Investigation of Variables Affecting Reading and Mathematics Achievement with Latent Regression Rasch Model

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Abstract

Purpose: Achievement in mathematics and reading is a function of many interrelated variables. Therefore, it is important to identify and compare the variables that affect success in these areas. The aim of this study is to examine the characteristics that are thought to be effective on achievement scores in reading and mathematics.

Method: The data of this study, which is a correlational study, were obtained from the PISA 2015 Turkey sample. The analysis of the research was carried out with The Latent Regression Rasch Model, which is one of the multilevel analysis methods.

Results: According to the results, female students were more successful than male students in reading and math. The student's SES and anxiety level were associated with success in both areas, and this relationship was more in mathematics than in reading. In addition, while there was no significant relationship between motivation and reading success, this relationship significantly increased mathematics achievement.

Recommendations: It is recommended to carry out the necessary studies in order to reduce the exam anxiety levels of the students, and to increase the motivation of success by giving importance to the cooperation of students, parents and schools. In addition, future studies can examine the relationships between different fields (such as science, foreign language) and different variables.

Keywords: PISA 2015, SES, Anxiety, Motivation

Turkish Abstract: Okuma ve Matematik Başarısını Etkileyen Değişkenlerin Örtük Regresyon Rasch

Modeli ile İncelenmesi

Özet

Çalışmanın amacı: Matematik ve okuma alanlarında elde edilen başarı, birbiriyle ilişkili birçok değişkenin bir fonksiyonudur. Dolayısıyla bu alanlarda başarıyı etkileyen değişkenlerin belirlenmesi ve karşılaştırılması önemlidir. Bu çalışmanın amacı, okuma ve matematik alanında elde edilen başarı puanları üzerinde etkili olabileceği düşünülen özelliklerin incelenmesidir.

Yöntem: İlişkisel tarama deseninde olan bu çalışmanın verileri PISA 2015 türkiye uygulamasından elde edilmiştir. Araştırmanın analizleri çok seviyeli analiz yöntemlerinden biri olan Örtük Regresyon Rasch modeli ile yürütülmüştür.

Bulgular: Elde edilen bulgulara göre okuma ve matematik alanında kız öğrencilerin erkek öğrencilere göre daha başarılı olduğu saptanmıştır. SED ve kaygı düzeyinin her iki alanda da başarıyla ilişkili olduğu, bu ilişkinin okuma alanına göre matematikte daha fazla olduğu görülmüştür. Ayrıca motivasyon ile okuma alanında anlamlı bir ilişkinin olmadığı fakat bu ilişkinin matematik başarısını anlamlı düzeyde arttırdığı belirlenmiştir.

Öneriler: Öğrencilerin sınav kaygı düzeylerinin düşürülmesi için gerekli rehberlik çalışmaları yürütülmesi, öğrenci, veli, okul işbirliğine önem verilerek öğrencilerin başarı motivasyonlarının arttırılması önerilmektedir. Ayrıca bundan sonra yapılacak olan çalışmalarda da farklı alanlar (fen, yabancı dil gibi) ve farklı değişkenler arasındaki ilişkiler incelenebilir.

Anahtar Kelimeler: PISA 2015, SED, Kaygı, Motivasyon

Introduction

Education is a complex process consisting of many components. It is very important for educators to examine the interactions between the components in order to better understand and manage this process. Especially in the field of education, success is measured by the scores students get from the exam. Variables related to success may be related to individual characteristics such as students' abilities, attitudes, perceptions, anxiety levels, socio-economic levels, motivations, as well as family, teacher and school characteristics.

Success is not only related to the intellectual and affective abilities of the person, but also related to the appropriate environment and conditions for the development and processing of these abilities. Therefore, one of the most important variables affecting success is the socio-economic status (SES) of the student (White, 1982). Although there are many different definitions of SES, DEEWR (2009) defined SES as individuals' and groups' access to social, cultural and economic resources and the relative value given to these resources by different individuals and groups.

When the studies in the field of reading were examined, it was seen that the SES variable had a positive effect on reading success, and that students with higher SES levels had higher reading achievements. Bradshaw, Ager, Burge, and Wheater (2010), in their study using the PISA 2009 UK sample, stated that students with high SES also have a high success in reading comprehension. Kotte, Liez, and Lopez (2005) investigated the variables that increase or decrease students' reading comprehension success by using PISA 2000 Germany and Spain data, and stated that students with higher SES have higher reading success. Similar results were observed when the studies in the field of mathematics were examined (Caldas & Bankston, 1997, 1999; Hanushek, 1997).

Gender is another variable that affects students' success. Garai and Scheinfeld (1968) analyzed the studies published before 1960 and concluded that the gender variable was unimportant in homework studies and that male students were better in areas that required arithmetic reasoning and mathematical ability. Fenemma (1974), in her study of 36 studies examining the relationship between gender and mathematics achievement, concluded that there was no significant difference between female and male students at primary education level, but that male students at higher education levels were better than female students in subjects that required advanced thinking skills. In some studies, it has been determined that there is no

significant relationship between gender and achievement (Gainer, 1962; Petty, Wang & Harbaurg, 2013).

Academic success of students can be affected by the characteristics of the student such as gender and SES, as well as by their affective characteristics. One of these factors is the academic anxiety level of the student. Anxiety is defined as a feeling of discomfort or physical symptoms of tension that people feel about future negativities (Endler & Kocovski, 2001). Exam anxiety, which is considered as a situation-specific type of anxiety, is defined as an individual's tendency to react in the form of excessive physiological arousal, anxiety, fear of failure, and tension in the face of a formal assessment situation (Speilberger & Vagg, 1995). In general, these symptoms, which occur intensely before and during the exam, may continue after the exam. While a moderate level of anxiety reflects positively on the performance of the students, the intense anxiety of the students about the exam affects their mental performance and causes a decrease in their success (Casbarro, 2005). When the literature is examined, it has been determined that there is a negative relationship between anxiety and academic achievement, and that the academic achievement of students with high anxiety levels is lower (Hembree, 1988; Rana & Mahmood, 2010; Ma and Xu, 2004).

The significant contribution of conceptually different motivational processes to success reveals that motivation is an important variable in terms of academic success (Steinmayr & Spinath, 2009). According to Pintrich and Schunk (2002), motivation refers to a process that regulates an individual's goal-directed behavior. Academic motivation is internal processes that encourage and direct behaviors aimed at achieving certain academic goals (Pintrich & Zusho, 2002). When the relationship between achievement and motivation is examined separately, Taboada, Tonks, Wigfield, and Guthrie (2009), Stutz, Schaffner, and Schiefele (2016), Türkben (2020) revealed that there is a positive relationship between intrinsic motivation and reading comprehension. Shores and Shannon (2007), on the other hand, found a positive relationship between motivation and mathematics achievement.

Achievement in mathematics and reading is a function of many interrelated variables (Singh, 2002). Therefore, it is important to identify and compare the variables that affect success in these areas. The aim of this study is to examine the characteristics that are thought to be effective on reading and mathematics achievement through the models of Explanatory Item Response Theory, which is a multi-level analysis technique. For this purpose, an answer

was sought for the problem of "how is the relationship between success in mathematics and reading and the student's gender, socio-economic level, motivation and anxiety level".

Method

Research Design

The aim of the study is to examine student characteristics related to reading and mathematics achievement. Therefore, this study is a correlational study. In correlational studies, it is determined whether there is a relationship between two or more variables, and if there is, the direction and size of this relationship (Karasar, 2006).

Research Sample

The study group of the research consists of 2373 (50.6% female, 49.4% male) students who responded to the items in the field of mathematics and 2418 (50.5% female, 49.5% male) students who responded to the items in the reading field in the PISA 2015 Turkey sample.

Research Instrument and Procedure

In the study, it was aimed to determine the variables that affect success in mathematics and reading. The data set of the research consists of the reading and mathematics subtests of the PISA 2015 Turkey sample. The dataset was downloaded from https://www.oecd.org/pisa/data/. The variables used in the research are gender (reference group girls), socioeconomic status (SES), test anxiety and achievement motivation.

PISA 2015 Turkey application was computer-based and a total of 66 main test forms were used. All booklets containing the items in the field of reading and mathematics were included in the study. There are 88 items in the reading area and 69 items in the math area. Among these items, 7 items in the field of reading and 5 items in the field of mathematics were scored in partial credit. Since the analysis method used in the research was suitable for dichotomous scoring, partial credit scoring items were deleted, and analyzes were carried out with 81 items in the reading area and 64 items in the mathematics area. In order to ensure consistency with the studies in the literature and PISA scoring procedures, in this study, missing items were considered as incorrect, inaccessible or invalid data for other reasons as missing.

Data Analysis

Since the aim of this study is to investigate individual characteristics related to reading and mathematics achievement, the analyzes of the research were carried out with the Latent Regression Rasch Model. The Latent Regression Rasch Model is one of the models of the

explanatory item response theory, in which individual characteristics are added as explanatory variables in order to examine the differences between individuals' ability levels, but no explanatory variable at the item level (De Boeck & Wilson, 2004; Zwinderman, 1991). Since this model only includes explanatory variables at the individual level, it is also known as "individual explanatory models". The Latent Regression Rasch Model, θ_p is considered as the dependent variable and a regression equation is established to explain this variable.

Before starting the analyses, unidimensionality and local independence, which are the basic assumptions of IRT, were checked, and it was seen that the mathematics and reading subtest met these assumptions. The analyzes of the study were carried out in the R program, within the framework of GDKMs, with the lme4 (Bates, Maechler, Bokler, & Walker, 2014) package suitable for the analysis of Latent Regression Rasch Models. The Maximum Likelihood (Laplace Approximation) method was used in the estimations of the models.

Results

Analyzes were started with the multilevel Rasch model (M0). With the Rasch model, which didn't include any explanatory variable at the individual and item level, the ability levels of the individuals and the difficulties of the items were estimated. When the results obtained were examined, it was seen that the variance of the individuals' ability level estimation was 1.018 logit in the mathematics field and 0.890 logit in the reading field. Then, The Latent Regression Rasch Model was established by including individual characteristics that are thought to be related to mathematics and reading success at the individual level. Table 1 shows the results.

Table 1

Fixed and Random Effects of Variables Related to Reading and Mathematics Achievement

	Reading		Mathematics	
	Estimate	SE	Estimate	SE
Fixed Effects				
Gender	-0.107***	0.021	-0.295***	0.018
SES	0.058***	0.008	0.259***	0.014
Motivation	0.003	0.011	0.094***	0.017
Anxiety	-0.028*	0.011	-0.111***	0.017
Random Effects				
σ_θ^2	0.495		0.502	

* p < .05; ** p < .01; *** p < .001

When Table 1 is examined, since female students are taken as the reference group, it is seen that female students are more successful than male students by 0.107 logit in the field of reading and 0.295 logit in the field of mathematics. These effects are statistically significant. The effect of the gender variable is higher in mathematics than in the field of reading.

Among the two students with a standard deviation difference between their SED levels, it was observed that the student with a higher SED level was 0.058 logit higher in reading and 0.259 logit higher in mathematics. Although this effect in the fields of reading and mathematics was statistically significant in both fields, the effect of SES on mathematics achievement was found to be considerably higher than in the field of reading.

When the relationship between the motivation levels of the students and their success is examined, Among the two students with a standard deviation difference between their motivation levels, it was observed that the student with a higher motivation level was 0.003 logit higher in reading and 0.094 logit higher in mathematics achievement. Although this effect in the field of reading is not statistically significant, it is significant in the field of mathematics. However, this effect, which also appeared in the field of mathematics, was found to be lower compared to other variables.

When the relationship between the students' anxiety levels and their achievements was examined, it was seen that among the two students with a standard deviation difference between their anxiety levels, the lower anxiety level was 0.028 logit higher in the reading field and 0.111 logit higher in the mathematics field. Although this effect in the fields of reading and mathematics is statistically significant in both fields, the effect of anxiety level on mathematics achievement is greater than in the field of reading.

Discussion, Conclusion and Recommendations

According to the results of the study, it was seen that female students were more successful than male students in both fields, and the gender effect was higher in mathematics than in reading. When the studies carried out in the field of reading are examined, Maslowski, Scheerens, and Luyten (2007) found that female students are more successful than male students in the field of reading in their studies using data from OECD countries participating in PISA 2000. Azina and Halimah (2012) found that female students were more successful in mathematics than male students in the studies they conducted, while Karabay (2015) found that males were more successful in mathematics.

According to the results of the study, it was seen that SES was significantly associated with success in both areas, and students with higher SES were more successful. Again, it was seen that mathematics achievement was more affected by SES than reading. Marks (1999) stated that there is a relationship between socio-economic background and achievement, and students who belong to a family or group with a good socio-economic status perform better than others. This result is similar to the findings of other studies in the literature (Kotte, Liez & Lopez, 2005; Hanushek, 1986).

According to the results obtained, while there was no significant effect of motivation in the field of reading, it was seen that it had a significant effect in the field of mathematics, and students with high motivation were more successful in the mathematics course. Although there are deep views on the theoretical explanation of motivation in the literature, it has been found that there are significant relationships between the two variables in studies examining the relationship between motivation and students' achievement (Fortier, Vallerand, & Guay, 1995; Turner, Chandler and Heffer, 2009).

According to the results, it was determined that reading and mathematics achievement were negatively affected by anxiety and this effect was more in the field of mathematics. According to the World Health Organization (WHO), normal anxiety is expressed as a positive emotion as it enables the person to protect himself/herself and fight against negativities. However, if these feelings start to become dominant and permanent, they start to affect the person negatively and become a disease (Spielberger and Reheiser, 2009). Some studies in the literature support this finding (Vitasari et al., 2010; Dordinejad et al., 2011; Steinmayr et al., 2016; Wine, 1971).

According to the results obtained from the study, it is recommended to carry out the necessary studies to reduce the exam anxiety levels of the students, and to increase the success motivation of the students by giving importance to the student, parent, school cooperation. In addition, it is recommended that students with low SES levels be supported as much as possible and their access to educational resources should be facilitated. In the study, individual characteristics related to reading and mathematics achievement were examined. In future studies, the relationships between different fields (such as science, foreign language) and different variables can be examined.

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