that students with low science performance generally have greater interest in science while those with high science performance have a lower level of interest (Bybee and McCrae, 2011; Sjøberg and Schreiner, 2005). Another engaging finding of the present study was that despite the low index scores of students in INTBRSCI, this index was very effective in predicting their science performance. On the other hand, the INSTSCIE index, the instrumental motivation for science, made a negative contribution to the prediction of students' science performance.

The similarity between the selected countries in terms of the ability of students' affective characteristics in predicting their science achievement was more prominent in two variables. One of these was students' epistemic beliefs, which explained that student achievement was at a higher level in all countries. In the literature, it is generally stated that affective characteristics such as self-efficacy and motivation have a strong relationship with epistemological views and academic achievement (Noble et. al., 2006). This relationship can, in fact, be seen as an endeavor to reinforce children's self-efficacy and motivation to learn as an intrinsic process. This is very valuable in the development of children's epistemological views, which are considered to be important predictors of academic cognition and learning motivation (Başbay, 2013). Louca, Elby, Hammer and Kagey (2004) have suggested that students' emotions and feelings affect their epistemological views, and affective characteristics such as self-efficacy and motivation play an important role in the development of these views. Particularly in studies on the relationship between science achievement and epistemological views, it has been shown that mature and inquiry-based epistemological views positively contribute to high science achievement (Topçu and Yılmaz – Tüzün, 2009). The relationship between affective characteristics, epistemology and academic achievement has been confirmed by several researchers, who have reported that motivation is a driving force behind self-efficacy beliefs (Bandura, 1993), and epistemological views affected by motivation and self-efficacy is a determining factor in the academic achievement of students (Noble et. al., 2006). Similarly, in the current study, it was determined that the variable of epistemic beliefs of students was very powerful in predicting their science performance. Regardless of the science performance of students, their epistemic beliefs predicted this performance at a similar level and a high rate.

Another variable of the students' engagement with scientific activities in their daily lives was found to have a negative effect on science achievement in all the countries included in this research. On the other hand, it was found that some index values, which can be considered to be under a greater influence of cultural differences, had different effects on different countries. For example, the effect of the sense of belonging variable on academic achievement was positive in some countries and negative in others. A significant finding of this study was that although the index scores for the selected affective characteristics of students resulted in slight differences between the countries, the total effect of these characteristics on science performance was very similar for all countries. This is also consistent with the results of a study conducted by Topçu (2016) to compare the predictive power of students' affective characteristics for their mathematics scores in TIMMS between two countries, Turkey and Korea. The author reported that although some of the selected affective characteristics seem to be insignificant for the Turkish and Korean samples, they had a similar predictive ability in terms of overall effect (Turkey 29%, Korea 36%). According to this result, regardless of the achievement level, affective characteristics of students are among the most important factors affecting their science achievement, predicting it at a rate of approximately 30%. Countries should take this into consideration when developing their educational policies and curricula. Taking the Turkish sample as an example, the students' motivation to learn science was higher than the OECD average but their science performance was low. On the other hand, in Hungary, students' science performance was below the OECD average and so was their motivation to learn science. At this point, it can be argued that efforts towards increasing student motivation to learn science can only be successful to a certain extent, but for greater development, it is necessary to consider and improve other factors in addition to the student’s affective characteristics.

In summary, it has been determined that the main factors determining the science performances of the students are the levels of enjoyment and epistemological beliefs in science learning. Other affective attributes, such as having the same impact as these two variables, are among the most interesting findings in researching similar contributions to student achievement in countries with different success levels. Another important finding of the study is that the common effect of the affective traits is similar to the variance of the students' science achievement in all the countries involved in the sampling. This finding can be interpreted in two ways. The first one may be that the content of the taught courses and teaching approaches are very similar in the determined countries, but they are not sufficient for the different interpretations that are expected to arise from these cultural differences. The second is to try to minimize scale errors as a result of adapting the questions asked to the students. This viewpoint seems more reasonable than the first.

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GENİŞ ÖZET

PISA, Ekonomik İşbirliği ve Kalkınma Örgütü (OECD) tarafından üç yılda bir yapılan ve katılımcı ülkelerde bulunan 15 yaşındaki çocukların, fen, matematik ve okuryazarlık düzeylerini belirleyen uluslararası bir karşılaştırmalı öğrenci izleme ve değerlendirme çalışmasıdır. Bu kapsamda, her bir ülkedeki 15 yaş gurubu öğrencilerinin fen, matematik ve okuma becerileri düzeylerinin belirlenebilmesinin yanı sıra; bu beceriler bakımından ülkeler arası karşılaştırmaların yapılabilmesi de mümkün olmaktadır. PISA kapsamında okuma becerileri, matematik okuryazarlığı ve bilim okuryazarlığı olmak üzere üç alanda öğrenci düzeyleri ölçülmekle birlikte; aile, okul ve sosyoekonomik durum gibi eğitim kalitesini etkileyebileceği öngörülen pek çok değişkene dair de veriler toplanmaktadır. Üç yılda bir yapılan bu uygulamanın her bir döngüsünde okuma becerileri, matematik okuryazarlığı ve bilim okuryazarlığı alanlarından biri uygulamanın temasını oluşturmaktadır. Ulusal ve ulusalar arası alan yazın incelendiğinde ekonomik-sosyal- kültürel-statü (ESKS), bütçeden eğitim ayrılan pay, ebeveynlerin eğitim durumu, okulların fiziki imkânları gibi pek çok değişkenin öğrencilerin performanslarını anlamlı düzeyde etkilediği belirlenmiştir. Bununla birlikte öğrencilerin duyuşsal özellikleri de performansı etileyen önemli değişkenler arasındadır (Dursun-Sürmeli ve Ünver, 2017). Literatürde öz-yeterlilik inancının (Ader, 2004; Pajares & Graham, 1999; Schunk, 1991; Zimmerman, Bandura & Martinez-Pons, 1992), motivasyon ve duyuşsal özelliklerin (Mcleod, 1992; Richardson & Suinn, 1972) öğrenci başarısı üzerindeki etkisini gösteren pek çok çalışma mevcuttur. Ek olarak ilgi, tutum, akademik benlik gibi duyuşsal özelliklerin akademik başarının %25'ini açıklama gücüne sahip olduğu ifade edilmektedir (Senemoğlu, 2010). Ancak öğrencilerin duyuşsal özelliklerinin farklı başarı performansı sergileyen ülkelerde başarıyı yordama düzeyleri hakkında bir çalışmaya rastlanmamıştır. PISA ve TIMSS araporları incelendiğinde, motivasyon ve başarı arasında bu uygulamalara katılan tüm ülkeleri kapsayan bir ilişkinin var olduğunu söylemek çok zordur. Örneğin Güney Kore'de öğrencilerin büyük bir çoğunluğunun feni sevme düzeyleri düşük iken, bu ülke yüksek fen başarısına sahiptir. Tersine Türkiye'de öğrencilerin fene ilişkin tutumu çok yüksek iken fen başarı oldukça düşüktür. Tutum ve başarı arasındaki farklı ilişki biçimlerine ilişkin literatürde üzerinde uzlaşılmış bir açıklamaya rastlanmamaktadır. Bu çalışma, fen başarısı ile duyuşsal özellikler arasındaki ilişkiye başka bir açıdan yaklaşmayı denemektedir. Çalışma kapsamında farklı başarı seviyelerinde yer alan ülkelerde, duyuşsal özelliklerin çocukların fen başarısını açıklama oranları karşılaştırmalı olarak incelenmeye çalışılmıştır. Bu çalışmada PISA 2015'den elde edilen veriler kullanılmıştır. PISA çalışmalarında tercih edilen örneklem tasarımı, iki aşamalı tabakalı örneklem olarak adlandırılmaktadır. Buna göre örneklem tasarımının ilk aşaması, 15 yaşındaki öğrencilerin kaydolabileceği bireysel okulların örneklenmesinden oluşmaktadır. İkinci aşamada ise, belirlenen okullardan öğrenciler seçilmektedir (OECD, 2016). Bu çalışma kapsamında, çalışmanın amacına uygun PISA tarafından tanımlanmış üç başarı düzeyinin (ortalama üstü, ortalama düzey, ortalama altı) her birinden seçkisiz yolla iki ülke seçilmiş ve seçilen ülkelerdeki sınava giren öğrencilerin tamamı analize dâhil edilmiştir. Yalnızca Türkiye ortalama altı başarı düzeyine kasıtlı olarak seçilmiştir.

Öğrencilerin duyuşsal özelliklerinin araştırmaya dâhil edilen ülkelerde başarıyla ilişkisinin benzerliği özellikle iki duyuşsal özellik özelinde belirginleşmektedir. Bunlardan biri olan öğrencilerin epistemolojik inançları değişkeni öğrenci başarısını araştırmaya dâhil edilen tüm ülkelerde diğer değişkenlerden daha yüksek düzeyde açıklamaktadır. Literatürde, genel olarak öz-yeterlilik ve motivasyon gibi duyuşsal özelliklerin epistemolojik görüş ve akademik başarı ile güçlü bir ilişkiye sahip olduğu ifade edilmektedir (Noble, Farah, & McCandliss, 2006). Bu ilişki gerçekte çocukların öz yeterlilik ve motivasyonlarını güçlendiren ve içsel bir süreç olan öğrenmeye yönelik çaba olarak görülebilir. Bu çabanın çocukların epistemolojik görüşlerinin gelişimi için değerli olduğu düşünülmektedir ve epistemolojik inançları akademik biliş ve öğrenme motivasyonunda oldukça önemli bir yordayıcı olarak değerlendirilmektedir (Başbay, 2013). Louca, Elby, Hammer & Kagey (2004) öğrencilerin duygu ve hislerinin epistemolojik görüşlerine etki ettiği ve epistemolojik görüşlerinin gelişiminde öz-yeterlilik ve motivasyon gibi duyuşsal özellikler önemli bir rol oynadığını ifade etmektedir. Özellikle fen başarı ile epistemolojik görüşler arasındaki ilişkinin ortaya konduğu çalışmalarda, olgunlaşmış ve sorgulamaya dayalı epistemolojik görüşlerin yüksek fen başarısına olumlu katkı sağladığı belirtilmektedir (Topçu ve Yılmaz - Tüzün, 2009). Motivasyonun, öz-yeterlilik inancında harekete geçirici bir özellik taşıması (Bandura, 1993), motivasyon ve öz yeterlilik gibi duyuşşal özelliklerin etkilediği epistemolojik görüşlerinde öğrencilerin akademik başarılarında belirleyici bir değişken olması (Noble, Farah, & McCandliss, 2006), bahsedilen bu duyuşsal özelliklerle, epistemoloji ve akademik başarı arasındaki ilişkiyi ortaya koymaktadır.

Öğrencilerin günlük yaşamlarında bilimsel etkinliklere katılımlarının bir diğer değişkeninin, bu araştırmaya katılan tüm ülkelerde fen başarısını olumsuz etkilediği bulunmuştur. Öte yandan, kültürel farklılıkların daha büyük etkisi altında sayılabilecek bazı endeks değerlerinin farklı ülkeler üzerinde farklı etkileri olduğu tespit edildi. Örneğin, değişkenlik hissinin akademik başarıya etkisi bazı ülkelerde olumlu, bazılarında olumsuzdur. Bu çalışmanın önemli bir bulgusu, öğrencilerin seçilen duygusal özellikleri için indeks puanlarının ülkeler arasında küçük farklılıklar doğurmasına rağmen, bu özelliklerin fen performansı üzerindeki toplam etkisinin tüm ülkeler için çok benzer olmasıydı. Bu aynı zamanda Topçu (2016) tarafından, öğrencilerin duygusal özelliklerinin tahmin edici gücünü, iki ülke, Türkiye ve Kore arasındaki TIMMS'deki matematik puanları için öngörülen gücünü karşılaştırmak için yapılan bir çalışmanın sonuçlarıyla tutarlıdır. Yazar, seçilen duygusal özelliklerin bir kısmının, Türk ve Kore örnekleri için önemsiz gibi görünmesine rağmen, genel etki açısından benzer bir öngörücü kabiliyete sahip olduklarını bildirmiştir (Türkiye % 29, Kore % 36). Bu sonuca göre, başarı seviyesine bakılmaksızın, öğrencilerin duygusal özellikleri, fen başarılarını etkileyen en önemli faktörler arasında olup, bunu% 30 civarında tahmin etmektedir. Ülkeler, eğitim politikalarını ve müfredatlarını geliştirirken bunu dikkate almalıdır. Türk örneklemini örnek alarak, öğrencilerin fen öğrenme motivasyonları OECD ortalamasından daha yüksekti ancak fen performansları düşüktü. Öte yandan, Macaristan'da, öğrencilerin fen performansı OECD ortalamasının altındaydı ve fen bilimlerini öğrenme motivasyonları da arttı. Bu noktada, fen bilgisi öğrenmek için öğrenci motivasyonunu arttırma çabalarının yalnızca bir dereceye kadar başarılı olabileceği iddia edilebilir, ancak daha büyük gelişme için, öğrencinin duygusal özelliklerine ek olarak diğer faktörleri de dikkate almak ve geliştirmek için gerekli olduğu söylenebilir.

Özet olarak, bu araştırmada öğrencilerin fen performanslarını belirleyen en temel faktörlerin fenden keyif alma durumları ve epistemolojik inanç düzeyleri olduğu belirlenmiştir. Çalışmanın bir diğer önemli bulgusu, duygusal özelliklerin ortak etkisinin, örneklemde yer alan tüm ülkelerde öğrencilerin fen başarısını benzer düzeyde yordamasıdır. Bu bulgu iki şekilde yorumlanabilir; birincisi, öğretilen derslerin ve öğretim yaklaşımlarının içeriğinin belirlenen ülkelerde çok benzer olması, ancak bu durum kültürel farklılıklardan doğması beklenen değişimleri açıklamak için yeterli olmamaktadır. İkincisi ise, öğrencilere sorulan soruların ölçme hatalarını en aza indirebilmek için kültürlere uyarlanmasıdır ki bu bakış açısı birincisinden daha makul görünmektedir.