

# Investigating Reading Literacy in PISA 2018 Assessment

İlhan Koyuncu<sup>\*a</sup>, Tahsin Fırat<sup>b</sup>

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<sup>\*a</sup>**Correspondance Details:** İlhan Koyuncu.  
Adiyaman University, Department of Educational  
Sciences, Adiyaman, Turkey.  
E-mail: ilhankoyuncu@gmail.com  
ORCID: <http://orcid.org/0000-0002-0009-5279>

<sup>b</sup>Tahsin Fırat. Adiyaman University, Department of  
Special Education, Adiyaman, Turkey.  
E-mail: tahsinfirat02@gmail.com  
ORCID: <http://orcid.org/0000-0002-3577-7907>

## Abstract

This study aims to investigate the predictors of reading performance and how reading performance predicts mathematics and science performances in PISA 2018 study. For this purpose, the country in the focus (Turkey), the highest performer (China [B-S-J-Z]) in the world, and the lowest performer (Mexico) among the OECD members countries were selected as the research sample. A total of 12058 students participated from China (Male=6283, Female=5775), 6890 students from Turkey (Male=3494, Female=3396), and 7299 students from Mexico (Male=3473, Female=3826) in PISA 2018 study. The results revealed that 'Index of economic, social and cultural status', 'Meta-cognition: assess credibility', and 'Meta-cognition: summarizing' are the most significant factors affecting students' reading literacy in all three countries. Total explained variance explained is 41%, 41%, and 39% for Turkey, China (B-S-J-Z) and Mexico, respectively. 'Index highest parental occupational status', 'Duration in early childhood education and care', 'Attitude towards school: learning activities', and 'Subjective well-being: Sense of belonging to school' are not significant predictors for reading literacy of students from all three countries. In addition, regarding the predictivity of reading literacy, total variance explained is 65% in mathematics performance and approximately 77% in science performance for all three countries.

## Keywords:

PISA 2018 Study, Reading Literacy, Mathematics Literacy, Science Literacy

## Introduction

Education plays an important role in social development. A good education system contributes to industrial, technological, and artistic development as well. Countries seeking to be a pioneer in these fields effectuate various education policies and allocate a considerable part of their budgets to education. In that regard, countries willing to test their academic achievement at national level and to see their level of competence in international platforms participate in some assessment processes and accordingly review their systems (Berberoğlu & Kalender, 2005; Tavşancıl, Yıldırım, & Bilican Demir, 2019). The Program for International Student Assessment (PISA) is one of the relevant assessment processes. It measures 15-year-old students' reading, mathematics, and science literacy every three years. Each cycle focuses on one of these three major domains of study,



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though two other domains are also included in the assessment. The focal subject was science in 2006 and 2015, mathematics in 2003 and 2012, and reading in 2000, 2009 and 2018 (Organisation for Economic Co-operation and Development [OECD], 2019a). The fact that the reading skills are chosen as the focal subject means that PISA 2018 results focus on reading skills rather than mathematics and science literacy. This study is important in terms of revealing which factors are more effective on reading performance and its relationship with mathematics and science achievement.

### ***Factors Affecting Reading Literacy***

Reading literacy refers to understanding, evaluating, using and engaging with written text to participate in the society, to achieve one's goals and to develop one's knowledge and potential (OECD, 2019b). In this context, it can be said that reading is a difficult and complex process that requires many cognitive skills (Adams, 1990). Therefore, it is possible to say that there are many factors that affect students' acquisition of reading skills and successful display of them (Esmer & Günes, 2019; Linnakyla, Malin, & Taube, 2004). Studies reveal that achievement in reading comprehension is affected by a variety of factors, i.e., fluent reading (Kim, Petscher, Schatschneider, & Foorman, 2010; Klaua & Guthrie, 2008), text structure information (Englert & Hiebert, 1984; Pyle et al., 2017), cognitive and metacognitive strategies knowledge (Firat & Koçak, 2019; King, 1991; Wu, 2014), vocabulary (Elleman, Lindo, Morphy, & Compton, 2009; Nelson & Stage, 2007), motivation (Becker, McElvany, & Kortenbruck, 2010; Logan, Medford, & Hughes, 2011; Taboada, Tonks, Wigfield, & Guthrie, 2009) and previous knowledge (Kendeou & Van Den Broek, 2007; Ozuru, Dempsey, & McNamara, 2009). The factors of achievement in such a difficult and multidimensional process also involve socioeconomic and familial conditions, school type, reading habits, learning strategies, and participation in preschool education (OECD, 2019a). For example, Hemmereichs, Agirdag, and Kavadias (2017) determined that participation of parents in literacy activities in preschool education of their children, parental education status, and socioeconomic status have significant effects on students' acquisition of reading skills.

### ***The Relationship of Reading Literacy with Mathematics and Science Performance***

Students' achievement in reading is important in terms of demonstrating their skills in other academic domains. If a student's reading literacy level is low, it generally implies difficulties in the acquisition of several other skills in most cases (Geske & Ozola, 2008).

In order to be successful in science and mathematics, the reader must first read and understand well the text and symbols and interpret what they read. Rindermann and Baumeister (2015) emphasized that it is very important to consider reading performance when interpreting students' achievement (including science and mathematics performance) in PISA. From PISA 2006, 2009 and 2012 data, as well as from their relevant studies with students and teachers, Akbasli, Sahin and Yaykiran (2016) found that reading comprehension is a significant predictor of mathematics and science achievement. Fuentes (1998) argued that mathematics and reading go hand in hand; students need to improve their reading so as to increase their mathematics achievement, in other words. It is possible to come across a number of studies that reveal the relationship between reading skills and mathematics achievement (Erdem, 2016; Ding & Homer, 2020; Grimm, 2008; Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2005; Osterholm, 2005).

In a longitudinal research on the covariance of the relationship between reading and mathematics achievement, for example, Grimm (2008) examined the associations between third grade reading comprehension and changes in three components of mathematics achievement (problem solving and data interpretation, mathematical concepts and estimation, mathematical computation) from third through eighth grade. Third grade reading comprehension was found to be a positive significant predictor of change for each component of mathematics. Students with a greater level of reading performance in early elementary school were found to be more rapid and successful in mathematics. Besides, reading comprehension was shown to be related to a conceptual understanding of mathematics and the application of mathematics knowledge. It is possible to come across several other studies that likewise reveal a close relationship between reading ability and science achievement (Bayat, Sekercioglu, & Bakir, 2014; Cano, García, Berben, & Justicia, 2014; Cromley, 2009; O'Reilly & McNamara, 2007). O'Reilly and McNamara (2007) found that reading skills help the learner compensate for deficits in science knowledge for most measures of achievement. Similarly, in a study via the PISA 2000, 2003 and 2006 data, Cromley (2009) revealed that greater level of reading skill brought higher science achievement.

### ***Importance of the Study***

Studies show that a variety of factors affect reading comprehension and the latter has an effect on science and mathematics achievement. Nevertheless, there are not many studies showing how effective these factors are on reading skills. Identifying the factors

that have more impact on reading skills will enable countries aiming to develop these skills to decide what to focus on or what changes they should make in their education policies and programs. We have not come across much findings in the related literature as well, regarding to what extent reading is effective on science and mathematics achievement. We therefore consider it important to determine the extent to which reading achievement affects science and mathematics achievement.

Accordingly, within the scope of this study, we analysed the assessment results of those who participated in PISA from Turkey, China (B-S-J-Z) and Mexico. Selected as a focus country, Turkey participated in the PISA test for the first time in 2003. Turkey's record of reading in PISA can be summarised as follows: In 2000, Turkey did not take part in the test in which 43 countries participated. Turkey ranked 35th out of 41 in 2003, 37th out of 57 in 2006, 41st out of 65 in 2009 and 2012, and 50th out of 72 countries in 2015. 79 countries participated in PISA 2018. In the domain of reading, Turkey ranked 40th out of 79 countries participating in PISA 2018, while ranking 31st among the 37 OECD countries. The rate of Turkish students ahead and at the second level of reading proficiency was 73.9%, which was below the OECD average. China was chosen as the second country. Regarding China's PISA history, Shanghai represented China in joining PISA for the first time in 2009. It ranked first in the PISA tests held in 2009 and 2012. In PISA 2015, the Chinese region consisting of four provinces/cities of Beijing-Shanghai-Jiangsu-Guangdong (B-S-J-G) ranked 27th in reading. China again ranked first in reading skills in PISA 2018. Moreover, China became the only country where more than 90% of its students performed at the proficiency level 2 or above. It is seen that Mexico's PISA record is poor in all tests held since 2000. It ranked last among the OECD countries and 7th from the bottom among the countries that took the test in 2000, while it was 3th from the bottom in 2003. This trend of failure continued in 2006, 2009, 2012 and 2015 as well. In PISA 2018, it ranked 53rd in general and 36th (second from the bottom) among the OECD countries. Colombia, the most failed OECD country in the PISA 2018, was not included in the study, as it had a recent PISA record as an OECD member country in 2018. The purpose for choosing these countries is the fact that Turkey, which the researchers are from, was at moderate performance level, China (B-S-J-Z) was the best performer, and Mexico was the worst performer in terms of reading skills. Thus, it was aimed to achieve more generalizable results by comparing the possible factors affecting reading literacy in countries with different performance levels and different characteristics.

### *Aim of the Study*

We aimed to investigate the predictors of reading performance and how reading performance predicts mathematics and science performance of Chinese (B-S-J-Z), Turkish and Mexican students in PISA 2018. For this purpose, we sought answers to the following research questions:

1. What are the statistically significant predictors of reading performance of Chinese (B-S-J-Z), Turkish and Mexican students in the PISA 2018?
2. What are the rankings of statistically significant variables in predicting reading performance of Chinese (B-S-J-Z), Turkish and Mexican students in the PISA 2018?
3. How does reading performance of Chinese (B-S-J-Z), Turkish and Mexican students predict their mathematics and science performance in the PISA 2018?

### *Method*

The method section consists of five sub-sections including research design, participants, data collection tools, validity and reliability, and data analysis.

### *Research Design*

This study aimed to examine the characteristics, background information, cognitive and non-cognitive outcomes in reading literacy skills of the Chinese (B-S-J-Z), Turkish and Mexican students. Since it is aimed to describe the data obtained from the student questionnaires of PISA 2018 for a specific group of students, the present study is a survey research. In addition, the relationship between background information, cognitive and non-cognitive tendencies of the students and reading, mathematics and science literacy skills was investigated in the scope of the present study. Therefore, it is also a correlational research which attempts to predict the student performance based on linear correlations between independent and dependent variables.

### *Participants*

The target population of the PISA 2018 study is 15-year-old students attending in different type of schools at grade 7 or higher across the world. For the purpose of the present study, the highest performer (China), the country in the focus (Turkey), and the lowest performer in the OECD members countries (Mexico) were selected as the research sample. A stratified sampling method was used in PISA studies. PISA 2018 technical report (OECD, n.d.) could be examined in detail to understand the whole sampling process. A total of 12058 students participated from China

(Male=6283, Female=5775), 6890 students from Turkey (Male=3494, Female=3396), and 7299 students from Mexico (Male=3473, Female=3826) in the PISA 2018 study.

### Data Collection Tools

Data used in this study were collected via student questionnaires and cognitive items developed to measure reading, science, and mathematics literacy in the PISA 2018 study. In order to measure reading skills, PISA 2018 defined various dimensions, including different types of text and cognitive processes in which the reader interacts with the text, as well as questions and tasks at different levels of difficulty. As part of the PISA 2018 reading assessment framework, there are four different cognitive processes that readers actively display while reading a text: "access to information", "interpretation", "evaluation and reflection", "fluent reading". Different text types show how the information in the text is organized (e.g. stories or explanatory texts). Within the scope of reading skills, two different types of questions were used: The questions that the student chooses from among the options (multiple choice, yes/no, true/false questions), and questions the answers of which are constructed by the student (questions with short or long answers) (OECD, 2019b).

The student questionnaire consists of items to assess a range of non-cognitive and demographic variables. In addition, 10 plausible values (PVs) were evaluated for reading, science and mathematics literacy and subscales of reading literacy. In large scale assessments (e.g. TIMSS, PISA etc.), more than one plausible value was calculated for each student from posterior distribution of ability parameters estimated with Item Response Theory (IRT) models. It is suggested in PISA manuals to use all these plausible values in analysing PISA data. Detailed information about scaling and analysing of test scores in PISA assessment were provided in PISA 2018 technical report (OECD, n.d.).

For the aim of the present study, non-cognitive and demographic variables that might affect reading literacy of students were selected for China (B-S-J-Z), Turkey and Mexico. Moreover, the variables not applied together in three countries were eliminated from the data. 21 variables that might predict students' reading performance were determined. The reason for choosing these variables arises from the fact that each of them is one of the factors affecting reading literacy or has characteristics close to these factors in the related literature (e.g. Artelt, Schiefele, & Schneider, 2001; Erdoğan & Gündendir, 2019; Geske & Ozola, 2008;

Kir, 2016; Manolitsis, Georgiou, & Tziraki, 2013; Mikk, 2015; Miyamoto, Pfost, & Artelt, 2019; Perry & McConney, 2010; Rajchert, Żuřtak, & Smulczyk, 2014; Sénéchal, 2006; Sénéchal & LeFevre, 2002; Soodla, Jögi, & Kikas, 2017; Shala & Grajcevci, 2018).

Instead of using too many variables in PISA data, the researchers preferred variables consisting of a combination of more than one variable. For example, index of economic, social, and cultural status (ESCS) consists of many variables such as home and cultural possessions, number of books, parents' education and occupation, etc. Consequently, among all the variables included in the PISA 2018 student data, the possible variables determined by the researchers that can affect the reading skills are as follows:

1. Attitude towards school: learning activities (ATLNACT)
2. Subjective well-being: Sense of belonging to school (BELONG)
3. Teacher-directed instruction (DIRINS)
4. Disciplinary climate in test language lessons (DISCLIMA)
5. Duration in early childhood education and care (DURECEC)
6. Parents' emotional support perceived by student (EMOSUPS)
7. Index of economic, social and cultural status (ESCS)
8. General fear of failure (GFOfAIL)
9. Highest education of parents (HISCED)
10. Index highest parental occupational status (HISEI)
11. Joy/Like reading (JOYREAD)
12. Meta-cognition: assess credibility (METASPAM)
13. Meta-cognition: summarizing (METASUM)
14. Perceived feedback (PERFEED)
15. Self-concept of reading: Perception of competence (SCREADCOMP)
16. Self-concept of reading: Perception of difficulty (SCREADDIFF)
17. Teacher's stimulation of reading engagement perceived by student (STIMREAD)
18. Teacher support in test language lessons (TEACHSUP)
19. Learning time (minutes per week) - in total (TMINS)
20. Meta-cognition: understanding and remembering (UNDREM)
21. Gender (GENDER)

Among these variables, gender was categorical and it was coded as a dummy variable in the analysis. The other variables were continuous or ordinal and hence they were included in the analysis as continuous variables.

### Validity and Reliability

The results of PISA studies, which have been implemented seven times since 2000, are widely used in the evaluation of education systems all over the world. In the Technical Report and Assessment and Analytical Framework documents published after each PISA cycle, the construction of scales and construct validity, selection of the representative sample, ensuring application reliability, coding reliability, reliability of

the scaling process are discussed in detail and shared as open access (see OECD, n.d.; OECD, 2019a). In the Assessment and Analytical Framework book, the structure of the scales used (reading, mathematics, science, questionnaires, etc.) is explained in detail. The Technical Report includes the construction process of scales, ensuring coding reliability, and the details of the scaling process. Therefore, PISA data which is collected for use in scientific studies as well, is a highly valid and reliable data.

### Data Analysis

Multiple linear regressions were performed to predict reading performance of the students from independent variables given above. The reason for choosing this analysis method is the fact that it is the preferred method in cases where the differentiation in a dependent variable is estimated based on more than one independent variable. In this study, the predictive power of the 21 variables given in the data collection section in estimating reading performances of the students was examined. To compare statistically regression coefficients for each of independent variables across countries, the following formula suggested by Clogg, Petkova, and Haritou (1995) was used.

$$Z = \frac{\beta_1 - \beta_2}{\sqrt{(SE_{\beta_1})^2 - (SE_{\beta_2})^2}}$$

where  $\beta_1$  and  $\beta_2$  are standardized regression coefficients and  $SE_{\beta_1}$  and  $SE_{\beta_2}$  are their standard errors. Besides, Fisher's (1921) z transformation was used to compare  $R^2$  values.

Besides, simple linear regressions were carried out to predict students' mathematics and science performance from reading literacy. Before performing the analysis, the assumptions of linear regression analysis were examined. Following results were obtained regarding the examination of the assumptions of multiple linear regression for each of plausible values:

1. There was at least one independent variable.
2. Dependent variable was continuous. Except gender, other independent variables were also continuous. Gender was dummy coded.
3. Independence of observations were satisfied.
4. There was very few residuals and extreme values (approximately 0.2% for each plausible value) that were negligible.
5. There was an approximately linear relationship between dependent and independent variables (Linearity).
6. The error in the relationship between independent and dependent variables were similar across all independent variables (Homoscedasticity).
7. There was no multicollinearity or singularity.

8. The variables were approximately normally distributed according to histograms and skewness-kurtosis values (-1, +1). The residuals have approximately standard normal distribution according to normal P-P plot and normal Q-Q plots.

10 plausible values were used as representative of reading, mathematics, and science performance of the students. Data were analysed based on PISA Data Analysis Manual (OECD, 2009). Therefore, the IEA International Database Analyzer (IDB Analyzer) was used to generate SPSS syntaxes. This software was developed by IEA Data Processing and Research Centre to analyse large-scale assessments data including PISA study. IDB Analyzer takes into account sampling design information and 10 plausible values while generating codes for the SPSS and SAS software to test hypothesis. The analysis was performed for each PV and then all results were combined as explained in PISA technical reports (see OECD, n.d.). This process that performed via SPSS syntaxes is more than just averaging all PVs. Whole syntaxes used in this study were generated via IDB Analyzer and the analyses were performed with SPSS software. 80 replications were performed for each of 10 plausible values.

### Results

The results of each research question have been provided separately in the following sections.

#### Prediction of Reading Literacy from Selected Independent Variables

In order to determine significant variables that predict students' reading literacy, multiple linear regressions were executed for data obtained from each country. Regression coefficients ( $B$ ), standard errors of regression coefficients [ $B$  (s.e.)], standardized regression coefficients ( $\beta$ ) and  $t$  values for each variable and country are given in Table 1.

According to Table 1, 'Index of economic, social and cultural status', 'Meta-cognition: Assess credibility', 'Meta-cognition: Summarizing', 'Teacher-directed instruction', 'Disciplinary climate in test language lessons', 'Self-concept of reading: Perception of difficulty', 'Highest education of parents', 'Perceived feedback', 'Meta-cognition: Understanding and remembering', 'Teacher's stimulation of reading engagement perceived by student', 'Parents' emotional support perceived by student', 'Joy/Like reading, and 'General fear of failure' are 13 significant variables that explained 41% variance of reading literacy of Turkish students, respectively. Except the 'highest education of parents' variable, the rest of the significant variables for Turkish students are also significant for Chinese students. In addition to these variables, 'gender' and

**Table 1**  
Multiple Linear Regression Results

Independent Variables	Turkey <sup>1</sup>				China (B-S-J-Z) <sup>2</sup>				Mexico <sup>3</sup>			
	B	B (s. e.)	$\beta$	t	B	B (s. e.)	$\beta$	t	B	B (s. e.)	$\beta$	t
Constant	526.47	15.65		33.65*	501.09	13.92	.	36.00*	461.00	1711	.	26.95*
1. ESCS	26.23	3.84	0.37	6.83*	14.90	3.46	0.19	4.31*	15.22	4.08	0.23	3.73*
2. METASPAM	22.8	1.81	0.26	12.56*	23.80	1.40	0.27	17.01*	14.77	1.75	0.18	8.46*
3. METASUM	14.95	1.6	0.17	9.34*	13.17	1.29	0.15	10.22*	14.98	2.10	0.17	7.15*
4. DIRINS	-10.21	1.86	-0.12	-5.49*	-7.69	1.41	-0.09	-5.45*	-8.92	2.45	-0.11	-3.64*
5. DISCLIMA	9.91	1.66	0.11	5.98*	5.91	1.44	0.07	4.11*	8.84	2.18	0.10	4.06*
6. SCOREADIFF	-9.09	1.8	-0.10	-5.04*	-7.40	1.30	-0.08	-5.70*	-5.93	2.09	-0.07	-2.84*
7. HISOED	-4.57	1.71	-0.10	-2.67*	2.10	1.56	0.04	1.35	-2.33	2.04	-0.05	-1.14
8. PERFEED	-6.11	2.1	-0.07	-2.91*	-4.18	1.38	-0.05	-3.03*	-9.73	1.76	-0.12	-5.51*
9. UNDREM	6.21	1.75	0.07	3.54*	8.82	1.07	0.10	8.28*	10.2	1.87	0.12	5.45*
10. STIMREAD	6.01	1.97	0.07	3.04*	8.18	1.50	0.10	5.44*	3.91	2.00	0.05	1.96*
11. EMOSUPS	5.14	1.44	0.06	3.58*	5.00	1.32	0.05	3.80*	-0.35	1.65	.00	-0.21
12. JOYREAD	4.87	2.06	0.06	2.36*	14.28	1.57	0.14	9.12*	7.92	1.88	0.09	4.22*
13. GFOFAIL	2.88	1.46	0.03	1.97*	5.60	1.37	0.06	4.07*	1.95	1.76	0.02	1.11
14. HISEI	0.11	0.11	0.03	0.96	0.11	0.09	0.03	1.28	0.19	0.15	0.05	1.33
15. DURECEC	-2.06	1.52	-0.02	-1.36	-0.96	1.23	-0.01	-0.78	-0.11	2.12	.00	-0.05
16. SCREADCOMP	2.09	1.9	0.02	1.10	-1.47	1.97	-0.01	-0.75	14.37	2.45	0.15	5.86*
17. GENDER_D2M	2.39	4.04	0.01	0.59	8.88	2.07	0.05	4.29*	8.55	3.95	0.05	2.16*
18. ATTLNACT	-0.73	1.31	-0.01	-0.56	1.93	1.12	0.02	1.73	2.21	1.57	0.03	1.41
19. BELONG	-1.01	1.53	-0.01	-0.66	-1.41	1.34	-0.01	-1.05	1.01	1.46	0.01	0.69
20. TEACHSUP	0.18	1.84	.00	0.10	0.93	1.77	0.01	0.53	7.28	2.61	0.08	2.78*
21. TMINS	.00	.00	.00	-0.17	0.02	0.00	0.09	5.05*	0.00	0.00	0.03	1.35

Note: GENDER D2M: Dummy coded GENDER variable. \*  $p < .05$  (Two tailed) 1  $R^2 = 0.41$  / Adjusted  $R^2 = 0.41$  / s.e. = .02 2  $R^2 = 0.41$  / Adjusted  $R^2 = 0.41$  / s.e. = .02 3  $R^2 = 0.39$  / Adjusted  $R^2 = 0.39$  / s.e. = .03

'learning time (minutes per week) - in total' are also significant variables for Chinese (B-S-J-Z) students and 14 significant variables explained 41% total variation in reading literacy of Chinese (B-S-J-Z) students. Except the 'highest education of parents', 'parents' emotional support perceived by student', and 'general fear of failure' variables, the rest of the significant variables for Turkish students are also significant for Mexican students. In addition to these variables, 'gender', 'self-concept of reading: Perception of competence', and 'teacher support in test language lessons' are also significant variables for Mexican students and 13 significant variables explained 39% total variation in reading literacy of Mexican students. As a result, 10 variables are significant for all three countries, 3 variables are significant for two countries, 4 variables are important for only one country, and 4 variables are significant for none of the three countries. The comparison of independent variables according to significance order is given in Table 2. The variables were ranked according to their standardized regression coefficient values. The insignificant variables were not included in ranking. Besides, Table 2 includes pairwise comparisons of countries in terms of standardized regression coefficients for each of independent variables.

In Table 2, it can be seen that 'Index of economic, social and cultural status', 'Meta-cognition: assess credibility', and 'Meta-cognition: summarizing' are the most significant factors affecting students' reading literacy in all three countries. In addition, irrespective of significance order, 'Teacher-directed instruction', 'Disciplinary climate in test language lessons', 'Self-concept of reading: Perception of difficulty', 'Perceived feedback', 'Meta-cognition: understanding and remembering', 'Teacher's stimulation of reading engagement perceived by student', and 'Joy/Like reading' are significant predictors of reading literacy of students from all three countries. 'Highest education of parents' variable is significant for only Turkish students; 'Learning time (minutes per week) - in total' variable is significant for only Chinese students; and 'Self-concept of reading: Perception of competence' and 'Teacher support in test language lessons' are significant variables for only Mexican students. 'Parents' emotional support perceived by student' and 'Joy/Like reading' are significant variables for both Turkish and Chinese (B-S-J-Z) students. 'Gender' is a significant variable for both Chinese (B-S-J-Z) and Mexican students. 'Index highest parental occupational status', 'Duration in early childhood education and care', 'Attitude towards school: learning activities', and

**Table 2**

Comparison of Variables with Respect to Significance Order Across Countries

Independent Variables	Rankings			Pairwise Comparisons (z values)		
	Turkey	China (B-S-J-Z)	Mexico	China (B-S-J-Z)-Turkey	Mexico-Turkey	China (B-S-J-Z)-Mexico
1. ESCS	1	2	1	-2.81*	-1.79	-0.55
2. METASPAM	2	1	2	0.45	-2.83*	4.02*
3. METASUM	3	3	3	-0.89	0.00	-0.89
4. DIRINS	4	6	6	1.06	0.28	0.55
5. DISCLIMA	5	8	7	-1.41	-0.35	-1.06
6. SCREADDIFF	6	7	10	0.89	1.06	-0.45
7. HISCED	6			2.80*	0.88	1.80
8. PERFEED	7	10	5	0.71	-1.77	2.47*
9. UNDREM	7	5	5	1.34	1.77	-0.89
10. STIMREAD	7	5	11	1.06	-0.71	1.77
11. EMOSUPS	8	10		-0.45	-2.12*	2.24*
12. JOYREAD	8	4	8	2.83*	1.06	1.77
13. GFOFAIL	9	9		1.34	-0.35	1.79
14. HISEI				0.00	0.40	-0.45
15. DURECEC				0.45	0.71	-0.45
16. SCREADCOMP			4	-1.06	3.61*	-4.44*
17. GENDER_D2M		10	11	1.79	1.41	0.00
18. ATTLNACT				1.34	1.41	-0.45
19. BELONG				0.00	0.71	-0.89
20. TEACHSUP			9	0.35	2.22*	-1.94
21. TMINIS		6		3.18*	1.06	2.12*
$R^2$				0.00	1.97*	2.24*

Note. \*Independent variables are ordered based on standardized regression coefficients. \*Values are significant at 0.05 level (two-tailed).

'Subjective well-being: Sense of belonging to school' are not significant predictors for reading literacy of students from all three countries.

According to Table 2, while 'Index of economic, social and cultural status' and 'Highest education of parents' of Turkish students were more significant predictive variables than those of Chinese (B-S-J-Z) students, the opposite is true for the 'Joy/Like reading' variable. Similarly, 'Meta-cognition: assess credibility' and 'Parents' emotional support perceived by student' of Turkish students was a more significant predictive variable than those of Mexican students. While 'Meta-cognition: assess credibility' of Chinese (B-S-J-Z) students was a more significant predictive variable than those of Mexican students, the opposite is true for the 'Perceived feedback' variable. For the other variables, there were not statistically significant differences between any of two countries in predicting reading literacy. In addition, while total explained variance ratios ( $R^2$ ) of the models were the same for China (B-S-J-Z) and Turkey, these two countries have significantly higher values than Mexico.

### Prediction of Mathematics and Science Performance from Reading Literacy

In order to examine how reading literacy predicts mathematics and science performance, simple linear regressions were executed for data obtained from each country. Regression coefficients ( $B$ ), standard errors of regression coefficients [ $B$  (s.e.)], standardized regression coefficients ( $\beta$ ) and  $t$  values for each variable and country are given in Table 3.

The results in Table 3 indicate that reading literacy is a significant predictor of mathematics performance of Turkish, Chinese (B-S-J-Z) and Mexican students. Total variance explained is 65% for all three countries, which means that students' mathematics performance is highly affected by their reading literacy. Similar to mathematics performance, reading literacy also significantly predicts students' science performance for all three countries. Approximately 77% of the total variation in science performance is explained by reading performance for all three countries, which means that students' science performance is highly

**Table 3**  
Simple Linear Regression Results for Mathematics and Science Performance

Dependent Variable: 1st to 10th Plausible Values in Mathematics						
	Independent Variables	R <sup>2</sup>	B	B (s. e.)	$\beta$	t
China (B-S-J-Z)	Constant	.65	178.18	8.58	.81	20.78*
	1st to 10 <sup>th</sup> Plausible Values in Reading		.74	.02		48.73*
Mexico	Constant	.65	92.97	7.15	.81	13.01*
	1st to 10 <sup>th</sup> Plausible Values in Reading		.75	.02		46.93*
Turkey	Constant	.65	75.11	7.79	.81	9.64*
	1st to 10 <sup>th</sup> Plausible Values in Reading		.81	.02		50.47*
Dependent Variable: 1st to 10th Plausible Values in Science						
	Independent Variables	R <sup>2</sup>	B	B (s. e.)	$\beta$	t
China	Constant	.77	127.09	5.36	.88	23.73*
	1st to 10 <sup>th</sup> Plausible Values in Reading		.83	.01		92.47*
Mexico	Constant	.77	90.95	6.13	.88	14.85*
	1st to 10 <sup>th</sup> Plausible Values in Reading		.78	.01		57.00*
Turkey	Constant	.76	81.64	5.94	.87	13.74*
	1st to 10 <sup>th</sup> Plausible Values in Reading		.83	.01		66.80*

Note. \*  $p < .05$  (Two tailed)

affected by their reading literacy. The total variance explained for science performance is higher than mathematics performance. In other words, the effect of reading literacy on science performance is higher than that of reading literacy on mathematics performance.

When standardized regression coefficients and total explained variance rates of regression models were statistically pairwise compared across countries, there were not any statistically significant differences between countries in predictivity of reading performance for both mathematics and science performances ( $p > .05$ )

## Discussion

This research was carried out to reveal what the predictors of reading performance are according to PISA 2018 and to what extent reading performance is effective on mathematics and science performance of Chinese (B-S-J-Z), Turkish and Mexican students. First of all, it was found that the most important factors of reading literacy in all three countries are the 'index of economic, social and cultural status', 'meta-cognition: assess credibility', and 'meta-cognition: summarizing'. The index of economic, social and cultural status handles student-level variables (e.g., education levels of the student's parents, home conditions, reading skills) and school-level variables (e.g., the lack of qualified teachers, place of settlement, school type). Economic, social and cultural status is a highly important factor for good education, albeit being not always a valid measure of achievement. Other studies using PISA data (Erdoğan & Güvendir, 2019; Rajchert et al., 2014; Shala & Grajcevcic, 2018) found that economic,

social and cultural status had an impact on reading achievement. Regarding the child-level reasons for this impact, it is possible to say that the environment in which the child lives, the environment to which the child is exposed and the family support the child receives have an effect on reading achievement during the school period. Geske and Ozola (2008) found that the socioeconomic status of family had a significant impact on the educational status of the parents and the reading support they offered to the child in the preschool period. Moreover, it was stated that students with high literacy score come from families who spent more time for reading.

Several previous studies found that children from families with lower socioeconomic status start school at a disadvantage (Aikens & Barbarin, 2008; Hindman, Skibbe, Miller, & Zimmerman, 2010; Sirin, 2005). Students who start school in an unprepared and unsuccessful position and are not supported by their parents in this process are likely to face increasing problems in their school life (see Ferrer et al., 2015). Stanovich (1986) defines this situation as "Matthew effect" (rich-get-richer and poor-get-poorer patterns of reading achievement). To put it in another way, if students who start reading unsuccessfully and are not supported afterwards, there will be an ever-widening gap between those students and the successful ones in terms of reading achievement. Vice versa, it was found that children supported by their families in early literacy skills in the pre-school period start school in a more prepared way, which significantly contributes to their vocabulary and reading achievement in the following years (Manolitsis et al., 2013; Sénéchal, 2006; Sénéchal & LeFevre, 2002). In this context, if it is desired to create a positive change in students' reading skills



in the light of PISA data, this change needs to be addressed starting from the pre-school period.

At the school level, it is observed that such factors as the lack of qualified teachers, school type and the region where the schools are located have an effect on reading achievement. The results of other studies also support the findings of the present research (Kir, 2016; Perry & McConney, 2010). This result raises questions over the "equality of opportunity" in education. The first reason for this result may be the fact that most of the countries conduct placements using central exams and grade point averages in transition from secondary to high school. This is the case for the countries included in the present research. Students with higher scores or grade point averages are enrolled in better high schools, while those with lower scores go to less successful high schools. Considering the PISA data from this point of view, it can be said that students who are good at reading receive education in more successful high schools, while those who are not good at reading receive education in less successful high schools. The second reason is that the level of economic development may differ among regions within countries. The eastern regions of Turkey are a bit less developed than the other regions of the country, for instance. Teachers appointed to work in these regions do not work there for a long time and want to be reappointed to other regions as soon as possible. As a consequence, students in these regions are deprived of more experienced and qualified teachers. It is not easy to eliminate this sort of negativities. Currently teachers in Turkey are obliged to work for four years at schools they are appointed to work. In addition, efforts are made to give incentives and to ensure that these regions are attractive for teachers who will work in there.

Secondly, other important factors affecting reading achievement were identified as 'Meta-cognition: assess credibility' and 'Meta-cognition: summarizing'. In a study using the PISA data, Artelt et al. (2001) found that metacognitive knowledge, decoding speed, and the number of books at home (as an indicator for family background) have considerable effects on reading comprehension, with the highest effects for metacognition. Several other studies also found that there is a close relationship between metacognition and reading achievement (Mikk, 2015; Miyamoto et al., 2019; Soodla et al., 2017). Students with metacognitive awareness know what strategies to use and when and where to use those strategies in the reading process (before, during and after) to better comprehend the text. This also requires students to make a plan to achieve the intended goal through selected strategies, to evaluate the progress accurately, to be monitored to make changes based on these evaluations, as well as to learn and evaluate these processes (Jacobs &

Paris, 1987). When the literature is reviewed, it is stated that students with metacognitive skills are actively involved in the reading process, can make a guess before reading, use reading strategies, track their understanding, arrange the previous information in line with the new information and control what they learn (Pressley & Gaskins, 2006; Roberts, Torgesen, Boartmen, & Scammacca, 2008; Swanson, 1999). From this point of view, it is possible to say that metacognition is a prerequisite for reflective and strategic learning. Students' achievement in reading literacy in the PISA test can therefore be explained by metacognitive skills that ensure active participation in the reading process and require the use of high-level comprehension strategies.

Thirdly, it is a result of the present research that students' reading achievement significantly predict their science (77%) and mathematics (65%) achievement. This result supports the results of the studies revealing the relationship between reading and mathematics achievement (Erdem, 2016; Grimm 2008), as well as between reading and science achievement (Cromley, 2009; O'Reilly & McNamara, 2007). Reading skill can be considered as an effective tool for acquiring, organizing, and applying knowledge in different fields. Therefore, the ability to read and understand written materials is a "cross-curricular" competence and an important precondition for success in school (Artelt et al., 2001). Reed, Petscher and Truckenmiller (2017) found that the factor of reading ability (discourse comprehension and word comprehension) accounted for 70% of the variance in grades 5 and 8 science performance and 64% of the variance in grade 9 science performance. They also emphasized the importance of vocabulary in science achievement. In this context, it is necessary to emphasize the importance of vocabulary in comprehending such texts. Considering the reasons for this result in the present research, it is necessary to carry out a number of reading tasks from basic to complex levels in order for students to be successful in both mathematics and science. First of all, students are expected to comprehend the definitions or the problem in the text while reading about science and mathematics. They are sometimes expected to conceptualize, ratiocinate and apply the information they read. Through a successful reading, they can match, interpret and ably use the information in science and mathematics texts with the information presented in tables, diagrams or various figures. In addition, considering that successful readers have metacognitive skills and enjoy reading, it may be possible that students use these skills in other academic fields other than reading, such as science and mathematics. In other words, it can be thought that these skills of successful readers may have direct or indirect effects on science and mathematics achievement. Indeed, Ding and

Homer (2020) showed that there is a significant relationship between the sub-dimensions of reading and mathematics achievement. It is possible to say that reading, mathematics, and science literacy skills are closely related in that regard, and it is not likely to develop a skill independently from another at an expected level. It is important therefore to develop reading, science, and mathematics skills together.

Finally, it was determined that the first three variables that predict the reading performance of Turkish, Chinese (B-S-J-Z), and Mexican students were the same. This result indicates that although the performance rankings of these countries are different, the factors affecting reading performance are similar. Therefore, countries that improve these three factors at the best level can be expected to be more successful in reading. Especially, it can be said that the education reforms made in recent years have an important effect on China's being the most successful country in the PISA study. Over the past fifteen years, China has been striving to transform their education from an exam-oriented system to one that values holistic and creative approaches to education and learning (Schulte, 2019). Therefore, it can be useful for other countries such as Turkey and Mexico which are aiming to be successful in PISA studies to examine the Chinese education system. On the other hand, it is a matter of criticism that China applies PISA only in a few developed provinces (Candido, Granskog, & Tung, 2020). In addition, other problems in the Chinese education system such as the course overload of students at schools, the emphasis on knowledge acquisition during the teaching process, and the prevalence of extracurricular education continue to be discussed (Yang & Fan, 2019).

## Conclusions

The results obtained from PISA data indicate that the reading achievement of countries with high (China) and low (Turkey and Mexico) performance is affected by the same factors, which provides important clues about the variables that should be supported and/or changed to improve reading skills. So, what will be effective in improving reading skills at child- and school-level? It has been concluded that the socioeconomic status of family had a significant influence on the educational status of the students. Besides, family support received by the students significantly contributes to their reading achievement. From a school perspective, quality of schools in terms of opportunities for reading activities, school administration and teacher support, and collaboration with families is an important indicator for high level reading performance. Moreover, it has been observed that students with high metacognitive skills show high success in reading as well. Besides, reading related variables such as enjoying reading, teacher's

stimulation of reading engagement, perception of difficulty, etc. were more effective in improving their reading performance. More importantly, supporting students' reading skills will contribute significantly to their development in other academic skills such as the ones in mathematics and science. The fact that these results obtained from three countries with different performance levels and characteristics have significant similarities indicates that they are generalizable.

## Limitations and Implications

The results of this study are limited to the Chinese (B-S-J-Z), Turkish and Mexican students participating the PISA study (students aged 15 years). In future studies, the results obtained from the local exams of the countries can be compared with the PISA results. Supporting the findings obtained through interview, observation and experimental applications will contribute to a more concrete analysis of reading comprehension. The fact that science and mathematics performance is closely related to reading comprehension is an important issue that should be emphasized in the studies to be conducted in these areas.

In this study, we aimed to focus on reading from its predictors and its predictivity perspectives. Even if it seems those are two separate subjects, the common aspect of them were reading comprehension. Besides, it is possible to examine them separately or combine them in a more advanced structural model. Therefore, this situation was also a limitation of our study. In future studies, the relationship between predictors of reading literacy, reading literacy itself, mathematics and science performance can be examined by more complex structural models.

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