

Identifying the Relationships Between Perseverance, Openness to Problem Solving, and Academic Success in PISA 2012 Turkey

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ABSTRACT

In this study, the predictive roles of perseverance and openness to problem solving on success in the lower and upper quartiles of score distribution are analyzed in scientific, mathematical, and reading domains of PISA 2012 Turkey sample. Since their index values can't be calculated due to missing values, some students are excluded from the sample. The study sample is comprised of 3,190 students. Regression models in which perseverance and openness to problem solving are predictive variables and success is response variable are formed for the lower and upper quartiles of score distribution of each domain. Models are analyzed by quantile regression analysis. It is found that there is a positive, medium level, significant relationship between perseverance and openness to problem solving. The results of quantile regression analysis show that perseverance predicts success better in the lower quartile of score distribution while openness to problem solving predicts success better in the upper quartile of score distribution in all domains. Based on these results, suggestions regarding classroom activities, assessment processes and feedback given to students are discussed respectively.

Key Words: Students achievement, Perseverance, Openness to problem solving, PISA, Quantile regression analysis

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INTRODUCTION

Various variables are known to be effective on student achievement and effects of those variables become more complex at the higher levels of education (Eski, 1985 Cited in: Karakaya, & Kutlu, 2002). Even though, the focus is generally on cognitive factors in educational researches, there have been some studies conducted lately suggesting that social and affective skills should have a connection with student achievement. Motivation is one of the psychological traits which functions as an explanatory factor on student achievement. Schunk, Pintrich, and Meece (2002) state that motivation is a process consisting of initiating and proceeding goal-oriented activities. Perseverance and openness to problem solving on which cognitive motivation theories focus are closely tied to motivation.

Perseverance was defined by Peterson and Seligman (2004) as willingly pursuing a goal-oriented behavior despite obstacles, difficulties and disappointments. Perseverance requires one to work hard even in the existence of difficulties and show efforts to reach a goal despite all the failures one faces. Dweck and Leggett (1988), who ran projects regarding perseverance, observed that some children with similar cognitive levels show perseverance to deal with difficult tasks while others avoid the tasks. Furthermore, Dweck (1975) noted that some students feel desperate and prefer to give up in the face of failure.

Perseverance is a psychological construct that has been studied more frequently lately thanks to coming into prominence of the cognitive theories of learning. However, in early research studies like the one conducted by Cox (1926 Cited in: Duckworth, Peterson, Matthews, & Kelly, 2007), it was determined that when intelligence is fixed, showing efforts decisively affects the achievement positively. Today, there have been studies focusing on skills with affective dimensions such as perseverance and openness to problem solving. Yet, there are limited studies investigating the relationship between perseverance and academic achievement. These studies reveal that perseverance is a variable that enhances achievement (Boyce, 2011; McCutcheon, 2014; Strayhorn, 2014).

Motivation theories also focus on openness to problem solving which is related to students' approaches towards problematic situations. Dweck (1986 Cited in: Dweck, 1999; Tollefson, 2000) describes two different goal orientations as task-oriented and result-oriented. Dweck (1999, 2006) supports the idea that result-oriented students see failure as an indicator of their skills. Those students believe that the obstacles they experience cannot be overcome because of inadequate cognitive skills. Task-oriented students, on the other hand, consider failure as an indicator of insufficient effort rather than cognitive skills. Those students believe that the skills necessary to accomplish a task can be improved through increased effort.

Two different approaches to the problem situations also affect the tasks that students prefer (Nicholls, 1983). Result-oriented students tend to avoid problems that may reveal their skill inadequacies. They care a great deal about the comments other people make regarding their skills and learning capacity. Task-oriented students, however, try to enhance their skills rather than to prove themselves to others. For this reason, they are more open to problems which may force them into acquiring new skills while enhancing their existing skills (Schunk et al., 2002; Stipek, 1988). Therefore, the goal orientations of students determine whether or not they are open to

problems or avoid problems. Accordingly, openness to problem solving is a variable which is thought to relate to students' beliefs in their own skills, their approaches to problem situations (goal orientations), and their will to participate in higher-order thinking processes (Scherer, & Gustafsson, 2015).

Openness to problem solving is identified as dealing simultaneously with more than one piece of information, quick understanding of situations, combining and linking information quickly, and the liking of complex problem situations. Openness to problem solving is also defined as an individuals' will to be a part of the problem-solving process based on their self-beliefs and interests (OECD, 2013). Openness to problem solving is considered important in academia due to its relation with student achievement. There are studies showing that openness to problem solving and student achievement are positively related. In a report by the OECD (2014), it states that students who are open to problem solving are more successful in mathematics. Another research study revealed that openness to problem solving is fourth among other variables in terms of the significance in explaining mathematic achievement in New Zealand (Ministry of Education, 2015). Besides, openness to problem solving shows positive correlations with creativity, divergent thinking, intelligence, and performance (Beaty, Nusbaum, & Silvia, 2014; Lin, Chen, Hsu, & Wang, 2012).

Positive relationships between perseverance, openness to problem solving and achievement do not imply that all successful students are persevering and open to problem solving. Showing less or no perseverance and not being open to problem solving are motivation problems that are not solely observed in students from the lower achievement group. Stipek (1988) states that awareness of schools is higher towards the motivation problems of students from the lower achievement group. However, motivation problems of students who have high success level; yet, fail to realize their own capacity, are often ignored or go unnoticed. This situation occurs because of the assumption that if a student is successful at school, they do not experience problems with motivation. However, the findings of various studies do not support this common assumption. Philips (1984) revealed that 23 out of 117 students expressed lower expectations of themselves than their real performance level in a national achievement test. They identify lower success criteria for themselves and demonstrate less effort. These findings indicate that even successful students may set lower criteria for themselves, avoid challenging problem situations, and fail to use their full capacity by giving up rather than showing perseverance.

It is considered that identifying the relationship between perseverance and openness to problem solving, which are thought to be theoretically connected, and the predictive roles of these variables on student achievement is significant since the primary goal of educational research is explaining students' achievement better. Theoretical foundations and research findings suggest that there are skills to be improved related to perseverance and openness to problem solving for both lower and upper-level success groups. It is also indicated that students from different success groups have different behaviors in terms of perseverance and openness to problem solving. Thus, it is thought that different patterns might be revealed in lower and upper success groups in terms of perseverance and openness to problem solving.

Therefore, this current study aims to investigate the relationship between perseverance and openness to problem solving for lower and upper success groups. These variables are thought

to be a guide regarding the skills necessary for both lower and upper success groups in teaching and assessing phases. In this study, quantile regression analysis, which is new to the educational research field, is conducted in order to reveal the relationship patterns for various success groups (Chen, & Chalhoub-Deville, 2014). When it is thought that the relationship between students' achievement and variables might change for different success levels, this method is considered to be important in educational researches as an alternative to linear regression analysis. The predictive roles of perseverance and openness to problem solving on success in the lower and upper quartiles of score distribution is investigated in scientific, mathematical, and reading domains of PISA 2012 Turkey sample. Within this scope, the research questions to be answered are;

- 1) What is the relationship between perseverance and openness to problem solving in PISA 2012?
- 2) Do perseverance and openness to problem solving predict student achievement for lower and upper quartiles in mathematics, science, and reading domains in PISA 2012?

METHOD

Research Design

In this study, it is aimed to investigate the predictive roles of perseverance and openness to problem solving on success in the lower and upper quartiles of score distribution of PISA 2012 Turkey sample. The research is designed as a relational survey model in order to investigate the relationships between the variables (Büyüköztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2011; Tabachnick, & Fidell, 2007).

Population and Sample

The sample of the study consists of 4,848 students from 170 schools in the PISA 2012 Turkey sample. Some students are excluded since their data includes missing or extreme values. The final study sample is comprised of 3,190 students. 49.4% of the sample are female students and 50.6% are male. 7th grade students make up 0.4% of the sample, with 8th grade students at 2.0%, 9th grade students at 26.7%, 10th grade students at 66.4%, 11th grade students at 4.2%, and 12th grade students making up 0.3% of the sample. The sample distribution according to gender and classroom level is presented in Table 1.

Table 1. *Sample distribution according to gender and classroom level*

Classroom Level	Gender		Total
	Female	Male	
7 th grade	7	5	12
8 th grade	30	34	64
9 th grade	345	506	851
10 th grade	1,111	1,006	2,117
11 th grade	79	56	135
12 th grade	5	6	11
Total	1,577	1,613	3190

Data Collection Tool

Achievement tests applied as 13 different booklets are used to determine students' achievement in mathematics, science, and reading domains in PISA. Five different datasets without missing values were created in PISA 2012 using multiple imputation method with the aim of obtaining sufficient data to provide information regarding the item. An average score showing achievement of the students for each domain was calculated based on these datasets. There are 10 items in PISA 2012 to measure students' perseverance and openness to problem solving. Scores that students obtained on these variables are converted to index values.

Data Analysis

Correlation analysis was conducted using Statistical Package for the Social Sciences (SPSS) program and Pearson correlation coefficient between variables was determined so as to answer the first research question. Quantile regression analysis was used in order to answer the second research question. Quantile regression analysis was developed as an alternative to methods such as least squares methods providing information only about the middle point of the dependent variable distribution. The most important advantage of quantile regression analysis is that the effect of independent variables can be analyzed for every point of the dependent variable distribution (Çelik, & Selim, 2014; Çiftçi, & Kangallı, 2015; Koenker, & Hallock, 2001).

The reason why quantile regression analysis has been preferred for this current study is that the aim is to investigate the predictive roles of perseverance and openness to problem solving on different success levels. If linear regression analysis based on the least square method was used, regression analysis would be required separately for each success group. That means conducting nine separate regression analyses for lower, middle, and upper quartiles of the score distribution on mathematics, science, and reading domains. However, quantile regression analysis provides estimates of three different slope coefficients in the lower, middle, and upper quartiles of score distribution in mathematics, science, and reading domains for the variables of perseverance and openness to problem solving. Thus, unlike linear regression analysis, when quantile regression analysis is employed, only three separate analyses are needed to answer the same research question. Since each analysis includes a specific amount of error, the less analysis that has to be performed, the less errors will be present in the results.

Constant and slope coefficient, which minimize the weighted total of errors' absolute values, are estimated in quantile regression analysis and different algorithms are used to estimate these parameters. Simplex is set as the default algorithm in R program for "quantreg" package. It is not suggested to use this algorithm for a sample of more than 5,000 or for models having in excess of 50 variables (Chen, & Chalhoub-Deville, 2014). In this current study, the predictive roles of perseverance and openness to problem solving on mathematics, science, and reading success in the lower and upper quartiles of score distribution is investigated using R program "quantreg" package simplex algorithm to estimate the parameter since the sample includes less than 5,000 and the model consists of only three variables. Regression models in which perseverance and openness to problem solving are predictive variables and success is a response variable are formed for the lower and upper quartiles of score distribution of each domain.

Data is controlled in terms of the appropriateness for the assumptions of the regression analysis. Scores of scales and achievement test are converted to standard scores in order to analyze the one-way extreme values. Students who exceeds ± 3 standard score are accepted as extreme values and excluded from the sample. In order to detect multiple extreme values, Mahalanobis distances were calculated and the significance of these distances then tested. As a result, 43 students were excluded from the sample. The criteria for multicollinearity of data is variance increase factor (VIF) of less than 10 and tolerance value greater than 0.10. According these criteria, multicollinearity problem was not detected in the data (VIF=1.204; TV=0.83) (Tabachnick, & Fidell, 2007).

FINDINGS

Pearson correlation coefficient between perseverance and openness to problem solving was calculated as it is considered that they are related to each other based on their theoretical backgrounds. The correlation between perseverance and openness to problem solving is medium level, positive, and significant (0.412, $p < 0.01$). This finding is consistent with findings of the research conducted by Akin and Arslan (2014). In their study, it was reported that learning-avoiding orientation has a negative correlation with perseverance, while learning-approach has a positive correlation with perseverance. It was also explored that students' positive approach to problem situations and liking complex problems showed a positive correlation with the effort shown while handling the task. As correlation coefficients express a mutual relationship, the positive relationship between perseverance and openness to problem solving means either students' being more open to problem solving increases the persistent effort or showing persistent effort enables students to be more open to the problems.

In order to answer the second research question, regression models in which perseverance and openness to problem solving are predictive variables and success is response variable were formed for 0.25, 0.50, and 0.75 percentages (lower, middle, and upper quartiles of score distribution) in all domains. Quantile regression analysis results for all percentages and domains are presented in Table 2.

Table 2. *Quantile regression analysis results*

Domain	Percentage (%)	Constant Coefficient	Openness to Problem Solving [Slope (r)]	Perseverance [Slope (r)]
Science	25	407.36	6,296*	7,904*
	50	453.45	12,35*	5,884*
	75	513.37	22,21*	3,517
Reading	25	412.52	6,72*	15,741*
	50	467.72	12,41*	11,322*
	75	526.07	17,66*	9,042*
Mathematics	25	378.74	8,38*	9,909*
	50	432.74	16,01*	6,170*
	75	501.21	26,28*	4,702

* $p < 0.0$

In Table 2, the regression model in which openness to problem solving and perseverance are predictive variables in all domains is statistically significant. Quantile regression analysis results show that perseverance and openness to problem solving have predictive roles in the lower and upper quartile of score distributions for all domains. This predictive role of perseverance is much more effective in the lower quartile of score distribution than the upper quartile, while the predictive role of openness to problem solving is much more effective in the upper quartile of score distribution than for the lower quartile. Figure 1 shows the changes in predictive roles of perseverance and openness to problem solving on lower and upper quartiles of score distributions.

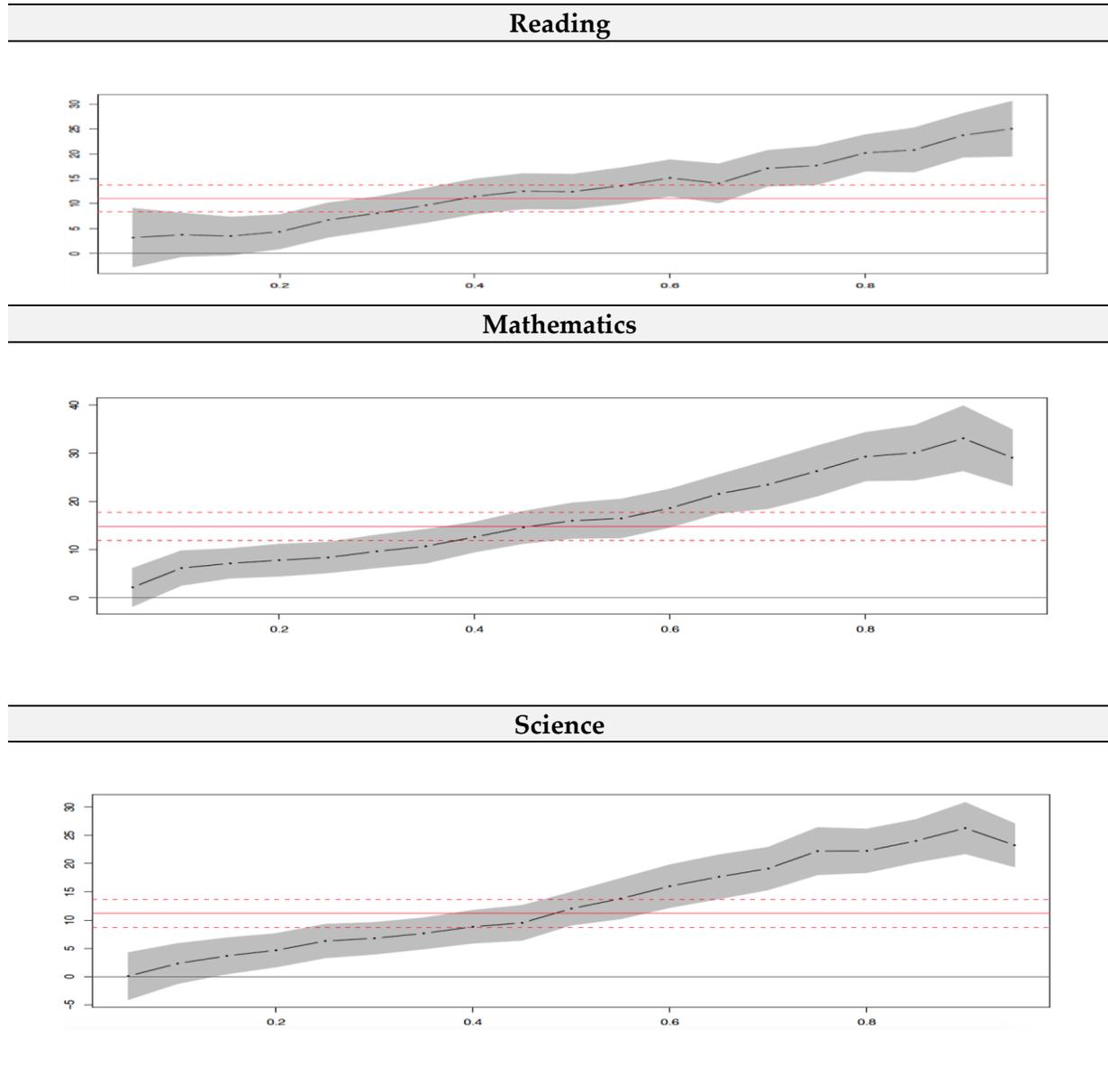


Figure 1. *Graphs of quantile regression analysis for openness to problem solving*

In the graphs of Figure 1, the horizontal axes present the percentages between 0.05 and 0.95 while the vertical axes present slope coefficients estimated for each percentages of openness

to problem solving. As can be seen from the graphs, slope coefficients are estimated at different points over the zero reference line. This means that openness to problem solving has positive correlations with success across all domains. As regression curves do not pass the zero reference line, this correlation between openness to problem solving and success in all domains is statistically significant. Furthermore, the value of slope coefficients estimated for openness to problem solving increases from lower quartiles to upper quartiles of score distributions. This pattern of the changes in the graphs reveals that openness to problem solving predicts success much more in the upper quartile of score distribution for all domains, while less so for the lower quartile of score distribution across all domains. Similarly, Figure 2 shows the changes in predictive roles of perseverance on lower and upper quartiles of score distribution.

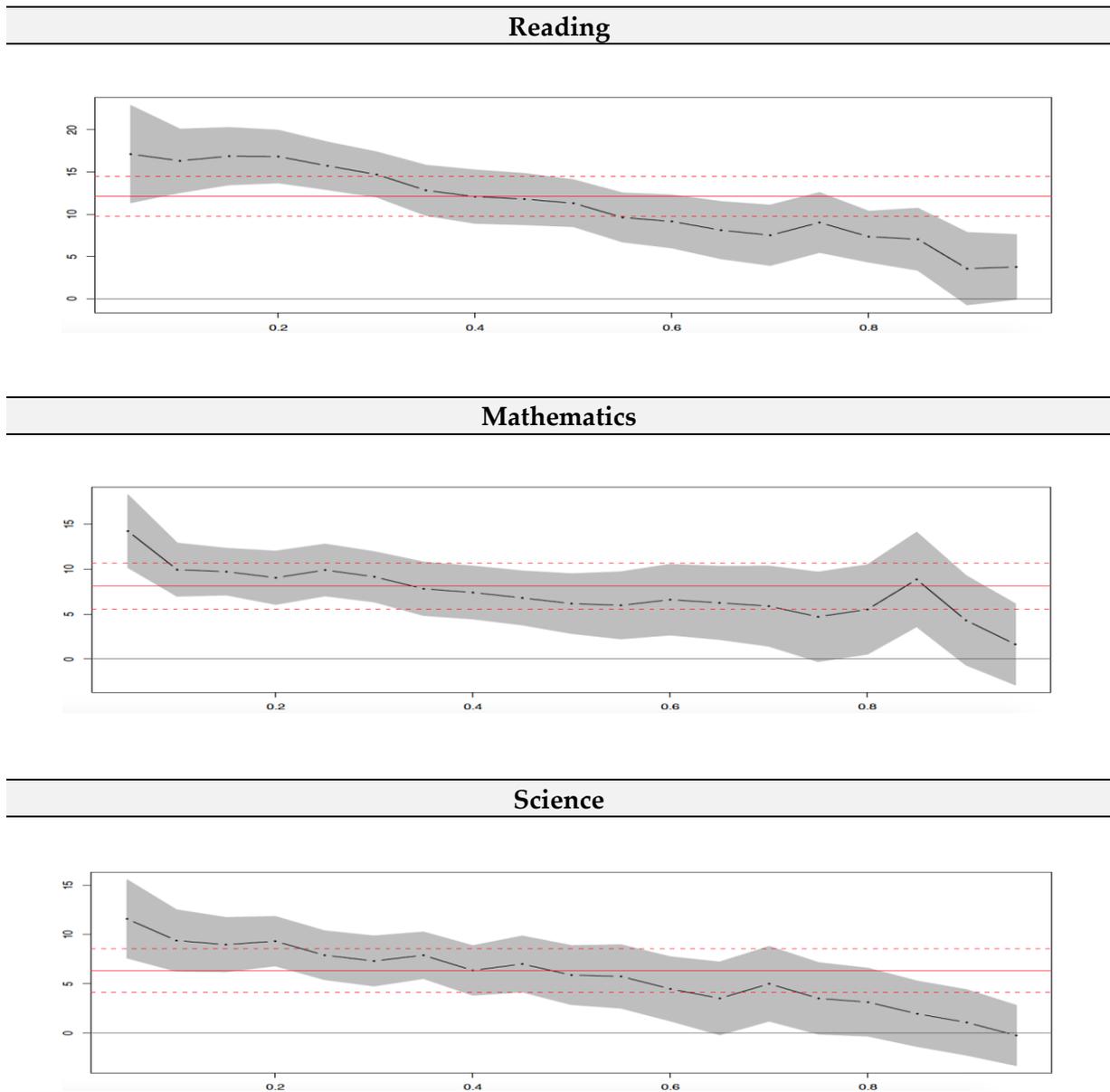


Figure 2. *Graphs of quantile regression analysis for perseverance*

As can be seen from Figure 2, slope coefficients estimated at different points is over the zero reference line. This means that perseverance has positive correlations with success across all domains. Besides, the value of slope coefficients estimated for perseverance decreases from lower quartiles to upper quartiles of score distributions. The pattern of the changes in slope coefficients reveal that perseverance predicts success much more in the lower quartile of score distribution for all domains while less so in the upper quartile of score distribution for all domains. Horizontal dashed lines show the confidence interval of curve estimation made at 0.50 percentages (Chen & Chalhoub-Deville, 2014). When Figure 1 and Figure 2 are analyzed together, it can be seen that the confidence interval on various percentages of perseverance coincides more with the confidence interval of 0.50 percentages, while the confidence interval on various percentages of openness to problem solving coincides less with the confidence interval of 0.50 percentages. This means that the effect of openness to problem solving varies more on different points of score distribution regarding success. Yet, even though it is not as clear as openness to problem solving, the effect of perseverance also varies on different points of score distribution regarding success. Perseverance is a better predictor of success in the lower quartile of score distribution and enhances success across all domains.

DISCUSSION, RESULTS, AND SUGGESTIONS

In this study, the relationship between perseverance and openness to problem solving variables which are thought to explain and increase the students' achievement is investigated. It is found that both perseverance and openness to problem solving are significant predictors of success. This finding of the study is parallel with the findings of the study conducted by Strayhorn (2014). In his study, Strayhorn found that student perseverance explained 26% of the variance of student success. Boyce (2011) observed an increase on 8th grade student success after they received training about perseverance. Similarly, the OECD (2014) mentioned that students who are open to problem solving are more successful in mathematics than those who are not.

Strayhorn (2014) revealed that there is a medium level positive relationship between perseverance and success for students with low-level success. Similar to this finding, this current study found that success of students from the lower quartile and perseverance are positively correlated. As the relation is positive, it indicates that as the perseverance of students from the lower quartile increases, their achievement also increases. In other words, perseverance is a better predictor for success of students from the lower quartile. According to Schunk et al. (2002), the effect of perseverance relates to students' success levels. Perseverance plays a fundamental role when students try to improve a skill or they are faced with obstacles. This finding of the current study is parallel with their ideas. Student success from the lower quartile who have a higher probability of experiencing failure on difficult tasks are predicted better by perseverance than the upper quartile group. Besides, Stipek (1988) advocates that students from the upper quartile are less likely to encounter failure in their education, and that's why they usually do not need to perform with perseverance in order to be successful. Most of the time, they might be successful even if their learning does not reach to the target level. Parallel to this finding, this current study observed that perseverance improves achievement in the upper quartile of score distribution; but, this increase was much lower than it for the lower quartile of score distribution.

Another finding of the current research is that the predictive role of openness to problem solving in the upper quartile is more powerful than for the lower quartile. Openness to problem solving is identified as a meaningful predictor for success in the upper quartile. According to the results of the research conducted by Blackwell, Trzesniewski, and Dweck (2007), students who consider difficult tasks as a learning opportunity acquire higher marks from mathematics. It was also found that students who are open to problem solving are much more successful in mathematics (OECD, 2014). The larger predictive role of openness to problem solving for the upper quartile means that if students see the obstacles and difficulties as an opportunity to learn and approach to new problem situations in a more positive attitude, this positive orientation increases their success. As Stipek (1988) cited, students with high success profile often do not need to experience perseverance; but, when faced with a challenging problem situation, not all of them are open to problem solving. Some successful students prefer avoiding the task that might compel them. Philips (1984) explained that some students from the upper quartile set lower criteria for themselves in terms of success. Successful students often do not need to show perseverance in order to accomplish a task; however, if they show a positive approach to the challenging situations and are open to new problems, this helps them improve their skills and enhance their success.

As a result of this current study, it was concluded that perseverance and openness to problem solving predict student achievement. This finding proves that students from both the lower and upper quartiles of score distributions are supposed to become skillful at dealing with obstacles, maintaining effort, grasping challenging problem situations as a learning opportunity, and being open to challenging problem situations. Perseverance, on the other hand, is found to be a better predictor of success for the lower quartile of the score distribution. Based on this finding, teachers are advised to design classroom activities focusing on students' understanding on the value of the effort and increasing the effort they spend so as to enable students from the lower quartile to move to the upper quartiles. For the assessment aspect, it is suggested that teachers use performance tasks that require the showing of effort and the employment of different strategies. Teachers are advised to avoid assessing the achievement solely based on the cognitive skills; instead, they are suggested to value the efforts students show while accomplishing the task and are suggested to focus on the successfully completed parts of the tasks and to the parts that need improvement (Schunk et al., 2002; Stipek, 1988).

It was concluded that openness to problem solving predicts success much better for students from the upper quartile of the score distribution. Based on this finding, it is suggested for teachers to plan classroom activities that can promote authentic learning and carry student success to higher levels. Authentic problem situations are advised to be used by teachers in order to enhance higher-order thinking processes (Brookhart, 2010; Hammond & Adamson, 2010). While constructing the authentic problem situations, teachers should focus not only on students from the lower quartile's motivation, but also on students from the upper quartiles so that these students can experience challenging tasks and be better ready for future obstacles (Stipek, 1988). In conclusion, so as to transform successful students' negative orientations towards the positive, and to make them more open to problem solving, they should be dealt challenging and authentic problem situations more often.

In this study, predictive roles of openness to problem solving and perseverance on different success levels are studied. The results of this study show that achievement can be increased by enhancing perseverance for the lower quartile of score distribution and openness to problem solving for the upper quartile of score distribution. An experimental study may be suggested for researchers who would like to study these variables and their effects on achievement. In such a study, the increase on achievement can be observed after the group is trained by using classroom activities and assessment procedures that might enhance skills of perseverance and openness to problem solving. Besides, a structural equation model can be developed in which some variables that might affect the relationship between perseverance and openness to problem solving such as task difficulty and students' self-confidence is tested as mediation variables.

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